

A CONTRIBUTION TO THE KNOWLEDGE OF THE ODONATA

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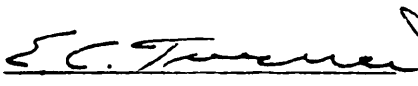
Frank Louis Carle

Dissertation submitted to the Graduate Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of
DOCTOR OF PHILOSOPHY

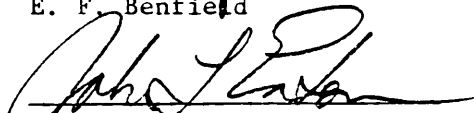
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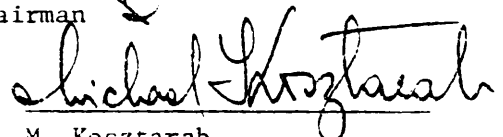
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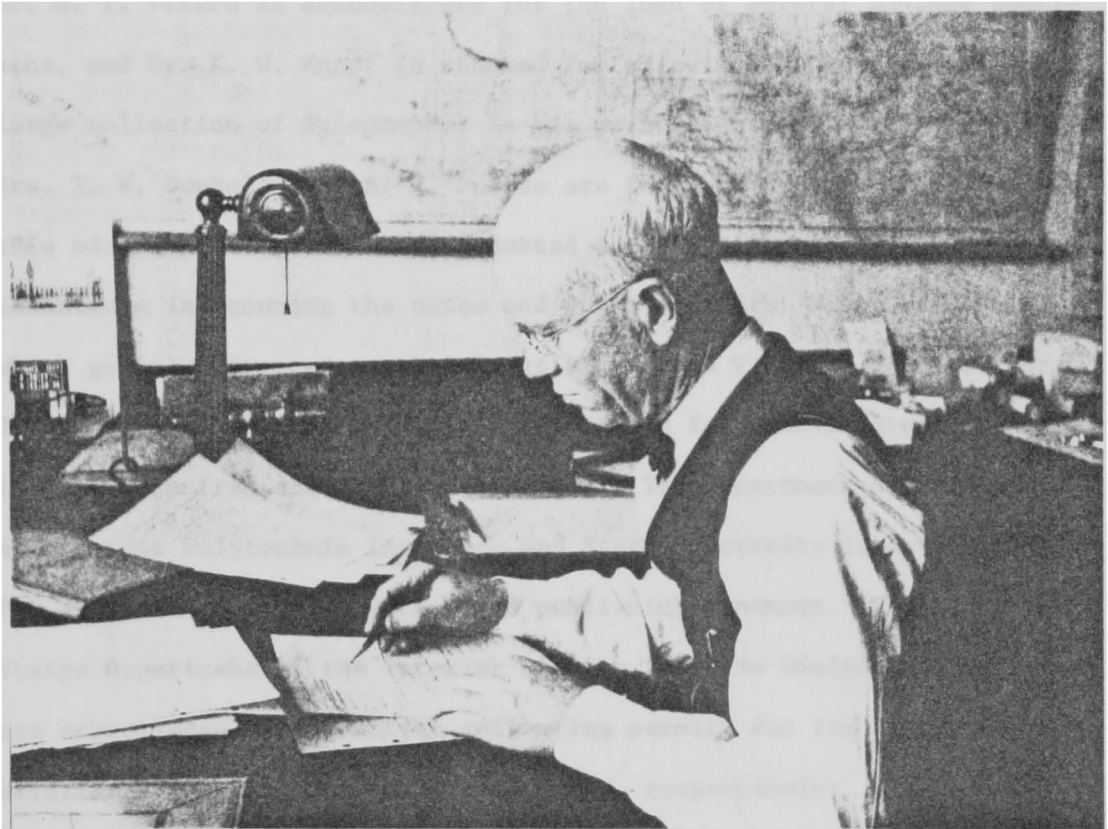
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To the memory of

E. B. Williamson

in honor of his valuable contributions
to our knowledge of the Odonata



Mr. Williamson writing his manuscript on the Dragonflies of
Missouri as photographed by Leonora K. Gloyd in April, 1932.

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INTRODUCTION

Dragonflies are among the most fascinating of living creatures; their beautiful coloration and amazing powers of flight cannot fail to impress even the casual observer. Complex territorial, mating, egg laying, and feeding behaviors await the more attentive observer, and the wide array of aquatic environments inhabited by dragonflies include many unique areas of special interest to naturalists. Adding to their allure, the dragonflies are truly ancient; protodonate fossils with wing spans exceeding two feet are known from the Upper Carboniferous and some fossil wings from the Jurassic are hardly distinguishable from those of extant gomphines and petalurines. This antiquity, although not reflected in current classifications, suggests that environmental perturbations which lead to the extinction of dragonflies are truly unusual. Accordingly, dragonflies show much promise for use in environmental monitoring (Carle 1979). Dragonflies are also useful insect predators and have occasionally been introduced for this purpose (Westfall 1978). Despite this beneficial nature of dragonflies, the knowledge of these ancient and beautiful insects is characterized by controversy and confusion.

The objective of this study is to examine critically the basis of the current theories on odonate wing vein homologies and copulatory process, and to apply these results to odonate phylogeny, particularly with regard to the Anisoptera of Virginia. In chapter one theories concerning the origin of insect wings and flight are reviewed and a new scenario for their origin proposed. Chapter two examines the various homology and nomenclatural systems applied to the longitudinal wing

veins of the Odonata, and a new system of wing vein homology proposed. The discal nodus, a heretofore overlooked component of the odonate wing mechanism is analyzed and its significance discussed relative to odonate phylogeny. A new odonate phylogeny is proposed based on a surprising almost total reversal of character state polarities as compared to the theories of Kennedy (1920), Tillyard (1928), and Fraser (1954). Chapter three is concerned with explaining the evolution of the odonate copulatory process. Scenarios assuming an original direct mode of sperm transfer require tandem oviposition and the accidental transfer of sperm to and from male anterior abdominal sterna. In contrast, assuming an original indirect transfer of sperm leads to a copulatory sequence similar to that of recent Odonata. The proposed scenario differs from those previously put forward in that extraordinary postures are not envisioned, the process is originally completed at rest, and development of the odonate tandem hold occurs just prior to sperm transfer. The historical knowledge and biogeography of Virginia Anisoptera are reviewed in chapter four. A methodology section is also included in chapter four, which in order to reduce redundancy, covers the techniques utilized throughout this study. In addition, the morphology and phylogeny of the Anisoptera are reviewed and identification keys to Eastern North American families and genera provided. Identification keys to 180 anisopterous species occurring in Virginia and surrounding states are also provided, along with a brief description of each family, genus, and species. Photographs of the wings and genitalia are presented, along with information on the biology, behavior, and seasonal and geographical distribution of each species. In the appendix to chapter four the males,

females, and nymphs of eight new Anisoptera discovered in the course of this study are described, along with information on their affinities, biology, and distribution.

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CHAPTER I

Thoughts on the Origin of Insect Flight

ABSTRACT

It is suggested that early Paleozoic landscapes were characterized by extensive seepage areas which provided relatively stable environmental conditions for early apterygotes. Increased dependence on the aquatic environment is envisioned as directing the development of pleural respiratory folds which could be ventilated by subcoxo-coxal muscles; pleural folds are not considered to be derived from preexisting insect structures such as paranota or coxal styli. It is also suggested that wing development may have been influenced by a thermoregulatory or swimming function of wings, or both. Flight is considered to have evolved in the reproductive adult stage in response to a continuous downstream displacement during the juvenile stage; flight eventually augmenting other forms of locomotion during the migration to upstream oviposition and nursery areas. Further, it is suggested that if the small stream theory is similar to the actual course of events then it is probable that pertinent fossil evidence will be scarce due to the high energy nature of the small stream environment.

INTRODUCTION

Speculation concerning past evolutionary events is perhaps the most intriguing aspect of evolutionary study, although inherently the most problematic. Such scenarios are based on the determination of character state polarity as are cladograms and phylogenies, but their impetus lies beyond morphology, being primarily concerned with the evolution of function. This is a noteworthy virtue as adaptive radiations are often triggered by functional adaptations of preexisting structures. A well-known example concerning preadaptation of flight involves the fossil "bird" *Archaeopteryx* which displays feathered wings and tail but lacks a well-developed breast bone for flight muscle attachment. The most ancient pterygote or winged insects are the Palaeoptera (living representatives are Ephemeroptera and Odonata) characterized by the inability to withdraw the wings into a folded arrangement flat over the abdomen. The abdominal gill plates of palaeopteran nymphs are obvious candidates for preadapted wings and have been suggested as such by several authors.

The origin of insect flight has been the subject of considerable speculation, the most favored scenario currently being the paranotal theory of Muller (1873-75). However, the paranotal theory did not receive general acceptance until Crampton (1916) considered, apparently incorrectly, insect wings to be of tergal origin. The paranotal theory proposes that protective thoracic paranota first acted as parachutes, then as gliding and steering wings, and finally as flapping wings. The considerable discontinuity between gliding and flapping *paranota* is also an objectionable supposition of the theory and has led to the proposal

of several alternative theories incorporating the idea of the preadapted "flapping" wing. The majority of these alternatives have involved an aquatic-related origin of insect wings; Woodworth (1906) proposed the origin of wings from gill opercula (gill-plates), Bradley (1942) and Grant (1945) from swimming gills, and Wigglesworth (1973, 1976) from gill plates derived from coxal styli. Rasnitsyn (1981) has proposed the origin of wings from movable structures which supposedly fused with the tergum and then again became movable coincident with the development of flight. In the present paper it is suggested that the environment of Paleozoic spring seeps provided suitable conditions for the evolution of insect flight, that wings originated from pleural respiratory folds ventilated by what are now the flight muscles, and that wing development may have been influenced by a swimming or thermoregulatory function, or both.

DISCUSSION

Mid-Paleozoic Terrestrial Environments

Silurian spring seeps may have been widespread, offering hospitable habitats to the early apterygote insects. Possible soil bacteria discovered in the Gowganda formation of Ontario suggest the presence of soils by the Mid-Prepaleozoic, and the textural and compositional maturity of Cambrian terrigenous sediments compared to those of the Ordovician suggest the development of soils and terrestrial plants by the Mid-Paleozoic (Dott and Batten 1971). Land plants appeared at least by the Silurian and by the late Devonian diverse lowland forests existed in Eastern North America, Greenland, and Britain (Andrews 1961). Fossil winged insects show considerable diversity in carboniferous rocks,

indicating, as in the case of land plants, an earlier origin than documented by known fossils. Silurian terrestrial plants included the psilophytes (Dott and Batten 1971) and probably also lichens, liverworts, mosses, and primitive ferns. This low and shallow-rooted vegetation would reduce runoff and evaporation, and although evapotranspiration would occur it would be much less than that associated with later more deeply rooted plants (cf. Hibbert 1967). These conditions would favor the accumulation of vast ground water reserves and the widespread formation of seepage areas. Therefore, seepage areas and spring-fed streams may have characterized large portions of the Paleozoic landscape at a time coinciding with the origin of insect wings and flight.

Seepage areas, springs, and spring-fed streams would afford a somewhat discontinuous but stable environment to the early apterygotes. Emerging groundwater generally remains at about the average annual air temperature, has stable chemical characteristics, and is relatively abundant in nutrients although oxygen concentrations near the source are typically lower than that of the atmosphere. Mid-Paleozoic seeps were probably only partially shaded by plants and therefore supported the growth of green algae which in addition to the inflow of allochthonous material formed the basis of innumerable productive seepage communities. It is clear that ancient apterygotes would be attracted to seepage areas, even though it is likely they originally inhabited the terrestrial environment.

Life History and Morphology of Protopterygota

The life history of protopterygotans is likely best approximated

among living forms by that of the Archaeonatha. A semiaquatic way of life for the Protopterygota is supported by the habitat requirements of archaeonathan genera such as *Allomachilis* and *Petrobius* which live in the damp crevices of coastal cliffs. Heeg (1967) found archaeonathans much more susceptible to dehydration than thysanurans, and Smith (1970) found that if mienertelids, the most primitive archaeonathans, were deprived of water in droplet form they would die in two or three days. In addition, the aquatic nymphal stage of the Palaeoptera, also suggests that protopterygotes were semiaquatic. It is likely that the protopterygotes were characterized by an ametabolous development which included several instars after the attainment of sexual maturity, indirect sperm transfer which was accomplished in the terrestrial environment via the substrate, and exophytic oviposition probably in moist detrital material. The diet probably combined items consumed by archaeonathans and ephemeropterans such as algae, diatoms, lichens, microscopic organisms, and detritus, all of which are generally relatively abundant in or near spring seeps. Smith (1970) reported that the archaeonathan *Machilinus* is attracted to warm surfaces, which indicates that protopterygotes were likely attracted by the stenothermal environment of spring seeps.

Protopterygotan morphology was characterized by a pronounced serial homology of body parts (Fig. 1), although the specialization of body segments had already led to the formation of the insectan tagmata, as evidenced by the morphology of Archaeonatha and fossil Monura. The mandibular, maxillary, labial, thoracic, and abdominal segments bore paired coxae, with each coxite in turn apparently bearing a lateral telopodite (leg), a sensory stylus, and an absorptive organ or vesicle.

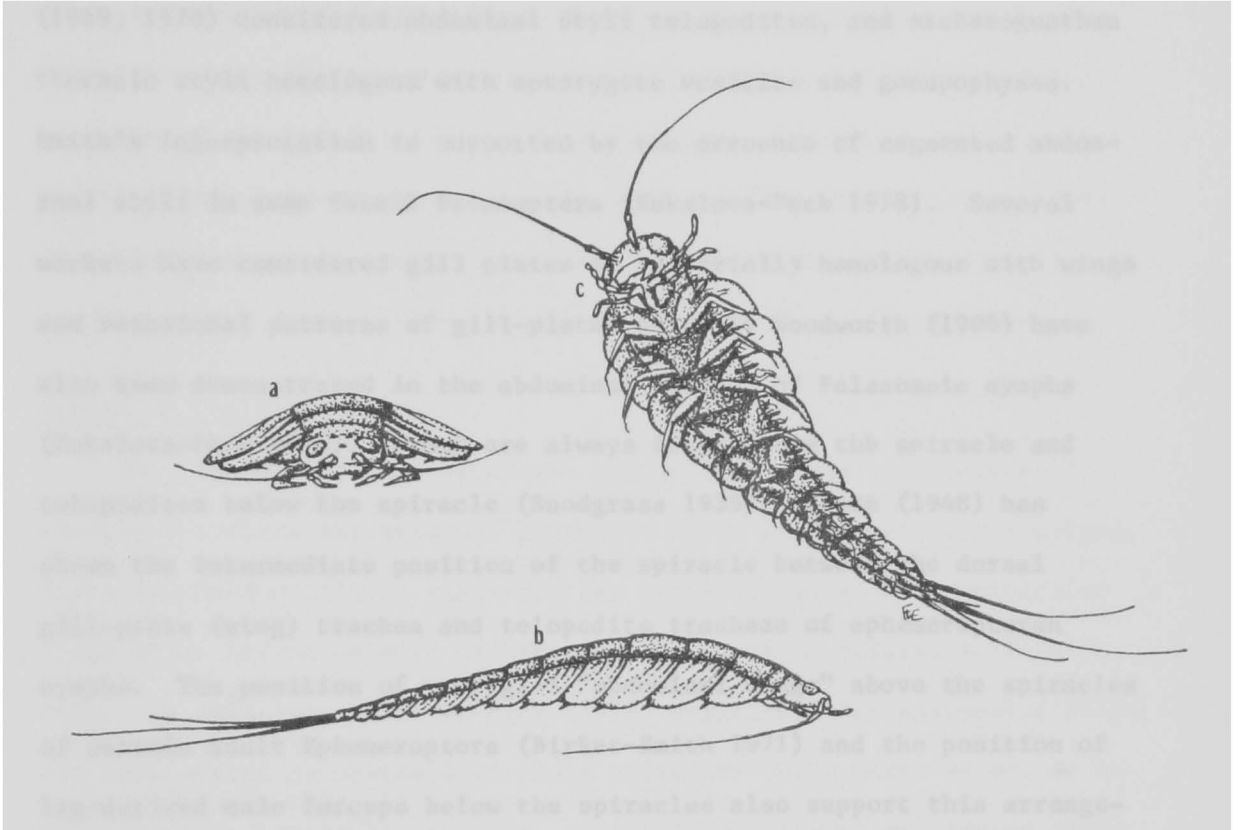


Figure 1. Hypothetical protopterygota: (a) anterior view of subadult, (b) lateral view of subadult, and (c) lateroventral view of adult in gliding posture; length of body 10-15 mm.

Snodgrass (1954) considered apterygote abdominal styli to be homologous with the lateral abdominal gills of Ephemeroptera and Zygoptera; and Wigglesworth (1973) considered archaeognathan coxal and abdominal styli, and ephemeropteran gill-plates homologous with wings. However, Smith (1969, 1970) considered abdominal styli telopodites, and archaeognathan thoracic styli homologous with apterygote vesicles and gonapophyses. Smith's interpretation is supported by the presence of segmented abdominal styli in some fossil Palaeoptera (Kukalova-Peck 1978). Several workers have considered gill plates to be serially homologous with wings and venational patterns of gill-plates noted by Woodworth (1906) have also been demonstrated in the abdominal "wings" of Palaeozoic nymphs (Kukalova-Peck 1978). Wings are always found above the spiracle and telopodites below the spiracle (Snodgrass 1935). Landa (1948) has shown the intermediate position of the spiracle between the dorsal gill-plate (wing) trachea and telopodite tracheae of ephemeropteran nymphs. The position of vestigial "abdominal wings" above the spiracles of certain adult Ephemeroptera (Birket-Smith 1971) and the position of leg-derived male forceps below the spiracles also support this arrangement. It is also noted that the lateral abdominal gills of certain zygopteran nymphs may be homologous with those of the Ephemeroptera as indicated by their position with respect to the developing female gonocoxae. Gill-plates arise from pleural evaginations above the spiracles which migrate with consecutively older instars toward the terga (Durken 1907, 1923) as do the thoracic wings (Tower 1903; Bocharova-Messner 1959, 1965, 1968). However, dorsal migration of stylus-derived wings proposed by Wigglesworth (1973, 1976) would be blocked by the subcoxal

annulus which E. L. Smith (Kukalova-Peck 1978) believes was developed in primitive apterygotes since it occurs in both recent Archaeognatha and fossil Monura. Palaeozoic nymphs have been found with articulating "wings" on three thoracic and nine or ten abdominal segments (Carpenter 1935, Kukalova 1968). As shown by Kukalova-Peck (1978) the immobile nature of recent nymphal thoracic wings is secondary and does not support the origin of wings from paranota. Therefore, the apparent desirability of proposing the origin of wings from old structures such as paranota or coxal styli is vacuous, and wings are likely derived from new structures arising from the pleural region above the spiracles.

Origin of Preflight Wings

The possibility that wings are entirely new insect structures greatly increases the array of scenarios which may explain their origin. Bocharova-Messner (1971) suggested the origin of wings from spiracular flaps which served sensory and protective functions related to respiration. In addition, Kukalova-Peck (1978) suggested that spiracular flaps may have served as opercula to close spiracles while under water, or to prevent water loss while on land; and Woodworth (1906) considered wings to be derived from gill-plates which were used to ventilate and protect filamentous gill-clusters. Indeed, the abundance of plesiomorphic characteristics shown by aquatic juveniles indicate that terrestrial apterygotes invaded the aquatic environment and that the origin of wings was somehow related to a change in respiratory function. An original respiratory function of the wings is somewhat supported by the wing pad spreading behavior of various Zygoptera in response to low oxygen levels.

A transition to aquatic respiration would be favored by the unique environment of the seepage area. Protopterygotes attracted by an abundant food supply and stable temperatures would encounter high oxygen concentrations during daylight due to photosynthetic activity. Low oxygen levels may have occurred after nightfall due to both the low oxygen content of emerging ground water and a substantial biological oxygen demand. The lowest oxygen concentrations would then coincide with the time of maximum possible benefit from the stenothermal nature of spring seeps. Therefore, it is possible that the wide range in oxygen concentrations allowed the gradual evolution of an increase in the efficiency of aquatic respiration. Plastrons (air cells) and the absorption of oxygen through the membranous pleural region were likely the initial mechanisms of aquatic respiration, and it is possible that setae present on the developing wing buds of recent insects may be vestiges originally used in the retention of plastrons. Increased dependence on the aquatic environment would select for a dendritic-like development of small tracheal branches above and lateral to the spiracles to aid in the distribution of oxygen through the original tracheal system. This could be augmented by the development of pleural folds on the thoracic, abdominal, and possibly the maxillary and labial segments to increase pleural surface area. Pleural folds would be preadapted for ventilation by the subcoxo-coxal muscles which would distort a membranous pleural region during walking, and it is perhaps significant that tergal-sternal muscles could also aid in ventilation by compressing the pleural region. These muscles would represent the primitive direct and indirect flight muscles, respectively. It is likely that the

uppermost gill folds became operculate both for ventilation and protection of the more delicate inner gills. A review of the literature reveals that elements of this scenario were first proposed by Oken (1811), Lang (1888), and Woodworth (1906). Efficiency could be improved by increasing the surface area to volume ratio through a flattening and expansion of the protowings. However, maintenance of sufficient blood flow through the protowings would require internal modifications.

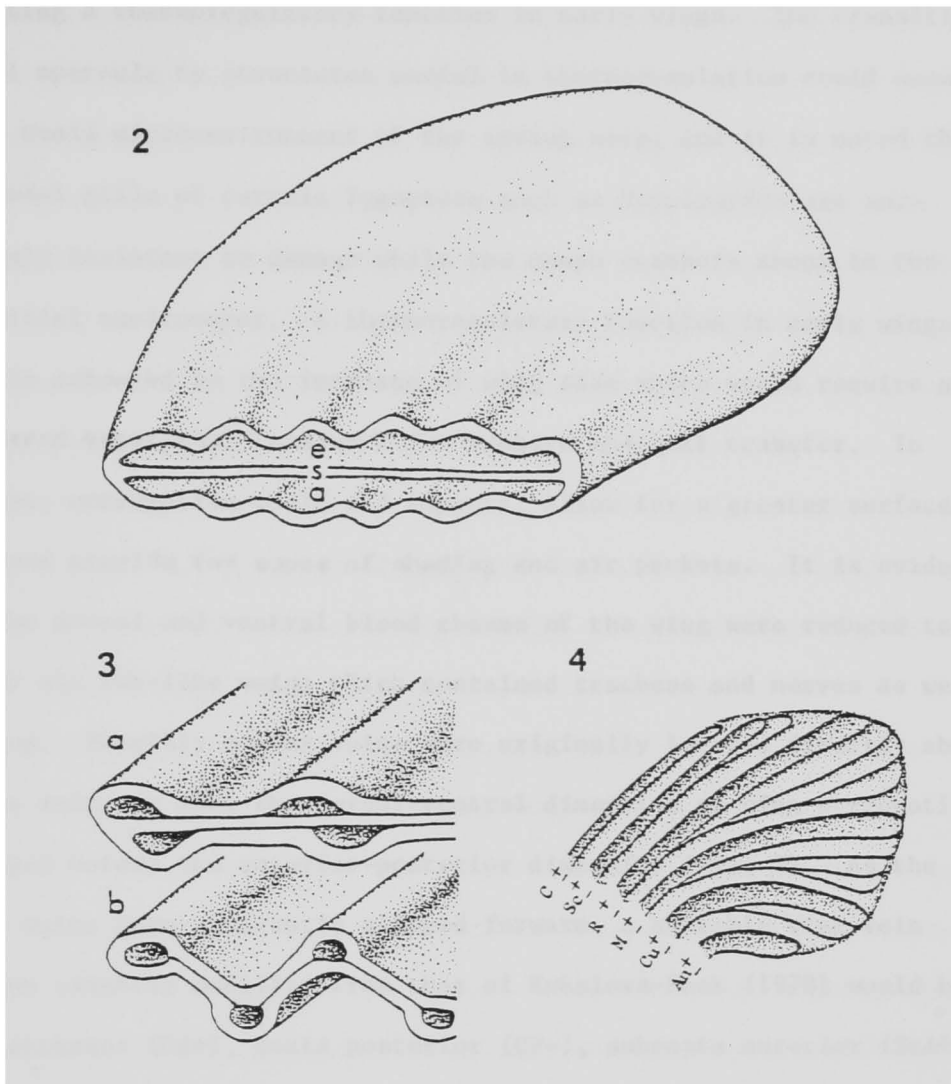
Preflight Wing Venation

Kukalova-Peck (1978) suggested that the haemocoel was restricted to channels which later became cuticularized and sclerotized to form a stiffening venational framework. Fluting was supposedly achieved by a differential excretion of cuticular material on the veinal tubes, and blood circulation achieved by a refluxing of blood into and out of six basal vein openings. If convex veins were primitively formed on the dorsal wing surface and concave veins formed on the ventral surface, then an alternate scenario is suggested. It is noted that this condition apparently persists as a plesiomorphic character in at least ephemeropteran wings (Spieth 1932), wing pads, and possibly gill-plates; in protoempheropteran wings; and in nymphal odonate wings (Calvert 1911), and wing pads. Nonalignment of blood channels and venation in the nymphal wings of recent insects is here considered an adaptation of the lacunae to subsequent changes in wing function. It is possible that as the wings became flattened, a septum was formed between the dorsal and ventral wing surfaces to maintain a sufficient blood flow (Fig. 2). Accessory dorsal pulsatile organs were eventually utilized, although

gravity probably maintained the circulatory gradient in the earliest wings. The dorsal convex chasm was the efferent route and the ventral concave chasm afferent. In addition to the obvious functions of blood circulation in the wing such as the transfer of nutrients and hormones, the blood transfers heat which may have been its most important function in the wings of early insects.

Preadaptation of Protowings

Prothoracic winglets of adult Palaeodictyoptera and wings of Paleozoic nymphs are characterized by a tubular cuticularized venation, a slight corrugation, and a hinge comprised of tergal sclerites and enlarged vein bases suggesting that preflight wings were significantly preadapted for flight (Kukalova-Peck 1978). The possibility of a preadapted hinge indicates that preflight wings were utilized in a flapping manner, either as gill opercula (Woodworth 1906) or possibly as spiracular flaps (Bocharova-Messner 1971). However, since corrugation and copious venation are not needed in the gill-plates of recent insects, it is possible that additional selective pressures acted in their development, notably the need to control body temperature. A semiaquatic insect adapted to the stable temperatures of emerging ground water would certainly benefit from a system which regulated body temperature while entering the terrestrial environment for reproductive purposes. Such a system is apparently utilized by the Odonata for either "heating up" in the morning or "cooling down" at midday; the system involves the wing, its circulatory system, and its variable orientation with respect to the sun. Certain fossil Palaeoptera have the dorsal veins hyperdeveloped



Figures 2-4. Hypothetical insectan protowings illustrating a possible scenario leading to the formation of corrugation and venation.

Figure 2. Section through protowing distal to hinge, note formation of septum; (s) septum, (a) afferent chasm, (e) efferent chasm.

Figure 3. Formation of corrugation and venation; (a) primary dorsal-ventral corrugation, (b) secondary anterior-posterior corrugation.

Figure 4. Branching or looping of the posterior (ventral) veins.

suggesting a thermoregulatory function in early wings. The transition of gill opercula to structures useful in thermoregulation could occur in the humid microenvironment of the spring seep, and it is noted that the caudal gills of certain Zygoptera such as *Megalagrion* are surprisingly resistant to damage while the nymph scampers about in the terrestrial environment. A thermoregulatory function in early wings would be enhanced by the increase of wing size which would require an associated venational framework for support and heat transfer. In addition, corrugation would aid support, allow for a greater surface area, and provide for zones of shading and air pockets. It is evident that the dorsal and ventral blood chasms of the wing were reduced to five or six rib-like veins which contained tracheae and nerves as well as blood. Possibly convex veins were originally located directly above concave veins so that the dorsal-ventral dimension of wing corrugation developed before the anterior-posterior dimension (Fig. 3). As the dorsal veins have apparently slipped forward, a suitable wing vein notation slightly modified from that of Kukalova-Peck (1978) would be: costa anterior (CA+), costa posterior (CP-), subcosta anterior (ScA+), subcosta posterior (ScP-), radius anterior (RA+), radius posterior (RP-), media anterior (MA+), media posterior (MP-), cubitus anterior (CuA+), cubitus posterior (CuP-), anal anterior (AnA+), and anal posterior (AnP-). However, evidence for recognizing C- and Sc+ is weak because the anterior wing margin questionably represents a vein, and Sc+ is vestigial when apparent. Improvements of the hinge involving a thickening of wing vein bases and a thinning of the wing in general coupled with changes in venation to improve a thermoregulatory function of wings

would lead to the modification of the original blood flow pattern. The concave (ventral) veins may have become multilooped in order to increase shading efficiency by increasing the width of troughs (Fig. 4). This process of looping was apparently carried to some dorsal veins, but vein pairs in the anterior wing region were probably not involved at all in order to maintain strength along the leading edge of the wing. Major vein pairs became fused basally and cross veins allowed the eventual anterior-posterior blood flow of existing Pterygota.

A thermoregulatory function of the wings not only offers a possible explanation for the increase in wing size and the development of venation and corrugation in the preflight wing, but may explain the muscular and articular changes necessary for pronation and supination. It is apparent that early insects could regulate their temperature while in the terrestrial environment by varying body orientation with respect to the sun, but considering only the wings it is obvious that at low angles of inclination only slight reorientations of the wings are necessary to regulate body temperature. This effect is particularly enhanced when the corrugations are characterized by wide troughs and oriented perpendicular to incoming light. Therefore, rotation and the associated modifications of the wing base can be considered an adaptation to thermoregulation and a preadaptation to flight.

Bradley (1942) and Grant (1945) have suggested that preflight wings became adapted for flight by serving as fins and propulsion devices in water. However, the original use of gill plates in swimming would probably not be similar to the gill-plate method employed by nymphal mayflies such as *Chloeon*, or the method used by certain adult Chaleid

wasps which swim under water with their wings. The original hinge was apparently straight, wide, and parallel to the body axis. Swimming, if achieved, was likely accomplished by undulating the body in an up and down fashion while altering the pitch of the gill-plates. The gill-plates could be tilted with the subcoxal-coxal muscles (precursors of the direct flight muscles), which is a possible explanation for the muscular and articular changes necessary for pronation and supination. However, the development of pronation and supination of gill-plates to improve the ventilation of inner gills may have been a preadaptation for both swimming and flying.

Development of Flight

The development of flight, like the origin of wings, was quite possibly brought about by conditions in the small stream environment. Life history was likely segregated into a semiaquatic juvenile stage and a terrestrial adult stage. However, it is noted that Kukalova-Peck (1978) believes that metamorphosis did not evolve until much later and occurred separately at least seven times in the Pterygota. The nymphal stage would be primarily a period of feeding characterized by a substantial increase in body size; in contrast the adult stage would be primarily concerned with reproduction. A continuous downstream displacement, or drift (cf. Waters 1972), characterized the nymphal stage which was compensated for by an upstream migration during the adult stage. Wigglesworth (1973, 1976) proposed that semiaquatic pterygotes "learned to fly" after being swept up by the thermal upcurrents of semiarid regions to be deposited with the next rainfall. However, advantages accrued to

adults while migrating to upstream reproductive areas also seem a plausible explanation for the origin of flight. Upstream migration was probably achieved through a combination of walking, swimming, jumping, and eventually gliding and flapping flight. The author has observed primitive archaenathans jumping from the surface of water, and primitive ephemeropterans (*Isonichia*) jumping back into water when disturbed while out of water to emerge. The author has also observed *Isonichia* to "swim" out of water into the air when startled; it is perhaps significant that this ability is developed in forms inhabiting rapid streams. Although these primitive forms do exercise some attitude control in flight, presumably with the cerci, legs, and antennae, Flower (1964) has calculated that attitude control and gliding distance would be improved in small insects with even rudimentary wings. This suggests that even small articulating lateral gill opercula might be advantageous in flight. Evening updrafts through stream valleys could have helped carry the early pterygotes to the upstream mating and nursery areas, and downstream drift of nymphs to areas containing unexploited food resources would gradually lengthen migratory routes and necessitate the gradual improvement of gliding and flapping flight. The specialization of the ovipositor for laying eggs in the protective environment of living and dead plant material surrounding seepage areas could lead to a further consolidation of reproductive sites and also to intense sexual selection between males which undoubtedly involved flight capabilities. Increased vagility coupled with the isolated nature of reproductive areas would set the stage for a dramatic adaptive radiation. Within the adaptive radiation precipitated by the origin of flight several parallel evolu-

tionary trends seem likely, among these are included: loss of the aquatic stage, loss of the ovipositor, specialization or loss of abdominal appendages, development of direct sperm transfer, development of male grasping and intormittent organs, reduction and loss of nymphal "wings", consolidation of the anterior and basal wing veins, and the formation of the metamorphic instar.

Fossil Protopterygota

The small stream theory concerning the origin of insect wings and flight has many implications if it does indeed depict the true course of events. Foremost are implications concerning the abundance and distribution of early pterygote fossils. If the assumption concerning the thermoregulatory function of preflight wings is correct; then regions of the Devonian geography characterized by seasonal climates may yield enlightening fossil evidence; these areas include Siberia, Greenland, and the southern continents as evidenced by the occurrence of Paleozoic "tree" rings (cf. Dott and Batten 1971). The high energy environment of the small stream is certainly not a suitable environment for insect fossilization, leaving a bias in the fossil record toward relatively advanced forms which lived near swamps and lakes. However, Rasnitsyn (1981) states that the "chances of fossilization were much higher for aquatic and amphibious insects than for terrestrial ones." Rasnitsyn's belief seems doubtful in light of the author's experience in carefully processing benthic lake and stream samples (cf. Carle 1980). Insect *remains* were primarily of hard bodied terrestrials, typically Coleoptera. This is apparently related to both the higher population levels and

higher durability of terrestrial insects. Therefore, bias in the insect fossil record is probably toward a disproportionate representation of Coleopteroids and Orthopteroids. However, the importance of fossil evidence in determining the correct phylogenetic classification of insects must not be underrated in light of the considerable degree of parallel evolution likely after the origin of insect flight.

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CHAPTER II

The Wing Vein Homologies, Wing Mechanism, and Phylogeny
of the Odonata

ABSTRACT

Development of the various homology and nomenclatural systems applied to the longitudinal wing veins of the Odonata are reviewed with special reference to apparent ambiguities. The pretracheation theory and various wing vein systems based on the theory such as that of Comstock and Needham are considered invalid as demonstrated by several authors. The process of vein loss is evaluated in the Palaeoptera and a new system of wing vein homology proposed for the Odonata. The odonate wing mechanism is analyzed and an important but heretofore overlooked component, the discal nodus, is characterized and considered a suitable key character for recent Odonata. The absence of the discal nodus and considerable basal fusion of CuP and the anal vein in *Kennedyia* and its allies sheds considerable doubt on the wing vein and phylogenetic schemes proposed by Tillyard and Fraser. With *Kennedyia* removed from the direct ancestry of recent Odonata the intercalated nature of Tillyard's IR₃ is without support; in the new system IR₃ is considered to be MA. New fossil evidence could support either system, although the new system is more consistent with evidence from phylogeny as determined from other morphologic characteristics and the process of vein fusion and reduction in the Palaeoptera.

INTRODUCTION

Few topics in Entomology are as controversial as the wing vein homologies of the Odonata. While conducting studies on the Odonata of Virginia it was necessary to choose among the many wing vein notations proposed in the past. A reasonable solution to the problem seemed to be to determine wing vein homologies from personal experience, and then to adopt the appropriate notation system as proposed by a previous author. However, it became increasingly apparent that agreement with previous authors was unlikely and that yet another system of wing vein homology and notation was indicated. Disagreement stemmed from fundamental differences involving the nature of the archetypal wing, the process of vein fusion and reduction, the odonate wing mechanism, and odonate phylogeny. Since the conclusions of previous authors were affected by historical context, a more or less chronological review of their proposed homologies and notations follows; these have been summarized in Table 1. The new system which is based on another possible interpretation of the evidence is also included.

HISTORICAL REVIEW

Early workers recognized the taxonomic value of odonate wing venation and developed a system of descriptive names which became well established with the publication of the monographs and synopses by Selys (1853, 1854, 1854-78, 1857, 1860-77, 1871-1878). Unfortunately later workers such as Kirby (1889) modified the original system, a predictable consequence since the system was not based on the homology of wing veins

Table 1. Various Nomenclatures for Longitudinal Wing Veins of the Odonata.

	vein type										
	± ^a	-	+	-	-	+	-	+	-	+	+
Redtenbacher 1886	I	II	III ₁	III ₂	IV	V	VI	VII	VIII	IX	
Comstock-Needham 1898	CC	Sc	R ₁	M ₁	M ₂	Rs	M ₃	M ₄	Cu ₁	Cu ₂	A ₁ A ₂ A ₃
Tillyard 1914	C	Sc	R	M ₁	M ₂	RS	M ₃	M ₄	Cu ₁	Cu ₂	A ₁ ^b A ₂ A ₃
Tillyard 1917	C	Sc	R	M ₁	M ₂	RS/MS ^c	M ₃	M ₄	Cu ₁	Cu ₂	A ₁ ^b A ₂
Tillyard 1922b	C	Sc	R	M ₁	M ₂	MS	M ₃	Cu ₁	Cu ₂	IA	
Lameere 1922	C	Sc	R	Sr ¹	Sr ² S ^d /Sr ³	Sr ⁴	M	Scu	P ^e	U ^e	
Martynov 1924	C	Sc	R	RS ₁	RS ₃ ^f	RS ₄	RS ₅	M	CuP	A ₁	
Tillyard 1925a	C	Sc	R ₁	R _{2a}	R _{2b}	IR _{2b}	R ₃	MA	Cu ₂	IA	A'
Tillyard-Fraser 1940	C ^g	Sc ^g	R ₁	R ₂	R ₃	IR ₃	R ₄₊₅	MA	CuP	A ₁	
Forbes 1943	C	Sc	R ₁	R ₂	R ₃	R ₄₊₅	M	Cu ₁	Pl ^h	IAx	IAx _a 3Ax ₁
Hamilton 1972	C	Sc	R	SA ^j	SP ^j	MA'	MP'	Cu	P+E ^j	A	
Present Author	CA	CP	RA	RP ₁	RP ₂	MA	MP	CuA	CuP	A ₁	A ₂ A ₃ ^k

^a/Convex proximal to nodus and neutral-concave distal to nodus.

^bCu_{2b} in the Libellulines and gomphines.

^cRS in the Anisoptera and MS in the Zygoptera.

^dS (secant) in the Anisoptera and Sr³ (third subradial) in the Zygoptera.

^eP (penultimate) or first anal and U (ultimate) or third anal.

^fLibelluline apical planate considered as RS₂.

^gC or anterior costa (CA) and Sc or posterior costa (CP).

^hPlical (Pl).

^jAnterior (A) and posterior (P) employed without reference to vein type.

^kPlical (P) and empusal (E).

^lA₃ of previous authors termed the anal brace.

among insect orders. Hagen (1846) showed that the wing veins of dragonflies are each developed on both the dorsal and ventral wing membrane and coincide with the wing tracheae. However, Calvert (1911) found that in the imaginal wings of nymphal *Cora* the convex (high) veins are developed on the dorsal (inner) wing membrane and the concave (low) veins developed on the ventral (outer) wing membrane. Spieth (1932) separated the wing membranes of mayflies and found an arrangement equivalent to that figured by Calvert. This arrangement can also be found in the wing pads of recent Palaeoptera and indeed has been shown in the wing pads of paleozoic mayflies by Carpenter (1979). These results not only indicate that the double venation noted by Hagen is secondary, but also that a fundamental difference exists between convex and concave wing veins as suggested by Adolf (1879). Redtenbacher (1886) attempted to homologize the venation of the Pterygota by employing Adolf's theory concerning the primitive corrugated nature of wings. A notation was developed in which each consecutive longitudinal vein was represented by Roman numerals from I to XII, with odd numbers designating convex veins and even numbers designating concave veins. Six vein pairs were recognized, although the costa was interpreted as a single vein, thus shifting the notation forward one pleat as compared to the notation of Kukalova-Peck (1978) in which the costal brace and anterior wing margin were considered longitudinal veins. Comstock (1893) employed Redtenbacher's notation but omitted veins V and VII. After studying the wing trachea of nymphal Odonata, Brauer and Redtenbacher (1888) rejected the fan-like protowing on the basis of tracheal distribution. Comstock and Needham (1898-99) homologized the wing venation of the Pterygota while

assuming that nymphal wing tracheation determines the position of veins and recapitulates the ancestral venation of adults. The Comstock-Needham system was reaffirmed and expanded specifically for the Odonata by Needham (1903), but the system remained questionable in several respects: R_s was convex, unbranched, and crossed M_1 and M_2 ; a "secondary" convex bridge vein was formed proximally between R_s and M_1+M_2 ; M_4 and Cu_2 were convex, and Cu_1 was concave (the opposite condition characterizing other Pterygota); and A was small and fused subapically to Cu_2 at a point where Cu_2 reversed its fluting (Comstock-Needham notation).

In a series of detailed papers on the pretracheation of nymphal wings Tillyard unintentionally furthered the confusion concerning odonate wing vein homologies and phylogeny. Tillyard (1914) made adult wing vein notation conform more closely to the nymphal wing tracheation by considering Cu to be $Cu+A$ as far as the first cubito-anal crossvein (referred to by Tillyard as the anal crossing, Ac), and A basal to Ac as a secondarily formed bridge-vein distally referred to as A_4 and proximally referred to as A^1 . Tillyard also concluded that the anal loop was not homologous throughout the Anisoptera, proposing the name "Italian loop" for it in the Libellulidae, and suggesting that the anal loop of *Hagenius* is similar to a subtriangle. Placing considerable importance on the formation of oblique-crossveins (tracheal crossings between longitudinal veins), Tillyard proposed the family Lestidae comprising the Lestini, *Synlestes*, *Chlorolestes*, *Epiophlebia*, and the fossil *Heterophlebia*; the latter two genera are generally regarded as belonging to a separate suborder the Anisozygoptera. After determining that R was unbranched in the Zygoptera, Tillyard (1915) proposed the

term "Zygopteroid Sector" (MS) for the vein labeled RS in the Anisoptera. Needham (1903) was aware of these tracheal specializations reported by Tillyard but he did not utilize them when determining wing vein homologies, possibly noting the unreliability of pretracheation theory in Trichoptera, Hymenoptera, and Diptera. Further study led Tillyard (1916) to suggest that the bridge of the Lestidae may be MS while beyond the oblique vein (O) it is "undoubtedly RS", and in the Petalurines and Cordulegasterines which often have two oblique veins the Rs of Needham is actually MS proximal to O₂. However, after actually studying the nymphal wing tracheation of *Uropetala*, Tillyard (1922a) reversed his decision and considered RS the segment of Needham's Rs between O₁ and O₂ (now referred to as O and O') and considered MS the segment of Needham's Rs distal to O₂. It is not surprising that Tillyard (1922a) began to lose faith in nymphal wing tracheation and suggested a totally new notation in which RS was considered the third branch of a five-branched media. Finally, Tillyard (1922b) showed that no ontogenetic stages of the supposed development of RS actually existed; he therefore turned to wing fluting to determine the wing vein homologies of the Odonata. Tillyard suggested that M₄ (MS of Tillyard's 1922a notation) was actually Cul, that Cul was actually Cu₂, and that Cu₂ was actually a distal extension of 1A.

Lameere (1922) proposed a modification of Adolf's theory in which six principal veins, the costal, radial, median, cubital, penultimate, and ultimate were recognized as convex, each with a posterior concave sector. Like Redtenbacher, Lameere did not recognize a fused costa and his notation was shifted forward one pleat as compared to that of

Kukalova-Peck (1978), while an additional vein pair, the ultimate, was recognized toward the posterior margin of the wing. Lameere also relied on the theory of pretracheation to determine homologies and therefore his third branch of the radial sector Sr^3 (MS of Tillyard, Rs of Comstock and Needham) was convex and considered a "supplementary branch" in the Anisoptera which was termed the secant (S). Pretracheation theory also indicated the cubital sector (Scu) was fused with the first anal or penultimate (P), thus the base of the cubitus was again considered double, but unlike Tillyard's (1914) analysis where the fusion extended only to Ac, here it extended to the branching of Needham's Cu_1-Cu_2 . This interpretation was also applied to fossil Protodonata in which an apparent oblique vein forms an anastomosis between his cubital and penultimate. Further, to reconcile these conclusions with the modified theory, Lameere proposed the unexplained loss of his Sm, Cu, Sp, and Su in the Odonata; Cu and Su in *Meganeura*; and M and Cu in the Ephemeroptera (Sm was regrettably considered to have reversed its fluting in the Ephemeroptera). With regard to phylogeny, Lameere considered the Odonata and Ephemeroptera derived from fossil genera now included in the Palaeodictyoptera; the Palaeodictyoptera are now characterized as having haustellate mouth-parts (Kukalova 1970). This misplacement was also entertained by Handlirsch (1906-08), Martynov (1938), Tillyard and Fraser (1938-40), and Fraser (1954, 1957). Tillyard (1925a, 1928) proposed the derivation of the Odonata from the Megasecoptera which are also now known to have haustellate mouth-parts. Carpenter (1931) emphasized the distinctness of protodonate and odonate venation from that of other Palaeoptera, and did not propose their origin from known fossil types.

Several authors have proposed possible phylogenies for the Odonata; the more comprehensive of these are included in Table 2.

In November of 1922, Martynov presented a paper to the Russian Entomological Society on the wing vein homologies of the Odonata and Ephemeroptera which was published in 1924. Unlike Lameere, Martynov (1924) placed little confidence in the theory of pretracheation and regarded the Rs of Comstock and Needham (1899) as the fourth branch of a five-branched radial sector in both Zygoptera and Anisoptera. Martynov noted that the RS of Morgan (1912) which supposedly supported a primitive crossing of M was concave in the Ephemeroptera and convex in the Odonata, this he reconciled by correcting Morgan's interpretation of the venation. In the region of the anal veins Martynov's results were equivalent to those of Tillyard (1922b); the small vein at the base of the protodonate wing which Lameere regarded as the base of his Scu (CuP in Martynov's notation) was considered by Martynov to be a basal remnant of CuA. Martynov also considered one of the M veins to be missing in the Odonata and although the existing vein was convex he did not consider it to be MA until reviewing Lameere's (1922) paper as indicated in a postscript to his original work. Like Lameere, Martynov rejected Adolf's theory concerning the original fan-like wing and selected the fossil dictyoneurines as exemplifying an archetypic venation; other Palaeodictyoptera with the *vein pairs* separating nearer the wing base were considered to be more advanced. Branches of a particular main vein were considered to be both convex and concave, therefore the odonate RS was considered five-branched with RS₂ and RS₄ convex. Inserted sectors were regarded as veins which had lost their basal attachment from other

Table 2. Phylogeny of the Odonatoids as Proposed by Various Authors.

Author	Lower		Upper		Triassic	Jurassic
	Carboniferous	Carboniferous	Permian	Triassic		
Handlirsch (1906-08)	Palaeodictyoptera	Protodonata		Anisozygoptera	Anisozygoptera	Zygoptera Anisoptera Anisozygoptera
Tillyard (1928)		Protodonata Protozygoptera	Zygoptera	Anisozygoptera	Anisoptera	Anisozygoptera Zygoptera
Megasecoptera						
Carpenter (1931)		Protodonata Protanisoptera Protozygoptera	Zygoptera	Anisozygoptera	Anisoptera	Anisozygoptera Zygoptera
Common Ancestor						
Martynov (1938)		Protodonata Protozygoptera Protanisoptera		Archizygoptera	Anisoptera	Anisoptera Anisozygoptera Zygoptera
Palaeodictyoptera						
Tillyard (1935-38)		Protodonata Protanisoptera Protozygoptera	Zygoptera	Anisozygoptera Archizygoptera	Anisoptera	Anisozygoptera Anisozygoptera Zygoptera
Palaeodictyoptera						
Fraser (1938-57)		Protodonata Protanisoptera Protozygoptera	Zygoptera	Anisozygoptera	Anisoptera	Anisoptera Anisozygoptera Zygoptera
Palaeodictyoptera						

veins, intercalated sectors being found only occasionally in the distal portion of the wing; Martynov apparently did not consider forms characterizing the Legions *Calopteryx* and *Thore* of Selys (1853, 1854). The Anisoptera were considered to be more primitive than the Zygoptera in wing form, distribution of the main longitudinal veins, and in the smaller reduction of the anal area. Equally disconcerting was the placement of the Anisozygoptera close to the Lestidae by the form of the quadrilateral which with the straightening out of CuP supposedly became rectangular, reaching its "maximum development" in forms such as *Calopteryx*. Later Martynov (1931, 1932) described *Permaeschna* from a rather poorly preserved wing in which he recognized CuA and MP. An unfamiliarity with extant Anisoptera was revealed when Martynov homologized MP and CuA with the planates of the Aeschnidae and Libellulidae (the immediate ancestors of these families, the Neopetalidae and Cordulegastriidae, respectively, do not have planates).

The basis for what was to become the rival notation to that of Comstock and Needham was presented by Tillyard (1925a), and then modified (Tillyard 1926). Like the interpretations of Lameere and Martynov both MP and CuA were considered to have unexplainably disappeared, MS was now considered an intercalated vein (IR_3), R was considered to be four-branched (the first branch convex, the last three concave), and the anal vein was considered to be fused with CuP proximal to AC. Tillyard based his new system on results from Kennedy's (1920) studies on the penis of the Zygoptera and on a pseudozygopterous fossil wing which Tillyard named *Kennedyia mirabilis*. Fraser (1957) followed the Kennedy-Tillyard interpretation in his classification of the Odonata although

Needham (1951) had pointed out that they had "read their evolution series for Zygoptera in reverse". The wings of *Kennedyia* are characterized by several unique features including extreme petiolation, arculus distal to "second primary antenodal", nodus undeveloped, "IR₃" poorly developed, and the apparent fusion of Cu₂ and 1A. Tillyard (1925a) also revived Woodworth's (1906) theory that the *main* wing veins developed from the wing margin inward. Because of superficial similarities with *Kennedyia* such as the loss of the inner side of the quadrangle, and noncoenagrionine characteristics such as nonalignment of postnodal crossveins and presence of the anal vein proximal to "Ac", the small coenagrionine *Hemiphlebia* was placed by Tillyard (Tillyard and Fraser 1938-40) at the "base" of the Calopterygidae; however, Fraser questioned this placement in the same paper. It is noted that among the odonatologists who did not accept Tillyard's venational interpretations were Williamson, Needham, Calvert, and Ris (Needham 1951). Carpenter (1931) also expressed doubt concerning Tillyard's interpretation, pointing to the apparent absence of Ac in the Protanisoptera. However, Carpenter's comment concerning the Protozygoptera, "There can not, of course, be any doubt that Cu₂ and 1A are fused in *Kennedyia* and *Progoneura*.", indicated agreement with Tillyard's interpretation at least with respect to the Zygoptera; this was reconciled by proposing a dual origin of the Odonata from protozygopterous and protanisopterous stock. Tillyard (1935) accepted Carpenter's theory and suggested that *Polytaxineura* foreshadows the Aeshnoidea and *Ditaxineura* the Libelluloidea. Fraser (1938) reported that the anal vein is not fused with "Cu₂", but with the hind margin of the zygopterous wing. Later Tillyard and Fraser (1938-40) presented an "ideal notation" for the Odonata.

C was replaced by CA, Sc by CP, R₁ by RA, R₂₋₅ by RP, Cul by CuA, and Cu₂ by CuP; only CuA and CuP were used in practice. It is noted that Kukalova-Peck (1978) has considered both C and Sc paired vein systems. Fraser (1948) was again prompted to modify the Tillyard notation by an apparently naive comment made by Zalesky (1944) concerning the change in costal fluting noted in a particular species of *Aeshna* (the change of the costal margin from a convex to a neutral-concave vein at the nodus is characteristic of *all* Odonata). Fraser considered the costa to terminate at the nodus at which point the subcosta turned forward to follow the postnodal margin of the wing, but the similar nature of the costal margin throughout its length indicates that C and Sc are fused beyond the nodus; this result was expressed by both Zalesky (1944) and Needham (1951).

A novel approach to the problem of wing vein homologies was taken by Forbes (1943) in which wing tracheation and corrugation were combined in a unique manner to achieve new vein homologies for the Pterygota. Wings were considered to originate from the meso- and metathoracic terga of a "pre-cockroach" with wing tracheation originating from both the leg trachea of the same segment and the spiracular trachea of the preceding segment. Not only is the paranotal theory in doubt because "wings" arise from the pleural region (Tower 1903; Durken 1907; Bocharova-Messner 1959, 1965, 1968), but also because prothoracic protowings of the Palaeodictyoptera were shown to be articulated (Kukalova-Peck 1978). The proposed original tracheal distribution is also in doubt since the tracheation of Archaeonantha and Ephemeroptera follow the segmental plan (Weber and Weidner 1974); further speculation that the

original veins were formed about the trachea contradicts the findings of several authors (Tower 1903, Sulc 1911, Marshall 1913, Tillyard 1922a, Martynov 1924, Kuntze 1935, Ross 1936, Fraser 1938, Holdsworth 1941, Henke 1953, Smart 1956, Whitten 1962, Leston 1962, Arnold 1964, Carpenter 1966, and Kukalova-Peck 1978). Corrugation was considered by Forbes to result from wing articulation with the thorax and the indirect action of flight muscles upon wing veins, these forces supposedly formed four "crucial" pleats in the Palaeoptera (redefined to include only the Ephemeroptera, Odonata, and Protodonata). Forbes compared his new notation for the Odonata to those of Comstock-Needham and Tillyard. The radius was considered five-branched, R_1 convex, R_2 and R_3 concave, and R_{4+5} convex. Tillyard's R_{4+5} was considered to be M, and Tillyard's MA was considered to be Cu_1 . The midbasal convex vein was considered to include the fusion of Cu in addition to the fused M and R recognized by other authors. A new name (plical, Pl) was introduced for CuP because of an apparent supposed primitiveness of neopterous wing folding. The small vein at the base of the protodonate wing (CuA of Martynov and Tillyard) was labeled 1Pl followed by 2Pl. Considering the midrib of the libelluline anal loop to be the second anal ($2A_x$), Forbes proposed a close relationship between the Libellulidae, the Aeschnidiidae, and the Meganeuridae. However, the midrib of the libelluline anal loop is secondarily formed as evidenced by its absence in annectent families such as the Cordulegastridae. In addition, the arrangement of aeschnidiine hind wing triangles are more specialized than those of extant Anisoptera.

The practice of renaming veins such as CuP for typological and topographical reasons was continued by Zalesky (1944) and Hamilton

(1972). A new terminology was introduced by Zalesky (1944), and his attempt to reconcile apparent inconsistencies in wing fluting led Fraser (1948) to comment "Zalesky has taken the facile and unusual method of adopting a notation of his own, which is apparently a return to the archaic meaningless systems which held sway among the fathers of Entomology". Hamilton (1971-72) superimposed a new terminology over that in use by designating CuP the plical (P), 1A the empusal (E), and 2A the first anal (1A). However, in the Odonata P and E were considered to be fused so that Hamilton's 1A was equivalent to the 1A of other authors. Evidence used to support the fusion of P and E was incorrectly interpreted; the small *convex* CuA at the base of the protodonate wing was considered to be his *concave* P, and the branched nature of trachea CuP is due to secondary tracheation of the distal portion of 1A, not to the fusion of the proposed trachea P and E. Also unfortunate was Hamilton's decision to confound existing terminologies by utilizing the designations anterior (A) and posterior (P) without reference to the concave or convex nature of veins. For example, the concave radial sector (S of Hamilton) was considered to have both a sector anterior (SA) and a sector posterior (SP). It is also noted that Kukalova-Peck (1978) considered the costa and subcosta paired veins and introduced the notations C+, C-, Sc+, and Sc-.

The array of proposed wing vein homologies and associated notations have not produced a universally accepted scheme for the Odonata. Most odonatologists employ either the Comstock-Needham system or one of Tillyard's later systems based on wing fluting. Opponents of the Comstock-Needham system point to the unacceptability of pretracheation

theory, while opponents of Tillyard's theories consider the total loss of MP and CuA highly improbable. Some recent textbook authors such as Borror and Delong (1976) have employed the Comstock-Needham system, but support for Tillyard's systems has been shown by several odonatologists including Garman (1927), Borror (1945), Chao (1953), and Walker (1958). Perhaps the most astonishing aspect of this controversy is that both the process of vein fusion and reduction and an integral component of the odonate wing mechanism, the discal nodus, have been entirely overlooked.

RESULTS AND DISCUSSION

Oversight regarding vein fusion and the discal nodus has resulted in the proposal of several improbable phylogenies for the Odonata; these hypotheses have in turn been used to support various systems of wing vein homology. The archetypical insect wing was apparently fan-like as suggested by Adolf (1879), which is supported by the fan-like venation of palaeodictyopterous prothoracic winglets and of mayfly wings (Figs. 1 and 2). At least five paired vein systems arose from the primitive wing base; the individual veins may be conveniently referred to as the costa anterior (CA), costa posterior (CP), radius anterior (RA), radius posterior (RP), media anterior (MA), media posterior (MP), cubitus anterior (CuA), cubitus posterior (CuP), anal anterior (A), and anal posterior (AP).

Vein Fusion and Reduction

A trend throughout the Pterygota has been toward the consolidation

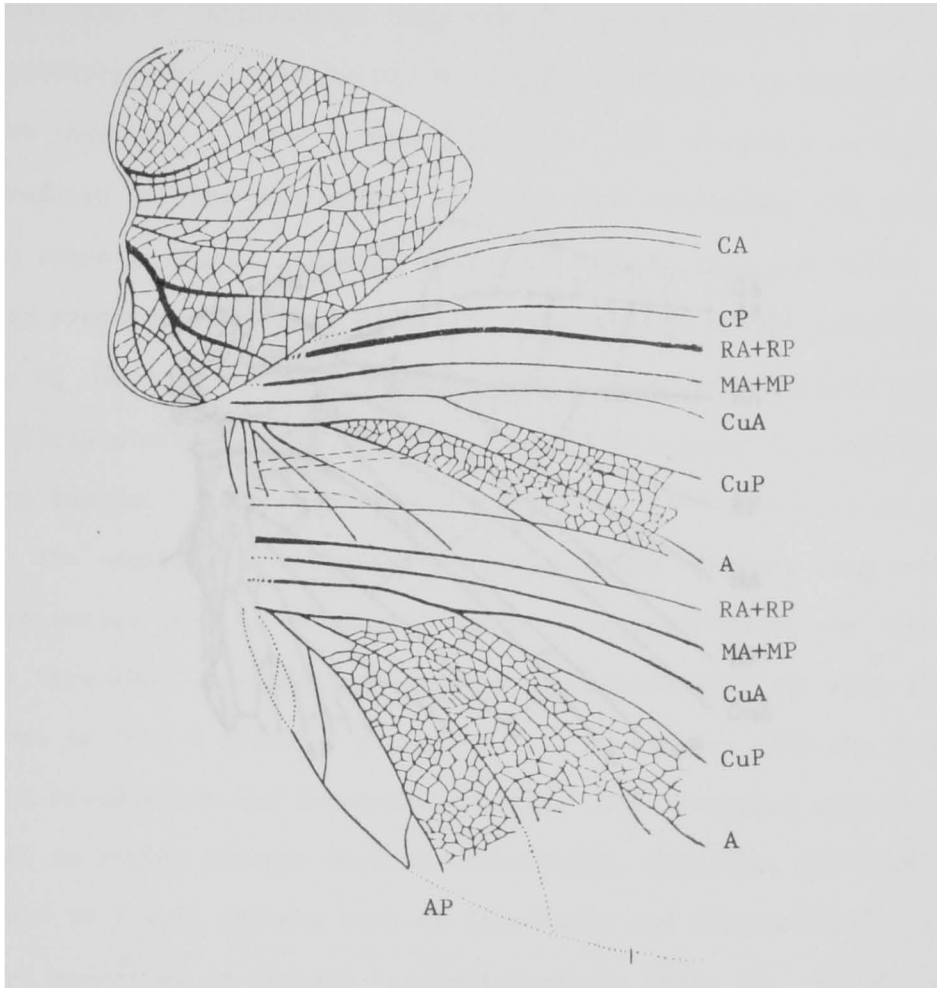


Fig. 1. Prothoracic winglet and base of meso- and metathoracic wings of *Stenodicta pygmaea* (Dictyoneuridae: Palaeodictyoptera). Although weakly corrugated the winglet exhibits a fanlike vein arrangement and is characterized by an apparent full complement of wing veins as are the wings. The radial and medial vein stems of the pterothoracic wings separate further distally than shown. After Kukalova (1970), vein interpretations added, missing costal veins of hind wing reinterpreted.

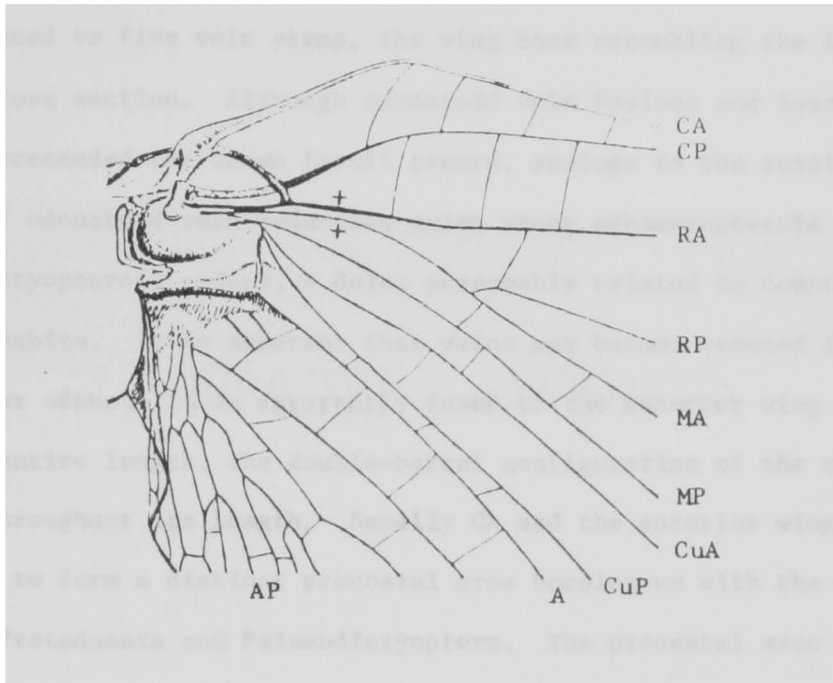


Fig. 2. Hind wing base of *Siphonurus mirus* (Siphonuridae:Ephemeroptera) illustrating the loss of fluting between RA and MA. Other longitudinal veins have retained their basal identity supporting an original fanlike arrangement of wing veins. After Kukulova-Peck (1974), vein interpretations completed.

or basal loss of longitudinal wing veins. The most ancient vein reduction probably occurred among the ancestral odonatoids to improve flight agility required by their predatory habits. The odonate wing base has been reduced to five vein stems, the wing base resembling the letter "w" in cross section. Although odonatoid vein fusions and losses largely preceded the known fossil record, analogs to the possible early stages of odonatoid vein reduction exist among ephemeropteroid and palaeodictyopteroid orders, a delay presumably related to nonpredacious feeding habits. It is apparent that veins may become reduced in several ways. The odonate CA is apparently fused to the anterior wing margin for its entire length, the double-barrel configuration of the costa apparent throughout its length. Basally CA and the anterior wing margin separate to form a distinct precostal area homologous with the precostal area of Protodonata and Palaeodictyoptera. The precostal area is most evident in recent Odonata such as *Tachopteryx*, *Hagenius*, and *Anotogaster*, and in fossil Odonata such as *Isophlebia* and *Polytaxineura*, but it is best preserved in certain Palaeodictyoptera (Fig. 1). The double-barreled configuration (parallel fusion) of convex veins apparently strengthens the wing by overcoming compressive force exerted while the wing is in the down or power stroke. Therefore, it is not surprising that the middle convex vein stem of the odonate wing base has also retained a double-barrel configuration while the intervening concave vein is no longer apparent basally. The initial stage of this sequence persists in the Ephemeroptera (Fig. 2). The double-barrel configuration of the protodonate midbasal vein stem affirms that it is a very ancient apomorphic feature of the odonatoid wing (Fig. 3). Also, in many petiolate

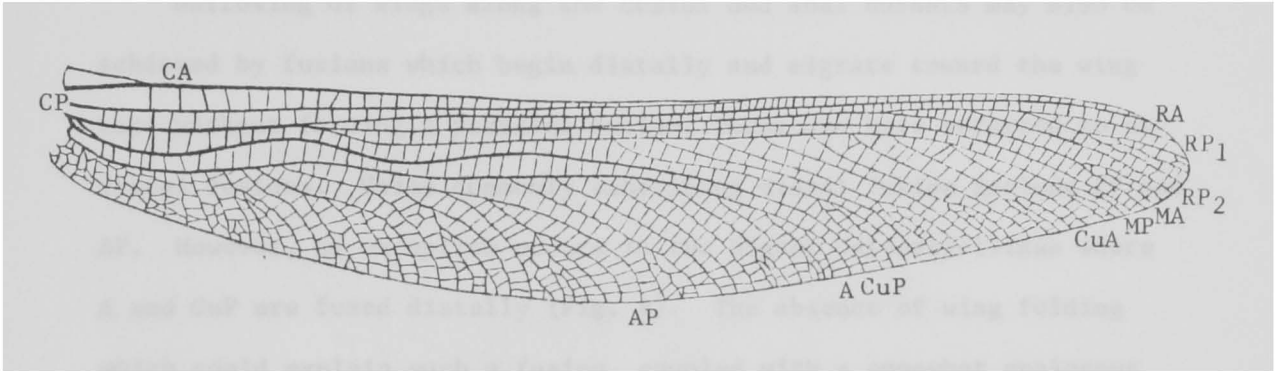


Fig. 3. Fore wing of *Typus* (Meganuridae:Protodonata) illustrating the crowding of longitudinal veins forward so that unlike the Odonata, most of the wing surface is posterior to MP. Relative crossvein densities and the arrangement of longitudinal veins indicate that lengthening of the protodonatan wing has occurred to a relatively greater extent in the basal half. MA and MP of the new system therefore appear considerably reduced. Note small basal remnant of CuA between the middle vein stem and CuP. After Carpenter (1931), vein interpretation modified.

odonate wings A and the posterior margin of the wing retain a double-barrel configuration so that the three convex basal vein stems all appear double in cross section. An extreme example of parallel fusion in the Palaeodictyoptera is found in the higher Calvertiellidae (Fig. 4).

Narrowing of wings along the costal and anal borders may also be achieved by fusions which begin distally and migrate toward the wing base without forming a parallel fusion, these are here referred to as distal fusions. Veins commonly exhibiting distal fusion include CP and AP. However, an exception occurs in the higher Calvertiellidae where A and CuP are fused distally (Fig. 4). The absence of wing folding which could explain such a fusion, coupled with a somewhat analogous arrangement of wing veins to that of the Odonata suggest that a wing mechanism similar to that of the Odonata could be responsible for such a fusion. The basal remnant of CuA in protodonate wings (Fig. 3) suggests that CuA and MP may have been lost through a gradual process of distal fusion as implied by Lameere, Martynov, and Tillyard (the small basal remnant of CuA is not concave as suggested by Hamilton (1972) or formed by the displaced base of the anal trachea as suggested by Needham (1951); this interpretation is supported by the convex basicubitale which transverses the odonate axillary plate.

However, vein fusion and reduction toward the center of the wing typically involves either parallel fusion or transverse point fusion. Transverse fusion results in attachment to the preceding vein, distal displacement, and the isolation of the vein base which may form an oblique crossvein or an "arculus". Oblique veins formed from transverse fusions are characteristically slanted with the anterior end distal,

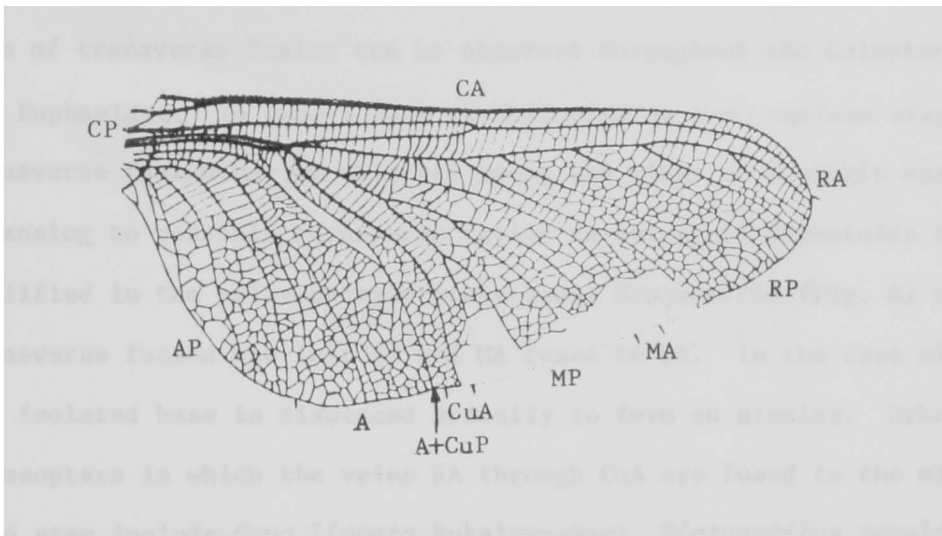


Fig. 4. Adult hind wing of *Carrizopteryx arroyo* (Calvertiellidae: Palaeodictyoptera) illustrating a pseudodonate wing vein arrangement. Note the fused middle vein stem and the pseudodonate nodal areas at the distal fusions of CP-RA and CuP-A. After Kukalova-Peck and Peck (1976) vein labels added.

and therefore may be distinguished from those formed by tracheal crossings which are characteristically slanted with the anterior end proximal. Both types can often be observed in the fore wings of *Echo* (Fig. 5). Forward displacement following transverse fusion presumably shifts apical wing stresses to the more anterior convex vein bases. The process of transverse fusion can be observed throughout the Calopterygidae and Euphaeidae. In genera such as *Metacrina* or *Echo* various stages of transverse fusion may be observed among the wings of a single specimen. An analog to possible transverse fusion in ancestral Odonatoids is exemplified in the palaeodictyopterous genus *Becquerelia* (Fig. 6) where transverse fusion has left RP and MA fused to RA. In the case of RP its isolated base is displaced apically to form an arculus. Other Palaeoptera in which the veins RA through CuA are fused to the midbasal vein stem include *Hana lineata* Kukalova-Peck, *Dictyoptilus sepultus* (Meunier), and *Moravia grandis* Carpenter. The occurrence of transverse fusion in ephemeropteroid orders adds further support for its occurrence in ancestral odonatoids.

Wing Vein Homologies

A new system of odonate wing vein homology is realized by considering the base of RP lost between RA and MA as in the Ephemeroptera (Fig. 2) which forms the double-barreled midbasal convex vein stem, and MP and CuA fused to the midbasal vein stem through the process of transverse fusion. However, unlike the condition preceding the transverse fusion of concave veins, CuA did not initially lose its basal integrity which is often the case with convex vein bases. Therefore, it is apparent that a two-point transverse fusion of CuA occurred which was

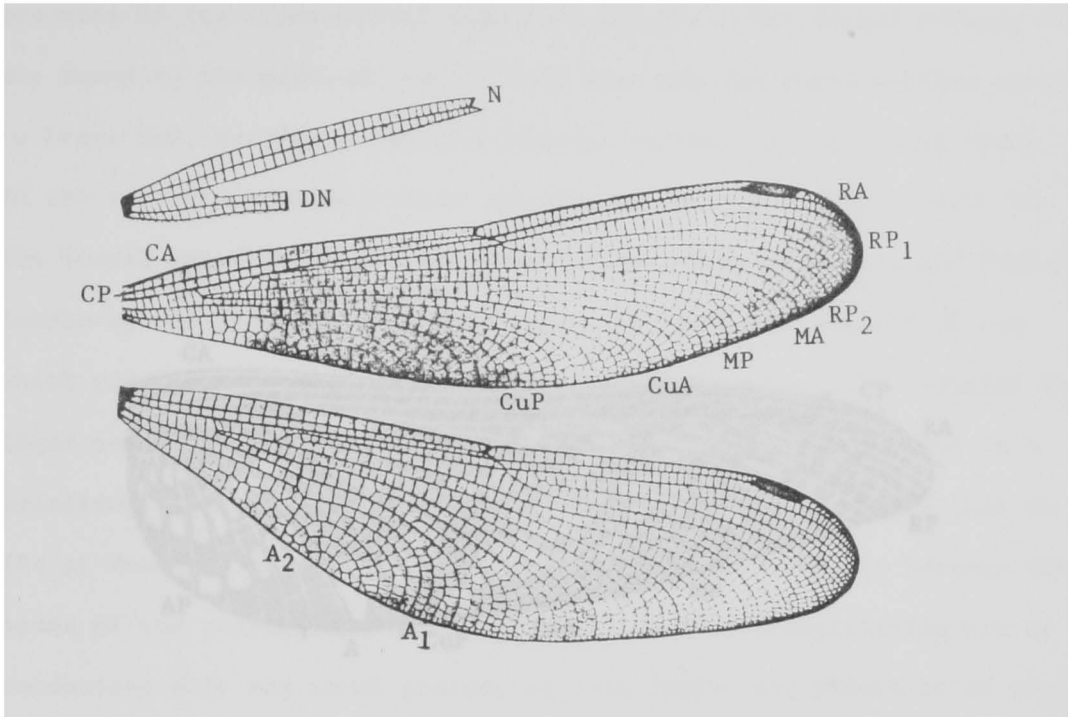


Fig. 5. Wings of *Echo modesta* (Calopterygidae:Odonata) with fore wing costal and discal pleats offset for clarity. The costal pleat terminates at the nodus (N), the *discal* pleat is here truncated at the discal nodus (DN), and the *distal* pleat arises between these at the branching of RP-MA-MP. The transverse fusion of RP to RA is apparent in the fore wing. Note the relative retraction of the fore wing discal nodus as compared to the hind wing discal nodus; retraction is indicated by relative cross-vein densities proximal and distal to the discal nodus, and greater atrophy at the base of the fore wing distal pleat. Also note in the fore wing the oblique detached base of RP between RA and MP, and oblique vein (tracheal crossing) between RP and MA. After Williamson (1904), vein interpretations added.

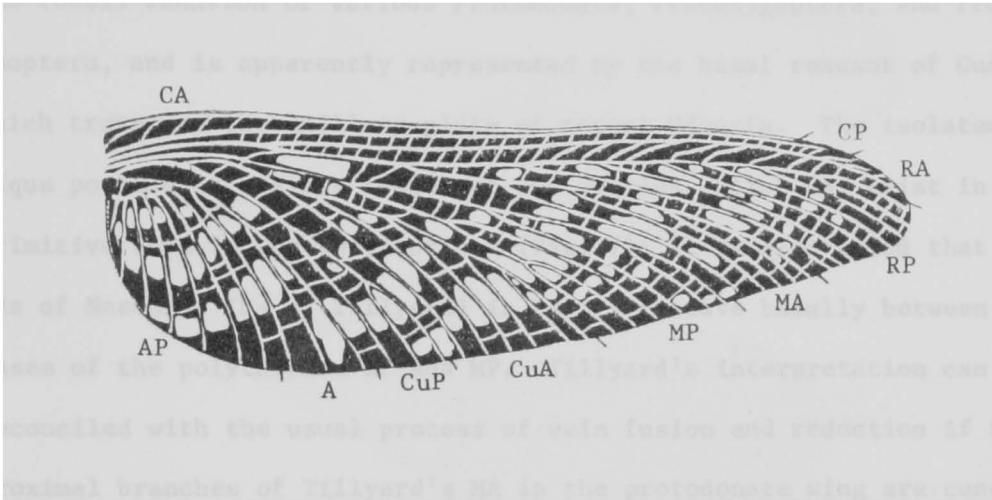


Fig. 6. Hind wing of *Becquerelia superba* (Spilapteridae:Palaeodictyoptera) illustrating the transverse point fusion of RP and MA. The isolated bases of RP and MA appear as oblique crossveins proximal to the distal portion of each vein, although the base of RP has moved distally to form an arculus. After Kukalova (1969), vein interpretations added.

preceded by its hypothetical sigmoid curvature. The distal portion of CuA was fused to the midbasal convex vein stem and the basal portion remained to brace CuP, serving a function similar to that of the costal brace in the ephemeropteroids. Basal bracing of CuP via CuA is evident in the fossil *venation* of various Protodonata, Protozygoptera, and Protanisoptera, and is apparently represented by the basal remnant of CuA which traverses the axillary plate of recent Odonata. The isolated oblique portion of CuA may represent the arculus, which may exist in a primitive form in the polythorines (Fig. 7); it is also noted that MA (Rs of Needham, IR₃ of Tillyard) is hardly concave basally between the bases of the polythorine RP and MP. Tillyard's interpretation can be reconciled with the usual process of vein fusion and reduction if the proximal branches of Tillyard's MA in the protodonate wing are considered to be the apically displaced remnants of MP and CuA. However, pectinate intercalated veins are likely to form through convergence in this region of the odonate wing to enhance the propagation of torsion waves described by Wootton (1981). These branches are developed in various polythorines, and calopterygines, in *Thaumatoneura*, and in the Protodonata; whereas MA (Tillyard's IR₃) and MP (Tillyard's R₄₊₅) are represented throughout the Protodonata and recent Odonata in an area of the wing where they could be easily lost. Tillyard's decision to treat these veins as branches of RP apparently stemmed from a similar arrangement of veins in the apical half of odonate, protodonate, protepheridan, ephemeropteran, and palaeodictyopteran wings, which had been described as "striking and obvious" by Martynov (1924). However, lengthening of the protodonate wing has primarily occurred in the basal half, so that

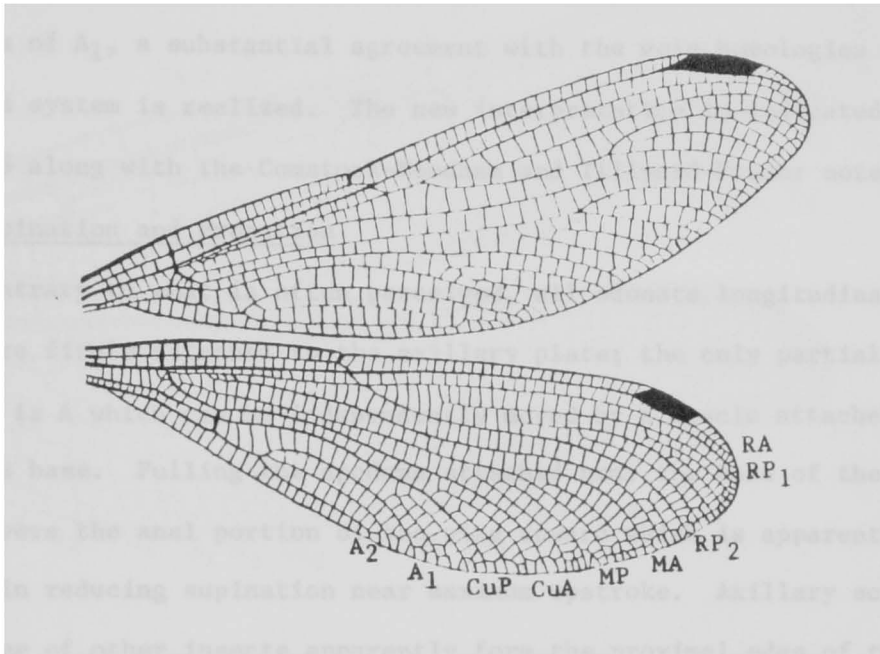


Fig. 7. Wings of *Chalcopteryx rutilans* (Polythoridae:Odonata) illustrating apparent retraction of the fore wing discal nodus relative to the hind wing discal nodus. Note the relatively weak basal attachment of MP as compared to MA, and the absence of a typical arculus. After Needham (1903), vein interpretations added.

A_1 terminates beyond the wing's midpoint. In other Palaeoptera A_1 generally terminates at about 1/4 the length of the wing. Therefore, if the arrangement of veins in the apical half of protodonate and odonate wings are compared to those of other Palaeoptera relative to the termination of A_1 , a substantial agreement with the vein homologies of the proposed system is realized. The new interpretation is indicated in Figure 8 along with the Comstock-Needham and Tillyard-Fraser notations.

Wing Supination and Pronation

Contrary to what is often perceived, all odonate longitudinal wing veins are firmly attached to the axillary plate; the only partial exception is A which can be independently moved by a muscle attached near its base. Pulling the apodeme attached near the base of the anal vein levers the anal portion of the wing upward which is apparently useful in reducing supination near maximum upstroke. Axillary sclerites one-three of other insects apparently form the proximal edge of the odonate axillary plate. The humeral plate articulates with the anterior lobe of the lateroprescutum and to the axillary plate at the base of the costal vein. The basalar sclerite and associated muscles are connected to the anterolateral corner of the humeral plate, contraction of these muscles during the downstroke apparently causes pronation of the wing necessary for forward flight. Pulling the apodeme attached to the posterior lobe of the lateroprescutum causes a rotation of the humeral plate which in turn tilts the axillary plate backward (causing wing supination and torsion) on an axis between the pleural wing process and the posterior nodal wing process. Attachment of the subalar sclerite near the pleural wing process and the orientation of the large anterior

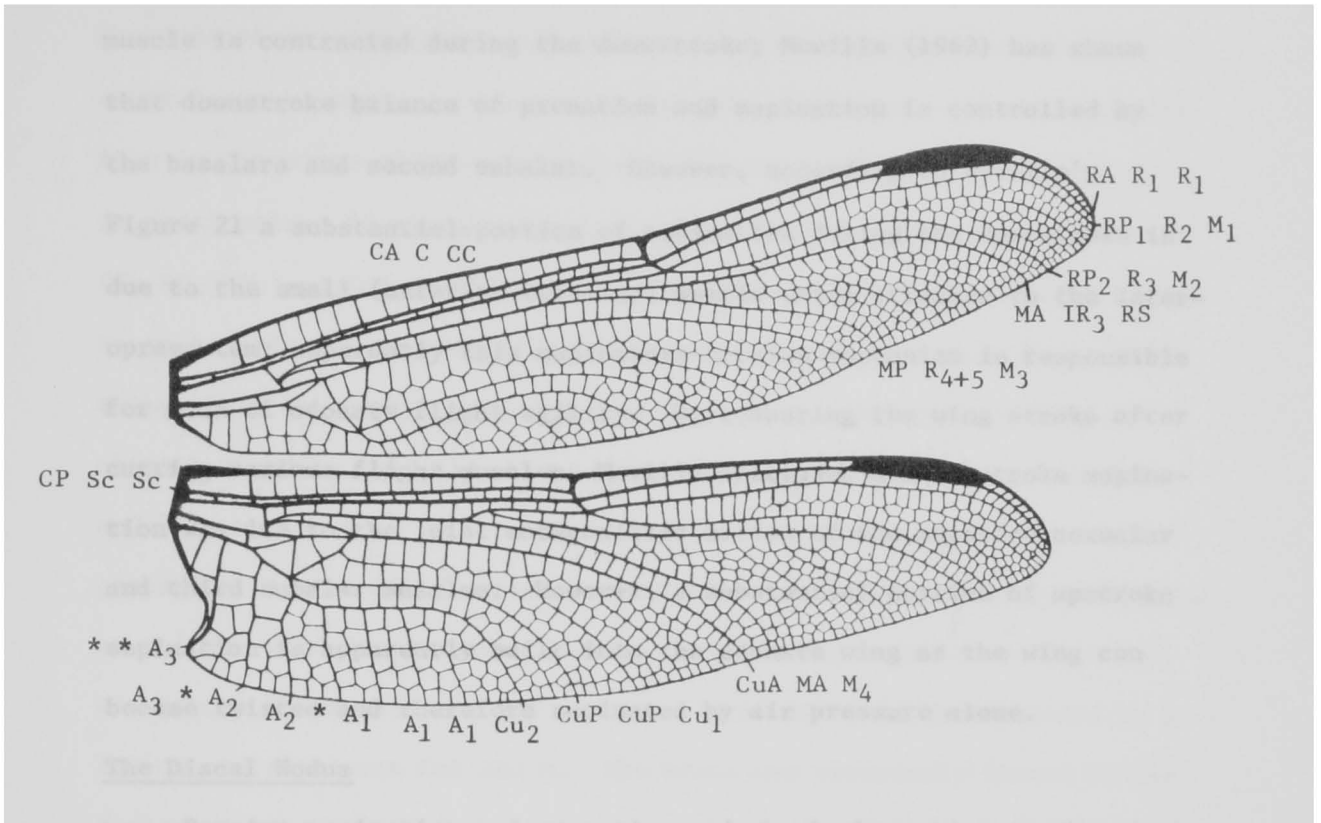


Fig. 8. Wings of *Aphylla williamsoni* Gloyd (Gomphidae:Odonata) comparing the proposed wing notation to those of Tillyard-Fraser and Comstock-Needham, respectively. The discal brace is less oblique in the narrower fore wings. Note the precostal area at the base of the costa, and the apical recession of the distal pleat characteristic of most Anisopteroids. Asterisks designate cases where an equivalent notation is not proposed.

subalar muscle apparently precludes significant supination when this muscle is contracted during the downstroke; Neville (1960) has shown that downstroke balance of pronation and supination is controlled by the basalars and second subalar. However, according to Neville's Figure 21 a substantial portion of supination during the downstroke is due to the small (anterior coxoalar) muscle which attaches to the lateroprescutum; apparently this supinatory-torsion mechanism is responsible for much of odonate flight agility. By comparing the wing stroke after cutting various flight muscles, Neville concluded that upstroke supination was due to the joint antagonistic action of the anterior coxoalar and third subalar muscles. However, a substantial portion of upstroke supination is apparently built into the odonate wing as the wing can become twisted and therefore supinated by air pressure alone.

The Discal Nodus

Passive supination and pronation and shock absorption at the wing stroke maxima possibly occurred in the Protodonata, and apparently occur in the Ephemeroptera and Odonata. In the Protodonata this is indicated by the crowding of longitudinal veins anteriorly, and the sigmoid curvature of CuP (Fig. 3). Wings of the Protodonata and Protozygoptera are asymmetrically supported by a relatively straight anterior portion; presumably this arrangement resulted in passive supination and pronation along an axis parallel to the costa during the upstroke and downstroke. In contrast, the wings of Protanisoptera, Anisozygoptera, Anisoptera, and Zygoptera are supported by an anterior portion which is at least slightly bent at the termination of the subcosta (nodus) so that the axis of bending runs obliquely through the wing. The portion

of the wing distal to the nodus is produced forward, especially so in Protanisoptera, and apparently improves pronation-supination reversal at wing stroke maxima. Passive supination, pronation, and shock absorption in the wings of extant Palaeoptera involve distinct compression or nodal points of the concave veins. Such nodal points are found on CP, RP, MP, and CuP of the Ephemeroptera, but because they are arranged in an anterior-posterior line they likely function in shock absorption rather than in passive supination or pronation. The odonate wing is characterized by only one such nodal point which is located along CuP and here referred to as the discal nodus. It is also noted that the posterior wing margin is connected to A by a membranous joint. Analogous to the increase in crossvein density which strengthens the nodal areas of several Ephemeroptera, the odonate discal nodus is strengthened by a strong brace between CuA and A. The brace was apparently formed by the fusion of crossveins of the interspaces bordering CuP, therefore its primitive orientation would be perpendicular to the longitudinal veins as suggested by Needham (1903) and Williamson (1913). Williamson (1913) was the first to call attention to the discal brace which he referred to as the "medio-anal link". In the Zygoptera and Anisozygoptera the distal side of the quadrangle and in the Anisoptera the distal side of the triangle is formed by the portion of the discal brace between CuA and CuP. Although the flexible nodal area is not visible dorsally, the discal brace is easily observed in both fossil and recent odonate wings; presence of the discal brace is therefore a convenient key character for recent Odonata.

The odonate nodus located at the fusion of CA and CP is not only

a point of bending, but also a point of twisting which acts in conjunction with the discal nodus as a shock absorber and in passive supination and pronation. The odonate wing mechanism may be conveniently described by viewing the human hand in lateral view with the thumb angled downward. From the wing base at the wrist two strong pleats extend out into the wing, one to the apex of the index finger and the other along the thumb. At the apex of the thumb is found the discal nodus which allows the wing to bend causing a twisting at the nodus located at the distal end of the index finger. Flexibility is apparently moderated by the relative position of a pleat between the thumb and index finger. Therefore, it is likely that the odonate nodus and discal nodus arose simultaneously.

Phylogenetic Considerations

New evidence concerning the process of vein fusion and loss, and the odonate wing mechanism, support an odonate phylogeny (Fig. 9) similar to that proposed by Martynov (1938) among suborders, and similar to that proposed by Needham (1903) and Munz (1919) among the families of recent Odonata. The most comprehensive phylogeny (Fig. 10) based upon Kennedy's and Tillyard's theory of the narrow archetypic odonate wing was presented and discussed by Fraser (1954, 1957). Although generally accepted, the Fraser phylogenies are considered highly improbable in light of the evidence presented herein. Advocates of the corrugated archetypic insect wing such as Lameere, Martynov, and Tillyard often referred to mechanical reasons for the unique venation of the Odonata, but unfortunately little attention was given to actual wing mechanisms, and the polarity of various character sequences were often viewed in reverse.

Figure 9. A Phylogeny of the Odonatoids Based on Proposed Character State Polarities and the Fossil Record.

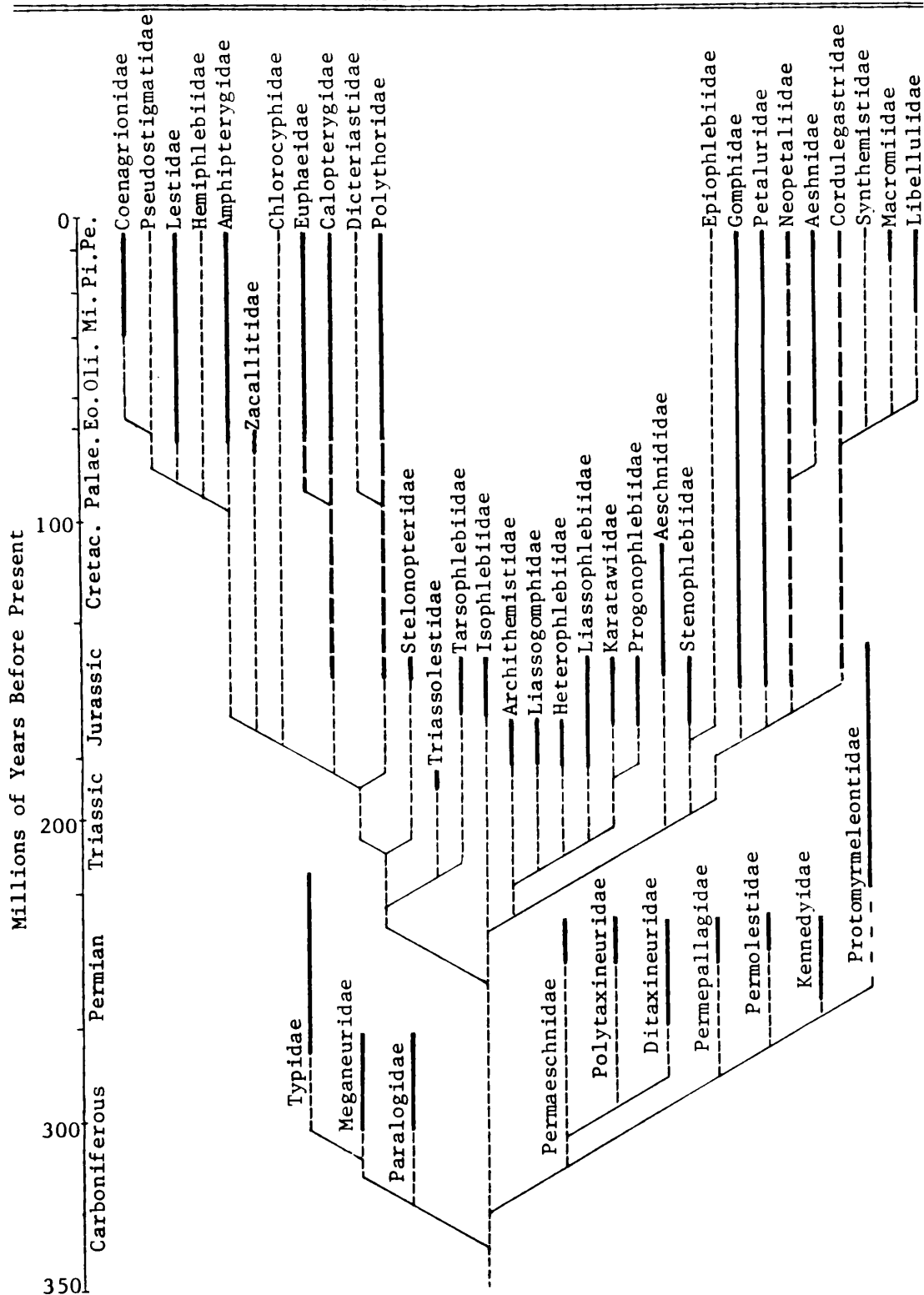
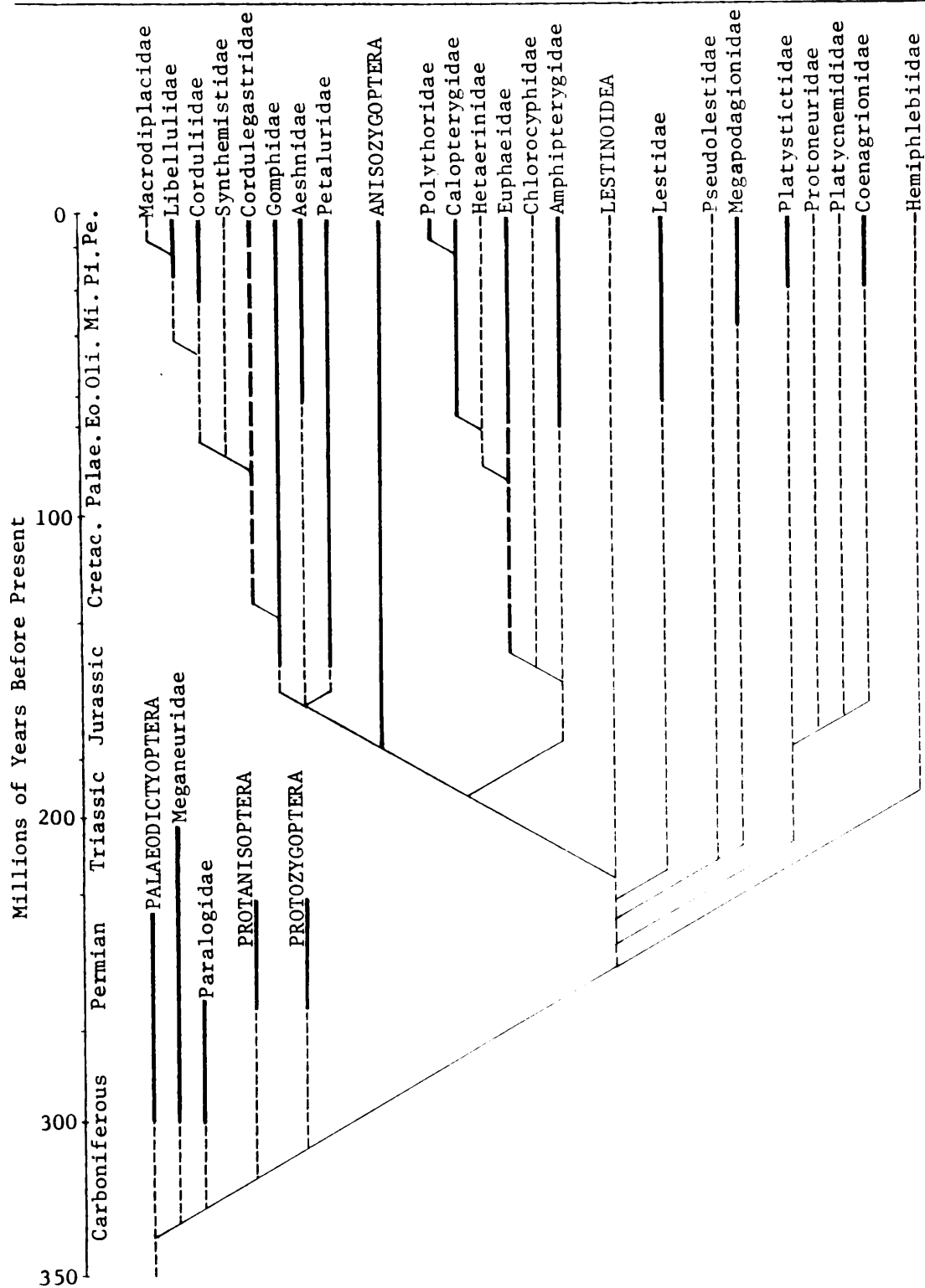


Figure 10. A Phylogeny of the Odonatoids Based on Fraser's (1957) "Origin and Descent of the Order Odonata".



Although previously overlooked the most significant component of the odonate wing mechanism may be considered the discal nodus and brace; it is absent in Protodonata, Protozygoptera, Archizygoptera, and Protanisoptera (although it may occur in *Permaeschna* for which Martynov has established the suborder Permanisoptera), and present in Anisozygoptera, Zygoptera, and Anisoptera.

The original arrangement of venational components comprising the odonate wing mechanism remains rather enigmatic. The Protodonata are the most ancient odonatoid group known¹, and although their wings are specialized in the basal lengthening and anterior crowding of longitudinal veins, the polarity of several less conspicuous character state sequences can be established from them (Fig. 3). These include the *absence* of the arculus, nodus, discal nodus and brace, pterostigmata², costal braces, hexagonal cells, and crossvein alignment across longitudinal veins; and the *presence* of the membranule, basal portion of CuA³, numerous antenodal crossveins, long precostal and subcostal areas, numerous intercalated sectors, and a straight CP. In the Meganeuridae CP terminates near the apex of the wing and an oblique vein at the origin of RP₂ (Sellards 1906; Carpenter 1939, 1943, 1947, 1960) may be homologous with the odonate subnodus. However, in the Paralogidae (including *Oligotypus*) CP terminates just beyond the middle of the wing and the subnodal crossing is not developed (Carpenter 1947, 1960). The most

¹ The Erasipteridae is incompletely known and possibly not an odonate group (F. M. Carpenter, personal communication).

² Carpenter (1947) has noted the presence of incipient "pterostigmata" in *Meganeuropsis americana*.

³ Apparently absent in the Paralogidae (Carpenter 1960).

flexible region of the protodonate discal pleat apparently occurs along the curve of CuP toward A; this is at about one-fourth wing length and is at about the location of the discal nodus in recent Odonata.

The wings of Protozygoptera (including *Permagrion*) are considerably specialized relative to those of Protodonata (Fig. 11). These specializations include: extreme petiolation, development of pterostigmata, loss of precostal areas, termination of CA at about one-third wing length, and generally only two antenodal crossveins, all of which give the wings a somewhat coenagrionid-like appearance. However, protozygopteran wings differ from those of recent Odonata in lacking the discal nodus, discal brace, and apparently the true odonate arculus and nodus. The arculus is apparently homologous with the protanisopteran arculus, but may not be homologous with the arculus of recent Odonata as indicated by its more distal location. The protozygopteran nodus is formed where CA makes an abrupt bend toward CP which lacks the sharp bends characterizing CP in the nodal region of recent Odonata. Tillyard's (1925a) contention that the wings of *Kennedyia* represent the archetypic odonate wing venation is also improbable because CuP and A are apparently fused basally and MA(IR₃) and RP₂(R₃) are reduced or absent; these specializations are not found in recent Odonata. The related *Permepal-lage angustissima* Martynov is characterized by having both MA and RP₂ well developed and the subcostal space about two-fifths wing length with numerous antenodal crossveins; costal braces are not developed. The two "primary antenodals" of *Kennedyia* and *Progoneura* are not homologous to the costal braces of recent Odonata as propoorted by Tillyard and Fraser in their narrow archetypic wing theory. Carpenter (1931,

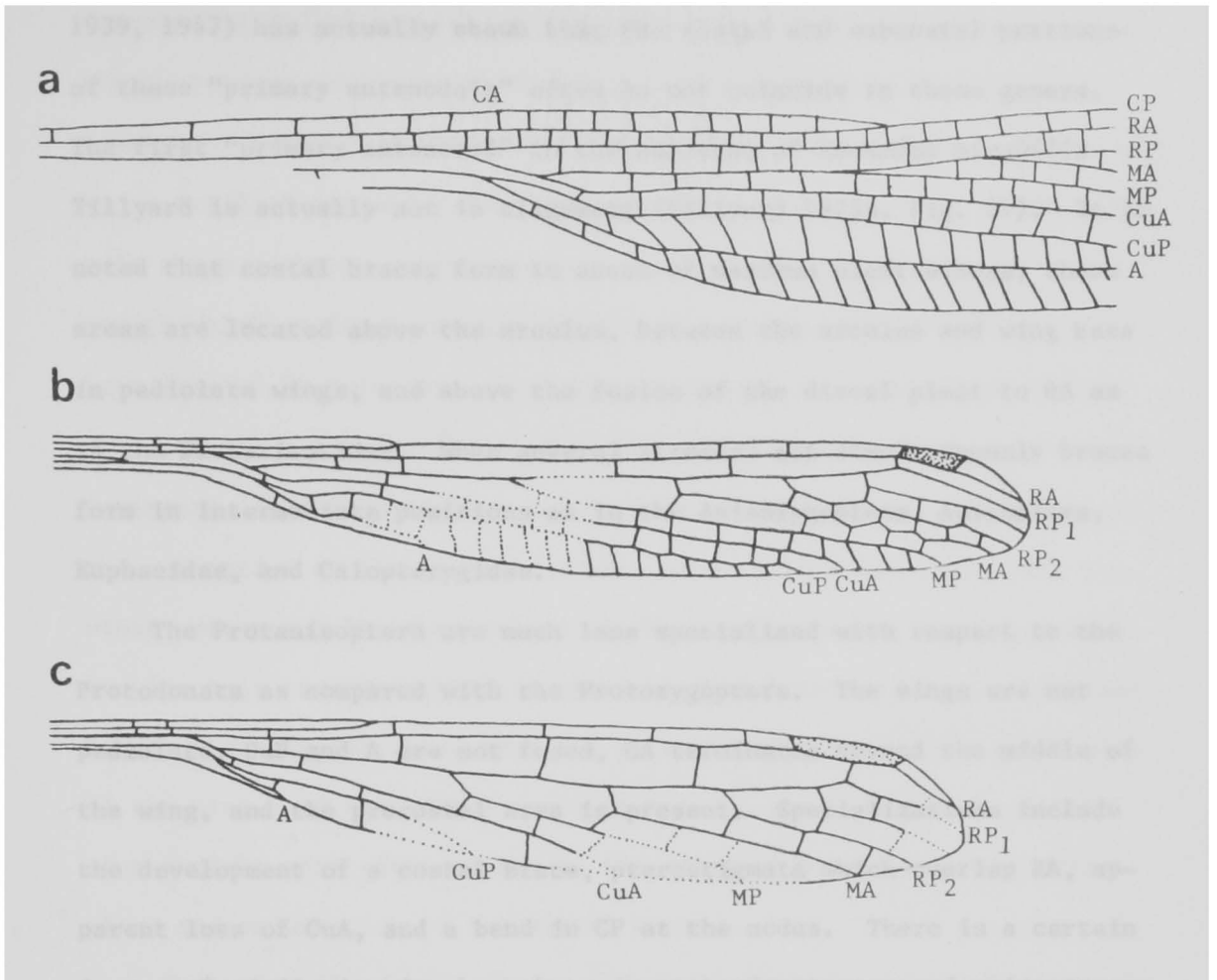


Fig. 11. Protozygoptera showing apparent fusion of A to CuP, (a) *L. me-pallage angustissima* Martynov, note numerous antenodals and well developed distal pleat (RP-MA-MP); (b) *Kennedyya mirabilis* Tillyard, note nonalignment of "first primary antenodal", and reduced nature of RP₂ and MA; (c) *Progoneura venula* Carpenter, note nonalignment of "primary antenodals", and reduced nature of longitudinal veins; (a) drawn from Martynov (1938), (b) redrawn from Tillyard (1925a), (c) redrawn from Carpenter (1947).

1939, 1947) has actually shown that the costal and subcostal portions of these "primary antenodals" often do not coincide in these genera. The first "primary antenodal" in the holotype of *Kennedyia mirabilis* Tillyard is actually not in alignment (Tillyard 1925a, Fig. 11). It is noted that costal braces form in areas of maximum pleat stress; these areas are located above the arculus, between the arculus and wing base in pediolate wings, and above the fusion of the discal pleat to RA as in the Dictyriastidae. When several stresses act simultaneously braces form in intermediate positions as in the Anisozygoptera, Anisoptera, Euphaeidae, and Calopterygidae.

The Protanisoptera are much less specialized with respect to the Protodonata as compared with the Protozygoptera. The wings are not pediolate, CuP and A are not fused, CA terminates beyond the middle of the wing, and the precostal area is present. Specializations include the development of a costal brace, pterostigmata which overlap RA, apparent loss of CuA, and a bend in CP at the nodus. There is a certain degree of similarity in shape between protanisopterous and anisopterous wings first noted by Carpenter (1931), but perhaps more important is the apparent similarity of the probable axis of bending in protanisopterous wings to that found in recent Odonata. In *Polytaxineura* (Fig. 12a) the axis of maximum bending apparently passes through CuP at about two-fifths the distance between the wing base and nodus; this is at about the location of the discal nodus in recent Odonata. However, the loss of CuA in *Ditaxineura*, *Polytaxineura*, and *Pholidoptilon* indicate that recent Odonata were derived from a more fully veined ancestor of the Protanisoptera. In this regard the poorly preserved holotype of

Permaeschna dolloi Martynov deserves careful study. An examination of the photograph published by Martynov (1931) indicates that the vein labeled by Martynov as CuA is *concealed* basally and possibly represented by an artifact distally; its basal portion may be the base of MP. The vein which probably represents CuA is represented in the fossil by a trough which at least in part follows the contour of CuP and has not been labeled by Martynov. This interpretation is represented in Fig. 12b with the basal portion of the wing added by comparison with *Polytaxineura*. Although similar to the vein arrangement of recent Odonata and supportive of the proposed system of wing vein homology, this and other venational interpretations of *Permaeschna* remain very uncertain. Despite this uncertainty it is apparent from both the wings of Protanisoptera and Protodonata, that the nodus likely formed near the middle of the wing, and the discal nodus at between one-fifth to one-fourth wing length; more problematic are the original position of the discal pleat and orientation of the discal brace.

The original odonate discal nodus was probably unbraced as are the nodal areas of Ephemeroptera. However, ephemeropteran wings are often characterized by an increased density of crossveins near nodal areas. The development of the odonate discal brace through an alignment of crossveins at the discal nodus is therefore probable, and indicates that its original orientation was likely perpendicular to the longitudinal veins. Early workers including Selys (1854), Kolbe (1881), Redtenbacher (1886), Calvert (1893), and Needham (1903) indirectly supported this view by considering the calopterygines the most generalized Odonata. Williamson (1913) referred to the discal brace as the medio-anal

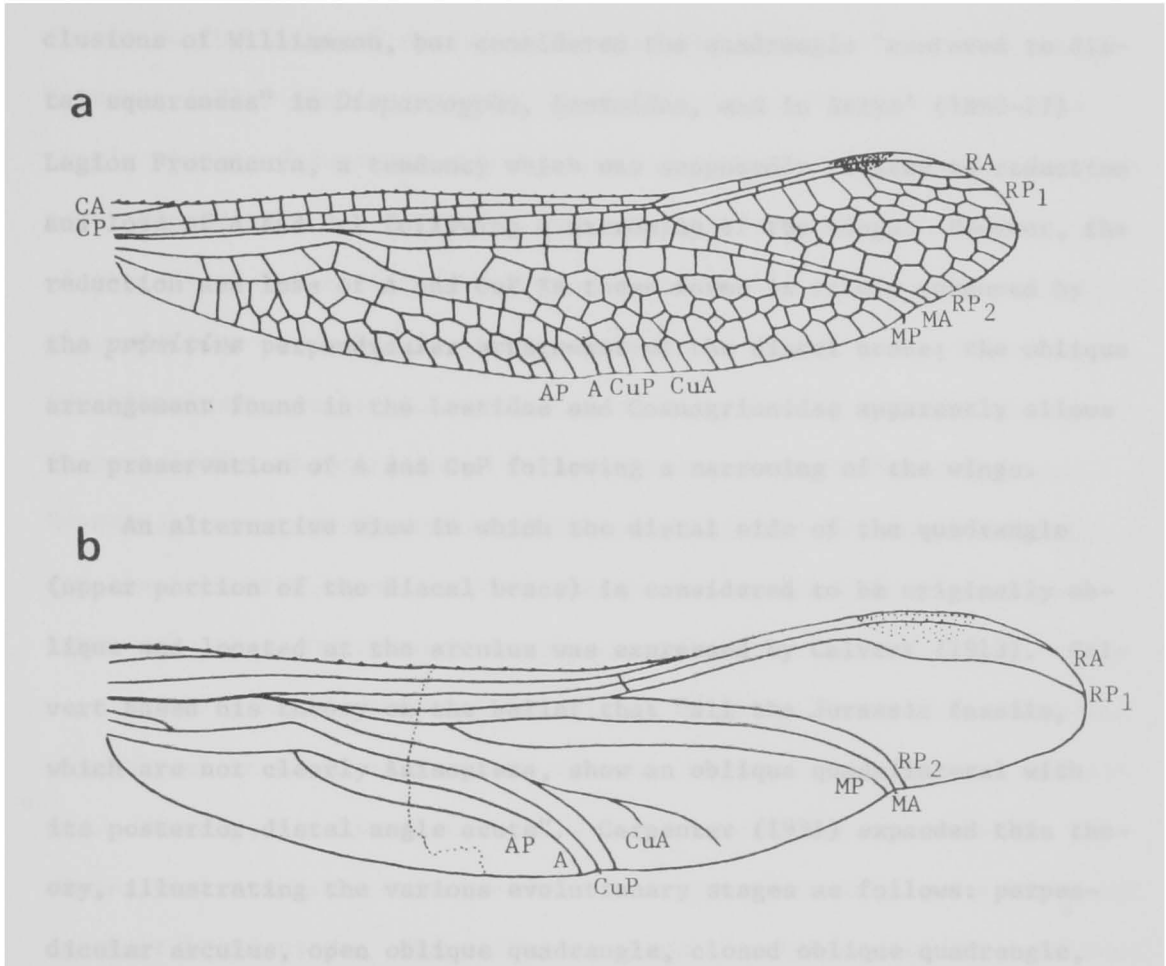


Fig. 12. Protanisoptera, (a) *Polytaxineura stanleyi* Tillyard; (b) *Perm-aeschna dolloi* Martynov, a possible venational interpretation based on the photograph of the holotype, basal portion added by comparison with *Polytaxineura*, note angulation of costal margin at nodus; (a) redrawn from Tillyard (1935), (b) modified from Martynov (1931).

link and considered it to lie originally between the arculus and nodus at a right angle to the main veins. Munz (1919) agreed with the conclusions of Williamson, but considered the quadrangle "restored to distal squareness" in *Disparocypha*, *Lestoidea*, and in Selys' (1860-77) Legion Protoneura, a tendency which was supposedly related to reduction and loss of A and CuP following a narrowing of the wings. However, the reduction and loss of A and CuP in these forms is likely enhanced by the *primitive* perpendicular arrangement of the discal brace; the oblique arrangement found in the Lestidae and Coenagrionidae apparently allows the preservation of A and CuP following a narrowing of the wings.

An alternative view in which the distal side of the quadrangle (upper portion of the discal brace) is considered to be originally oblique and located at the arculus was expressed by Calvert (1913). Calvert based his theory on the belief that "all the Jurassic fossils, which are not clearly Anisoptera, show an oblique quadrilateral with its posterior distal angle acute". Carpenter (1931) expanded this theory, illustrating the various evolutionary stages as follows: perpendicular arculus, open oblique quadrangle, closed oblique quadrangle, and finally a division of the quadrangle into supratriangle and triangle. Unfortunately, these authors did not recognize the true nature of the discal brace as evidenced by no mention of either its lower portion or the discal nodus. *Isophlebia* was listed as an example of an open oblique quadrangle by Carpenter (1931), but it actually exemplifies the position and orientation of the discal brace of the opposite theory, that is, a long rectangular quadrangle with several enclosed crossveins. Calvert's theory was also supported by Tillyard (1914) who

placed *Epiophlebia*, *Heterophlebia*, *Synlestes*, *Chlorolestes*, and the Lestini in a new family which he considered closely allied to the Anisoptera on the basis of the sharply angulated nature of the quadrangle. Martynov (1924) also considered Zygoptera with a distally acute quadrangle closely related to the Anisoptera. Such conclusions are directly contradicted by analysis of the odonate wing mechanism; the upper end of the discal brace tilts *toward* the arculus to form the acute quadrangle, and *away* from the arculus in forming the anisopterous triangle. Additional support for Calvert's theory was shown by Tillyard (1925a) in postulating the derivation of the Odonata from the Protozygoptera. However, as previously indicated the many specializations of *Kennedyia* and its relatives, combined with the absence of the discal nodus and brace make this phylogenetic sequence unlikely.

The original location of the distal brace as stated previously was probably at about two-fifths the distance between the wing base and nodus. However, its location shows a definite relationship to wing shape, with the brace more proximal in long narrow wings and more distal in short broad wings. The different shape of protodonatan fore and hind wings therefore suggests that the primitive discal brace developed at a more proximal location in fore wings. However, the Protodonata may be more specialized in this respect than ancestral Odonata as evidenced by the similar fore and hind wings of many broad-winged Zygoptera. Calopterygines with the fore and hind wings different in shape typically show a basal recession of the fore wing discal brace as evidenced by the increased basal atrophy of the distal pleat (Figs. 5 and 7). An extreme example illustrating the migration of the discal brace out into the wing

is shown in the secondarily broadened hind wings of *Pseudolestes* (Fig. 13). The anisopterous triangle was derived from a condition where the discal brace was also located well out in the wing with at least one crossvein in the quadrangle. Needham's (1903) explanation concerning the formation of the upper side of the triangle through a reorientation of this crossvein is supported by various anisozygopteran fossils (Fig. 14), and suggestions by Martynov (1924) that it was a remnant of Cu_1 and by Hamilton (1972) that it and the distal side of the triangle were formed by sclerotization along lines of folding seem unlikely.

According to the proposed odonate wing vein homologies the origin of the distal pleat (branching of RP, MA, and MP) was primitively located well toward the wing base. Among recent forms this condition is exemplified by the Polythoridae, Calopterygidae, Euphaeidae, Dictyristidae, Chlorocyphidae, Amphipterygidae, and Lestidae. It is noted that MA is hardly concave basally in the Polythoridae, and is often joined to RP in a more typical manner than is MP. Fossil Odonata which exhibit a strong development of the distal pleat include the Zocalitidae (Eocene); Euphaeidae, Amphipterygidae, Steleopteridae, and Iso-phlebiidae (upper Jurassic); Archithemistidae (Liassic); and *Triassolestes* (Triassic). These groups also exhibit a closed quadrangle in the fore and hind wings which is not strongly acute posterodistally with the exception of most Lestidae. The orientation of the discal brace (line of bending) is affected by the relative positions of several wing features including the distal pleat, arculus, nodus, and relative expanse of the anal field. When the distal pleat extends basally between the nodal areas the discal brace is tilted toward the base of the distal

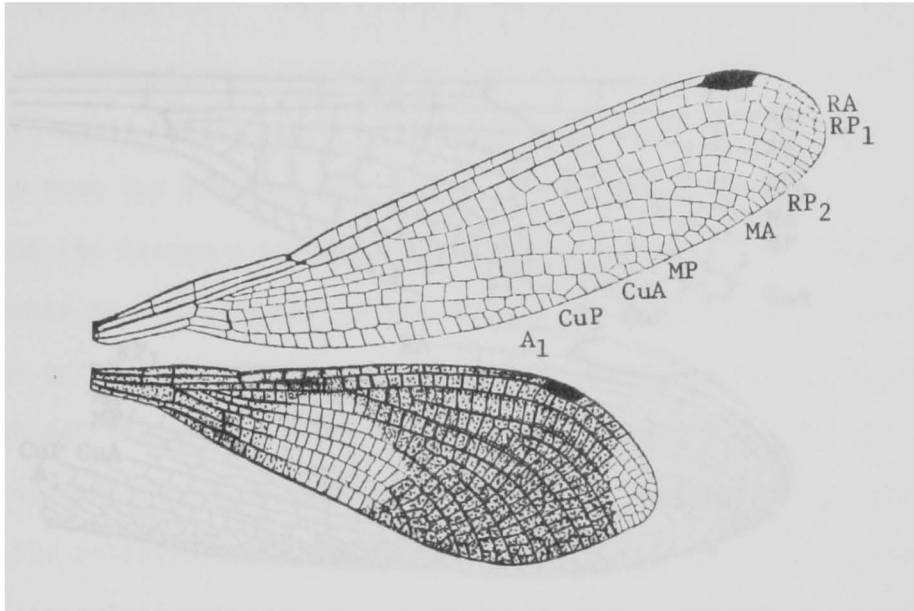


Fig. 13. Wings of *Pseudolestes mirabilis* (Lestidae:Odonata) illustrating the secondary apical migration of the discal nodus in the broadened hind wings. The typical condition characterizing the narrow-winged Zygoptera is found in the fore wing where both the nodus and discal nodus have receded basally. Note that crossvein densities relative to the hind wing discal brace are reversed as compared to the condition in the broad-winged Zygoptera, indicating its apical migration. After Needham (1951), vein interpretations added.

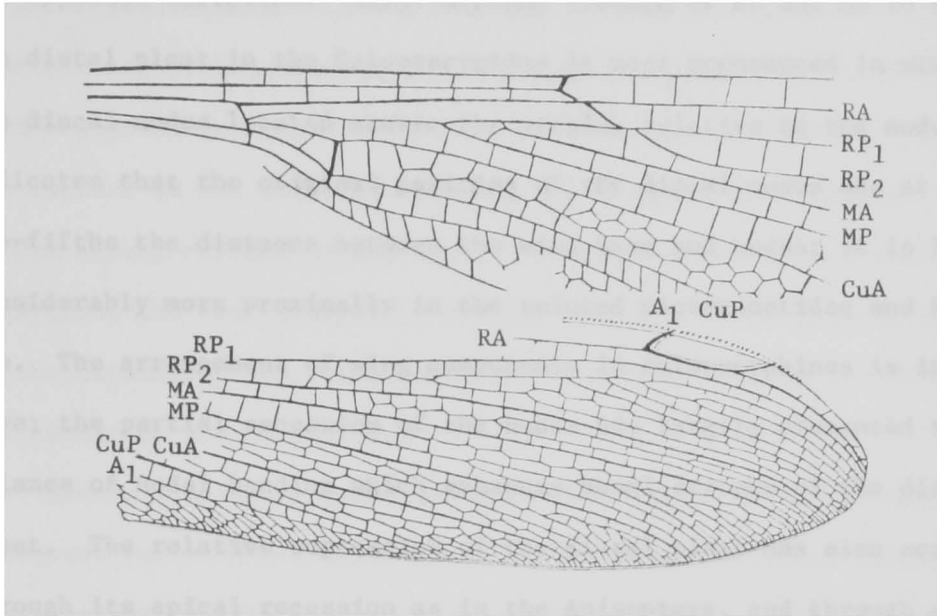


Fig. 14. Fossil wing illustrating an intermediate stage in triangle formation. Fluting at the discal nodus has been reduced by the migration of CuP toward A; the crossvein destined to form the upper side of the triangle is oblique. Note the apical recession of the distal pleat (RP-MA-MP) characteristic of Anisopteroids and the formation of regular pentagons and hexagons at the proximal ends of intercalated sectors. After Needham (1903), vein interpretations added.

pleat as in most chlorocyphines, but when the distal pleat has atrophied between the nodal areas as in *Hetaerina* the discal brace is tilted in the opposite direction. Basal atrophy (fusion of RP and MA to RA) of the distal pleat in the Calopterygidae is most pronounced in wings with the discal nodus located nearer the arculus relative to the nodus. This indicates that the original position of the discal nodus was at about two-fifths the distance between the wing base and nodus; it is located considerably more proximally in the related Dicteriastidae and Euphaeidae. The arrangement of wing components in chlorocyphines is instructive; the partial recession of the nodus has largely prevented the imbalance of nodal bending which enhances basal atrophy of the distal pleat. The relative suppression of the distal pleat has also occurred through its apical recession as in the Anisoptera, and through a relative basal recession of the nodal areas as in the majority of the narrow-winged Zygoptera. The latter case most often leads to the formation of the distally acute quadrangle.

Basing character state polarity for additional aspects of odonate morphology on protodonate and general palaeopteran morphology indicates that the following character states are nonderived: nymphal ligula cleft, nymph with lateral abdominal gills, presence of the pterothoracic interpleural suture, compound eyes widely separated dorsally, frons not expanded, occiput unspecialized, male cerci forceplike, and epiproct and paraprocts valvelike. The latter three characteristics may be used to show that the Anisozygoptera is likely polyphyletic or at least paraphyletic. Odonata which possess the discal nodus may be divided into two groups: the more primitive in which the occiput is unspecialized

and the male cerci are applied between the female prothorax and pterothorax in a forceplike manner during copulation (this is the condition in the Protodonata and in the Polythoridae, other Zygoptera typically have the paraprocts specialized to engage the prothorax); and the more advanced group in which the occiput is specialized, and the male cerci are applied to the posterior surface and paraprocts or epiproct applied to the dorsal surface of the head. The zygopteroid groups include the Zygoptera, and the Tarsophlebiidae and Sieblosidae (=Amphipterygidae) of the Anisozygoptera. The anisopteroid groups include the Anisoptera and remaining Anisozygoptera.

Several characteristics indicate that the broad-winged Zygoptera represent the original zygopteroid stock. These include: nymphal ligula cleft, nymph with lateral abdominal gills (Polythoridae and Euphaeidae), pterothoracic interpleural suture complete (Polythoridae, Calopterygidae, and some Euphaeidae), CP terminating near midwing, discal brace perpendicular to longitudinal veins, quadrangle with crossveins (Polythoridae, Calopterygidae, Dicteryastidae, Chlorocyphidae, and some Euphaeidae and Amphipterygidae), origin of distal pleat near arculus, numerous intercalated sectors, scarcity of hexagonal cells, absence of crossvein alignment across longitudinal veins, numerous antenodal crossveins, absence of typical costal braces (Calopterygidae and Euphaeidae), absence of proximal costal brace (Polythoridae and Dicteryastidae), absence of typical arculus (Polythoridae), and frequent absence of pterostigmata (Calopterygidae). The fossil record of the broad-winged damselflies is meager, which is to be expected in light of the almost exclusive small-stream habitat preference of this damselfly group. The

Calopterygidae is first represented by *Eocalopteryx* (Eocene), the Polythoridae by *Protothore* (Eocene), the Euphaeidae by *Euphaeopsis* and *Pseudoeuphaea* (upper Jurassic), the Zacallitidae by *Zacallites* (Eocene), and the Amphipterygidae by *Sieblusia* (Oligocene). The specialized Tarsophlebiidae and Steleopteridae are known only from the upper Jurassic. The Coenagrionidae is apparently not represented until the Miocene; the absence of fossil coenagrionines from the Mesozoic in light of their preference for lentic habitats sheds considerable doubt on the origin of the Odonata from Protozygoptera.

Among the anisopteroid groups the distinctly calopterygidlike Isophlebiidae is evidently the most generalized. An intermediate condition exists between the zygopteroid and anisopteroid groups in which the occiput is specialized, the male cerci are suited for embracing the female occiput and possibly thorax, and the male *paraprocts* are suited for holding the dorsal surface of the female head (Hagen 1866, Plate 4). The male epiproct is specialized presumably for this purpose in the Heterophlebioidea (Tillyard 1925b, Fig. 5) and Stenophlebiidae (Hagen 1866, Plate 3), and in recent Epiophlebiidae and Anisoptera. It is perhaps significant that Epiophlebiidae and primitive Anisoptera (Gomphidae and Petaluridae) have the epiproct divaricate as if it has functionally replaced elongate paraprocts. Isophlebiine wings are characterized by archaic features characteristic of anisopteroids in general which include the termination of CP near midwing, numerous antenodals, the absence of crossvein alignment across longitudinal veins, and the apparent presence of the *membranule*. They differ from anisopteroid wings and are similar to those of broad-winged Zygoptera in the following

archaic features: wings similar in shape, discal brace nearly perpendicular to main veins, CuA and CuP not divergent at discal brace, numerous intercalated sectors, pterostigmata absent (at least in male *Isophlebia*), distal pleat arising nearer arculus than nodus, and wings folded mayflylike at rest. The latter two characteristics are apparently less specialized than in even the Protodonata, suggesting a very ancient dichotomy. Characteristics which indicate an affinity of the Isophlebiidae to the Protodonata include the long precostal area (apparently extended beyond the nodus) and their large size. If Handlirsh (1908) estimated the wing length of *Hemerobioides gigantea* Westwood correctly it is the largest odonate species known, with a wing span of nearly 30 cm. The specialized nature of isophlebiine venation in the region of the anal field can be derived from a venation pattern similar to that of the Calopterygidae by an alignment of the gaff with the discal brace and an atrophy of A slightly proximal to the discal brace. The body of isophlebiines is robust with short legs as is the case in Protodonata and in anisopteroid groups in general. The pterothoracic interpleural suture is apparently indicated as complete by Hagen (1866), as it is in various broad-winged Zygoptera and in the Heterophlebioidea (Asahina 1957). Isophlebiines are known from only a few upper Jurassic fossils, the majority of which are from the Solenhofen slate of Bavaria. Tillyard (1917) described the Solenhofen slate as unique in that although formed in shallow marine bays, "Dragonflies, were carried thither, probably by floods, from the neighbouring streams". The current lack of fossil isophlebiines from the Triassic and Liassic may be related to a preference for small stream habitats as shown by the broad-winged

Zygoptera.

The remaining anisopteroid groups are characterized by the lengthening of the upper portion of the discal brace, the consequent divergence of CuP from CuA, and generally the formation of two costal braces. Nonderived character states of these groups not previously listed include: postfrons, antefrons, and clypeus level; "molar" region of mandible elongate and movable; first labial palpal segments not approximate medially; anal loop absent; planates absent; auricles absent; longitudinal abdominal carinae absent; and ovipositor complete. The distal pleat is recessed apically (least so in the Archithemistidae) leading to a diverse array of venational arrangements. These can be grouped into three categories: fore wing discal brace tilted toward arculus and hind wing discal brace tilted away from arculus (Heterophlebioidea), discal brace tilted toward arculus in both fore and hind wings (Stenophlebiidae and Epiophlebiidae), and discal brace tilted away from arculus in both fore and hind wings (Liassogomphidae, Aeschnidiidae, and Anisoptera). The latter two categories are questionably monophyletic. Narrowing of odonate wings is typically accompanied by a tilting of the discal brace toward the arculus with the coincident formation of the distally acute quadrangle and eventual formation of the proximally open quadrangle. This sequence has occurred independently in the fore wings of the Heterophlebioidea, and in both fore and hind wings of the Tarso-phlebiidae, various narrow-winged Zygoptera, and slightly so in the Epiophlebiidae (Fig. 15) and Stenophlebiidae. The resulting wing mechanism is apparently similar to that of the Protozygoptera and evidently fosters a sculling flight mode. Widening of the odonate wing is typically

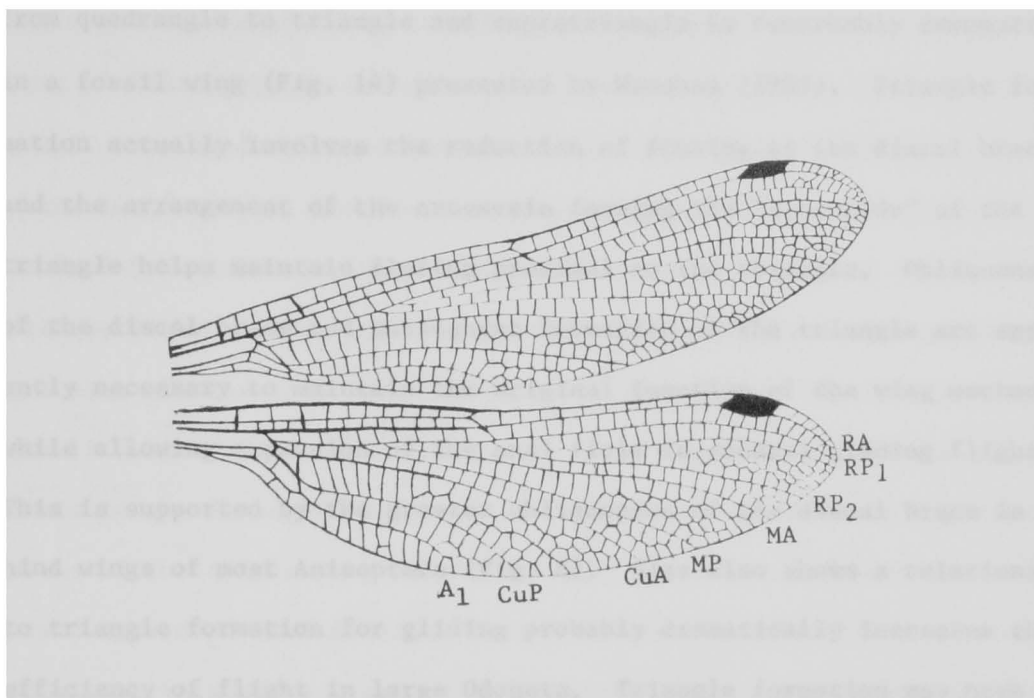


Fig. 15. Wings of *Epiophlebia superstes* (Epiophlebiidae:Odonata) illustrating the basal recession of the discal nodus following the apical recession of the distal pleat. Recession of the discal nodus toward the arculus is accentuated in the narrower fore wings. Note the similar relative positions of the arculus and costal braces as compared to the anisopterous condition. Drawn from Needham (1903), vein interpretations added.

accompanied by a tilting of the discal brace away from the arculus, eventually leading to the formation of the triangle. The transition from quadrangle to triangle and supratriangle is remarkably demonstrated in a fossil wing (Fig. 14) presented by Needham (1903). Triangle formation actually involves the reduction of fluting at the discal brace, and the arrangement of the crossvein forming the "upperside" of the triangle helps maintain fluting proximal to the triangle. Obliqueness of the discal brace and subsequent formation of the triangle are apparently necessary to maintain the original function of the wing mechanism while allowing expansion of the anal field to enhance gliding flight. This is supported by the greater obliqueness of the discal brace in the hind wings of most Anisoptera (Fig. 8). Size also shows a relationship to triangle formation for gliding probably dramatically increases the efficiency of flight in large Odonata. Triangle formation may have occurred independently in the Liassogomphidae-Heterophlebiidae, Aesch-nidiidae, and Anisoptera. The sequence toward triangle formation has also begun in the broad-winged zygopteran genus *Hetaerina*.

The Heterophlebioidea were apparently the most abundant Odonata during the Jurassic, but they were doubtfully the most ancient anisopteroids as might be implied by their representation in the lower Lias-sic. In addition to the different wing mechanisms in fore and hind wings, the group is characterized by a reduced number of antenodal crossveins of the anterior series. The Liassogomphidae, although placed within the Gomphidae by Handlirsch (1906-08, 1939), seems closely related to the Heterophlebiidae, indicating the Heterophlebiidae to be a possible annectant between the Liassogomphidae and Liassophlebiidae.

Tillyard (1925b) listed several similarities of *Liassogomphus* to *Heterophlebia* including the unique arrangement of the upper side of the triangle and the termination of the anal vein beyond the nodus. The fore wing of *Palaeogomphus* indicates that the fore wing of *Liassogomphus* had a well developed triangle (Cowley 1942). The Stenophlebiidae which is characterized by an intermediate type of wing mechanism, was probably derived from a broad-winged ancestor with typically developed triangles; this is probably also the case for the Epiophlebiidae. The two families are also similar in possessing elongate posteriorly directed posterior hamuli (which implies the absence of either zygopteran or anisopteran penis in the Stenophlebiidae as in the Epiophlebiidae), incised basal plate of the ovipositor, relatively well developed antennae, and compound eyes separated dorsally by a relatively smaller distance than in primitive Anisoptera. Epiophlebiidae differ in the expanded antefrons and hyperdeveloped interocellar ridge; it is noted that the nymph of *Epiophlebia* is anisopteran in general appearance whereas the only known Jurassic odonate nymphs, *Samarra*, are distinctly zygopteran. The Aeschnidiidae which Fraser (1957) placed within the Cordulegastridae on the basis of the elongate ovipositor is doubtfully related to any anisopteran family. Both fore and hind wings have the triangles transversely elongated with the subtriangle and supratriangle arranged similar to that of libelluline fore wings. Other nontypical anisopteran characteristics include: anal loop absent, discal brace located well out in wing, arculus absent, compound eyes widely separated, venation dense, and size occasionally very large (wing span ca. 20 cm in *Urogomphus giganteus* Germar). In anisopteroid groups where the anal region of the

hind wing is expanded the inner border is typically incised in the male, indicating that the hind legs were used in achieving the copulatory position in flight as they are apparently used by extant Anisoptera. The establishment of the copulatory position in flight may be characteristic of all anisopteroid groups as it appears that the anisopteroid tandem hold is related to this behavior.

SUMMARY

Several systems of wing vein homology and associated notations have been proposed for the Odonata. Descriptive names were abandoned in the nineteenth century in favor of notations which expressed apparent homologies with other insects. Two theories have been followed in determining wing vein homologies. The corrugated or fluted wing theory first employed by Redtenbacher (1886) bases homologies on the convex (dorsal) and concave (ventral) alteration of wing veins, and the pretracheation theory of Comstock and Needham (1898) bases homologies on the tracheation of wing veins as determined from nymphal wing pads. Several authors have since shown pretracheation theory to be incorrect. Redtenbacher's system, although similar to that of the proposed system, was subsequently modified by several workers with the eventual acceptance of Tillyard's (1926) system as the alternative to that of Comstock-Needham. Tillyard's system is based on the narrow-winged *Kennedy miribialis* Tillyard in which MA (Tillyard's IR₃) is weakly developed and considered an intercalated vein. The proposed system requires the transverse fusion of CuA and MA to the median vein stem. Unfortunately,

definitive fossil evidence is not available supporting either Tillyard's supposed intercalated nature of MA(IR₃), or the new system's supposed transverse fusion of MP and CuA. However, the general mode of vein loss throughout the Palaeoptera documented by recent and fossil evidence favors the new interpretation as does phylogenetic evidence from other sources. The decision to employ either the Tillyard-Fraser or the new system is at present, rather academic, but at least the new system is less difficult to learn due to the nondisjunct complement of longitudinal veins between the arculus and nodus, and the orderly nature of the terminology. Also, subscripts are used only on veins which are homologous throughout the Odonata, descriptive names sufficing when intercalated sectors are referred to. Authors supporting the corrugated wing theory often suggested mechanical reasons for the unique venation of the Odonata, but unfortunately little attention was given to actual wing mechanisms.

Venational components of the odonate wing mechanism include the nodus, discal nodus, and distal pleat. During wing downstroke the discal nodal gap is open and the nodal region of the costal margin is twisted. This leads to a propellerlike torsion of the wing in which the large distal portion of the wing is pronated. During upstroke the discal nodal gap is closed and the nodal region of the costal margin is twisted in the opposite direction, leading to supination of the large distal portion of the wing. Shock absorption is apparently also a function of the odonate wing mechanism for wing stroke inertia at wing stroke maxima is utilized in supination-pronation reversal. The development of the distal pleat (branching of RP, MA, and MP of the new system) between the costal and discal pleats apparently regulates the

degree of nodal bending. This explanation of odonate wing function favors a primitive distally square quadrangle (discal brace perpendicular to the longitudinal veins) and indicates that either the proximally open quadrangle, or triangle and subtriangle are likely to form in different forms through parallel evolution. These specializations are related to the basal width of the wings, which is in turn related to a sculling or gliding flight mode.

Early odonatologists arrived at phylogenetic schemes similar to that expressed herein while considering the relationships of extant Odonata. However, as fossil evidence gradually accumulated earlier conclusions were rejected in favor of phylogenies based on archetypes such as *Tarsophlebiopsis* and *Kennedyia*. Justification for the proposed polarities of various character sequences were often vague and the possibilities of parallel or convergent evolution were not considered. The proposed phylogenetic scheme is most similar to that of Martynov (1938) among suborders, and to those of Needham (1903) and Munz (1919) among recent Odonata. The discal nodus has been overlooked by previous odonatologists and the associated discal brace may be used to place odonotoids into two groups. Those without the discal brace include the Protodonata, Protanisoptera, Protozygoptera, and Archizygoptera, whereas those with the discal brace include the Zygoptera, Anisozygoptera, and Anisoptera. The polarity of several odonate character sequences may be inferred from other Palaeoptera, particularly from the Protoephemeroptera, Ephemeroptera, and Protodonata. Apparently nonderived odonate wing characteristics include: precostal area well developed, nodus located near midwing, numerous antenodals, absence of costal braces,

absence of crossvein alignment across longitudinal veins, numerous intercalated sectors, absence of hexagonal cells, absence of planates, absence of anal loop, pterostigmata absent, distal pleat arising near arculus, discal brace perpendicular to longitudinal veins, discal nodus located at ca. $2/5$ distance between wing base and nodus, CuP not divergent from CuA at discal brace, quadrangle closed proximally and enclosing several crossveins, and wings similar in shape and held vertically at rest. Additional nonderived odonate character states include: "molar" region of mandible movable and elongate, ligula cleft, first palpal segments of labium not contiguous medially, clypeus and antefrons not expanded, postfrons level, compound eyes widely separated dorsally, occiput not specialized, pterothoracic interpleural suture complete, pterothoracic pleural sulci verticle, auricles absent, longitudinal abdominal carina absent, male cerci forceplike, and male epiproct and paraprocts valvelike. The largest proportion of these characteristics among recent Odonata is shown by the broad-winged Zygoptera. It is noted that nymphal Euphaeidae and Polythoridae have rectal, caudal, and lateral abdominal gills which would be expected in primitive Odonata. The scarcity of broad-winged Zygoptera in the fossil record is undoubtedly related to their almost exclusive preference for small stream habitats. However, all Mesozoic Zygoptera (Traisolestidae, Stelenopteridae, Tarsophlebiidae, and Euphaeidae) are referable to the broad-winged Zygoptera. The Coenagrionidae is not represented until the Miocene despite a preference for lacustrine habitats, shedding considerable doubt on the derivation of recent Odonata from the Protozygoptera. The most generalized anisopteroid group is the Isophlebiidae

which is known from a few upper Jurassic fossils. The wing venation is similar to that of the Calopterygidae, and the long precostal area and gigantic size suggest a relationship with the Protodonata.

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CHAPTER III

Evolution of the Odonate Copulatory Process

Abstract

Odonate copulation is unique among that of pterygote orders in that the primary genitalia do not meet during copulation. Previous explanations concerning the evolution of the odonate copulatory process have been influenced by phylogenetic schemes which consider the narrow-winged damselflies the most generalized Odonata. However, fossil evidence and the comparative morphology of recent Odonata indicate that the broad-winged damselflies represent the most generalized Odonata among recent forms, supporting general evolutionary trends toward male domination of the copulatory process, and toward completion of the copulatory process in flight. One group of scenarios explaining the origin of the odonate copulatory process assumes the original direct transfer of sperm between primary genitalia. These scenarios require that oviposition originally be in tandem, and that sperm transfer to and from the male anterior abdominal sterna originally be accidental. Scenarios assuming the original indirect transfer of spermatophores as in the Apterygota avoid such problems, and lead to an original copulatory sequence, which when slightly modified, is essentially that of existing Odonata. The proposed scenario differs from those previously put forward in that extraordinary postures are not envisioned, the process is originally completed at rest, and development of the odonate tandem hold occurs just prior to sperm transfer. The tandem hold is considered to have developed to prevent female predation while the male guided her to his spermatophores.

Introduction

Odonata are unique among winged insects in that the primary genitalia do not meet during copulation¹. Prior to copulation the male transfers sperm to secondary genitalia located on his second and third abdominal sterna from which it is transferred to the female primary genitalia. The male secondary genitalia consists of paired anterior and posterior hamuli and a medial tonguelike organ of the second abdominal sternum, and an anteromedial organ of the third abdominal sternum. The male terminalia are used to hold the female head or thorax during the copulatory process, thus leading to the formation of the familiar odonate "copulatory wheel". The male terminalia and female head or thorax are generally specifically distinct as are the male secondary genitalia and structures surrounding the female genitalia. Characteristics which are less obviously related to the copulatory process include color and color patterns, and various structural modifications of the tibiae, wings, and abdomen. Diverse copulatory behavior also occurs and ranges from brief in-flight copulations of a few seconds, to lengthy and complex sequences involving displays and guarding. Fraser (1939) and Moore (1960) illustrated complicated scenarios explaining the evolution of odonate indirect sperm transfer from the direct contact of male and female genitalia employed by other Pterygota. Brinck (1962) considered the indirect method primitive for the Odonata and suggested an original copulatory sequence similar to that found in the Anisoptera. A comparative evaluation of behavior and morphology including fossil evidence indicates that at least two additional scenarios may explain the origin of the

¹However, in certain advanced Cimicoidea (Hemiptera) the primary genitalia also do not meet during copulation (cf. Hinton 1964).

odonate copulatory process.

Discussion

Odonate Phylogeny and the Fossil Record

The odonate phylogeny followed will undoubtedly influence explanations concerning the evolution of the odonate copulatory process. Kennedy (1920) proposed the origin of the Zygoptera from a narrow-winged archetype based on a study of the male penis, and the discovery of the narrow-winged Permian fossil *Kennedyia* led Tillyard (1925) to propose the origin of the entire Odonata from a narrow-winged ancestor. Phylogenies based on this view are illustrated in Fraser (1954, 1957) and are currently widely accepted, and consequently followed in evaluating odonate reproductive behavior. However, Tillyard's venational interpretations on which his phylogenetic views are based, were not adopted by several Odonatologists including Calvert, Needham, Ris, and Williamson (Needham 1951). Later Tillyard (1935) accepted the dual origin of recent Odonata from the Protozygoptera and Protanisoptera first proposed by Carpenter (1931). Another possibility was suggested by Martynov (1938) who proposed the origin of the Odonata from more fully veined contemporaries of the Protozygoptera and Protanisoptera. Martynov's view is supported by the absence of the discal brace and reduced longitudinal veins in the Protozygoptera and Protanisoptera. Protozygoptera are also characterized by the extensive basal fusion of A to CuP, and frequent nonalignment of "primary antenodals". In recent Odonata A is fused to the hind margin of the wing when fused², and the "primary

²Fraser (1938) has even demonstrated fusion of A to the hind margin of the wing in the supposedly ultraprimitive *Hemiphysalia*.

antenodals" are thickened costal braces when developed which are never nonaligned. The polarity of odonate morphoclines are therefore in doubt, the above evidence supporting the views of early Odonatologists such as Selys (1854), Redtenbacher (1886), Calvert (1893), and Needham (1903), who considered the Calopterygoidea the most generalized Odonata. Many Calopterygoidea exhibit complicated reproductive behaviors indicating that evolutionary trends within the Odonata may have been toward a shortening and simplification of the copulatory process.

Fossil evidence concerning morphologic specializations related to the odonate copulatory process is incomplete, but adequate enough when taken together with the morphology of recent forms to establish a polarity for several morphological and behavioral sequences. It appears that the original odonatoid tandem hold was achieved by clasping the male cerci between the female prothorax and metathorax, the male epi-proct and paraprocts being valvelike as in recent females. This is the condition in male Protodonata (=Meganisoptera) and various Zygoptera including the Polythoridae. Additional support for an original tandem hold on the female thorax is found in the protodonate occipital region, which is not specialized to receive the male terminalia. Therefore, the original dichotomy of Odonata possessing the discal brace (Zygoptera, Anisozygoptera, and Anisoptera) was likely between a zygopteroid group in which the male terminalia were applied to the female thorax, and an anisopteroid group in which the male terminalia were applied to the female head. The zygopteroid group includes the Zygoptera, and the Tarsophlebiidae and Sieblosidae (=Amphipterygidae) of the Anisozygoptera. The anisopteroid group includes the Anisoptera and remaining Anisozy-

goptera. In place of the transverse action used to effect the primitive zygoteroid tandem hold the anisopteroid tandem grip employs a dorsal-ventral action. A dorsal-ventral action has also been developed in some Zygotera with elongated paraprocts, suggesting a possible intermediate condition in early anisopteroid evolution. This condition is indicated in fossil Isophlebiidae in which the male cerci are suited for embracing the posterior surface of the female head and the *paraprocts* are suited for embracing the dorsal surface of the head. The divaricate epiproct of primitive anisopteroid groups has apparently functionally replaced elongate paraprocts.

The anisopteroid tandem hold may be related to the establishment of the copulatory position in flight. This is apparently accomplished with the aid of the hind legs, and requires that expanded male hind wings be notched proximally for clearance as in Heterophlebioidea, Epiophlebioidea, and most Anisoptera. The Anisoptera are unique in that they possess auricles³ which may be used to guide the male hind legs in grasping and manipulating the female abdomen. It is noted that the spines on the hind tibiae of male Anisoptera are reduced, presumably related to contact with the male body. In addition Anisoptera which have lost the auricles have also lost the notched male hind wing margin, and have the abdomen strengthened by longitudinal carinae (except in

³Anisopteran auricles are derived from lateral swellings anterior to the antecostal suture of abdominal segment two, possibly analogous structures in the Euphaeidae are derived from the lateral carinae of this segment. Williamson (1904) suggested that auricles may serve "as a guide to the female in bringing her vulva in contact with the male genitalia". Tillyard (1917) suggested that auricles functioned in conjunction with the anal angle of the hind wings in controlling flight, but Fraser (1943) adopted the view of Williamson.

Anatopaster). Tibial keels are also developed in most Anisoptera and may be used in male-female conspecific recognition just prior to the establishment of the tandem hold, the tibial keels presumably oriented to the female compound eyes in a specific manner while the male grasps the female head.

Fossil evidence concerning the male secondary genitalia is scarce, being unknown for Paleozoic forms. Hagen (1866) has illustrated the secondary genitalia of *Tarsophlebia* and *Stenophlebia*. In *T. eximia* Hagen the posterior hamuli, sperm vesicle, and penile shaft were depicted and resemble those of the Zygoptera. In *S. aequalis* Hagen the anterior and posterior hamuli were depicted and are of a distinctly anisopteroid type. The elongate posterior hamuli of *S. aequalis* and the notched margin of the female abdominal sternum eight in *S. phryne* Hagen actually suggest the condition in *Epiophlebia*. The penis of recent Odonata is not homologous; in the Zygoptera it is developed from the medial organ of segment two, and in the Anisoptera from the medial organ of abdominal segment three. A unique arrangement occurs in *Epiophlebia* where elongate posterior hamuli apparently act in conjunction with the relatively small medial organs of sterna two and three to effect sperm transfer. The polarity of the various morphoclines leading to the development of the secondary genitalia remains problematic. One possibility is that the shaft of the zygopteran penis originally developed as a guide for the female primary genitalia in obtaining sperm from the vesicle on sternum three, with the head of the zygopteran penis and anisopteran penis developing secondarily. Zygopteran posterior hamuli act in association with the dorsal surface of the penile shaft

(cf. Miller and Miller 1981) which is involved in sperm transfer, indicating a possible first step toward the involvement of the posterior hamuli in sperm transfer and eventually leading to the condition found in *Epiophlebia*. Following this view the anisopteran penis developed through an anterior extension of the sperm vesicle between the posterior hamuli and posterior to the zygopteran penile shaft.

The Odonate Copulatory Process

The fundamental odonate copulatory process begins with the establishment of a male territory encompassing a suitable oviposition site (T), male-female conspecific recognition which may involve a male courtship display and a female acceptance posture (R), securing a tandem hold on the female and tandem flight (t_1), the union of male secondary and female primary genitalia followed by the indirect transfer of sperm (I), and male guarding behavior which may involve tandem oviposition (t_2). Therefore the odonate copulatory process may be expressed (T, R, t_1 , I, t_2). Transfer of sperm between male primary and secondary genitalia occurs between steps t_1 and I (e.g. Bick and Bick 1965a), although the author has occasionally observed anisopteran males apparently transferring sperm to the secondary genitalia during step T. The male penis is also believed to function in removing previously deposited sperm from the female reproductive tract prior to the transfer of sperm (cf. Waage 1979, Miller and Miller 1981, Miller 1981). Although considerable variation of the copulatory process exists, the direct transfer of sperm (D) between the primary genitalia does not occur in the Odonata.

Previous perceptions concerning the evolution of copulatory related behaviors within the Odonata (cf. Heymer 1972, 1974) have been biased

by adherence to phylogenetic schemes which consider the Calopterygidae the most specialized Odonata. Considering the Calopterygoidea the most generalized Odonata supports a reverse polarity for various odonate behaviors, particularly those involving territories, recognition, and guarding. Relatively variable factors such as the nature of preferred oviposition sites have undoubtedly influenced the copulatory process leading to considerable parallel and convergent evolution. However, a general trend reflected in the new theory is increased male domination throughout the copulatory process.

The territory defended by odonate males varies considerably with the nature of oviposition sites; in general the more local the oviposition site, the smaller and more constant the male territory. Support for localized oviposition sites among early Odonata is found in the almost exclusive small stream habitats of the Calopterygoidea, and in the endophytic oviposition and the habit of male perching while on territory throughout the Zygoptera. Perching near an oviposition site also seems to be the primitive method in the Anisoptera, being found throughout the Gomphidae and Petaluridae and in the more primitive genera of other families such as *Zoraena* of the Cordulegastridae and *Gomphaeschna* of the Aeshnidae. Exceptions include many Libellulidae which have apparently regained the habit of perching on territory possibly in response to their invasion of lentic habitats, and the "mating flight" of *Epiophlebia* which according to Asahina's (1950) illustration is similar to the patrol and search flight pattern of *Cordulegaster*. This pattern is typical of Anisoptera whose preferred oviposition sites are arranged somewhat continually along streams and includes species of *Cordulegaster*,

Boyeria, *Somatochlora*, and *Macromia*. Such behavior typically creates a dynamic procession of male "territories" moving in an upstream direction, the orderliness of which is disrupted by wild chases when one male gets too close to another. Search and patrol flight patterns are also utilized by lentic species of genera such as *Aeshna*, *Somatochlora*, and *Tetragoneuria*, but hovering tends to be more pronounced. A somewhat similar searching behavior has developed among the narrow-winged Zygoptera (e.g. Bick and Hornuff 1966). The previously mentioned examples indicate that evolutionary trends during the territorial segment of the odonate copulatory process have been away from the male's defense of a territory to which females are attracted, and toward the male's active search of females and defense of only the immediate search area.

Male-female conspecific recognition is often elaborate in the Calopterygoidea, suggesting that predacious habits required precontact conspecific recognition in early Odonata. Courtship displays have been described for species of *Calopteryx*, *Chlorocypha*, *Rhinocypha*, and *Platycypha* (cf. Heymer 1972, Waage 1973, Robertson 1982), and in primitive genera of other zygopteran groups including *Hemiphlebia* (Tillyard 1917) and *Platycnemis* (Buchholtz 1956). In the Coenagrionoidea and Anisoptera male-female conspecific recognition is generally much more subtle (e.g. Bick and Bick 1966, Heymer 1974). The author has observed what may be a subtle display in an attempted heterospecific pairing between a male *Nehalennia irene* Hagen and a female *Enallagma hageni* Walsh. The male hovered before the female, flew over her head, seized her head and thorax with his legs, and affixed his terminalia to her thorax. Upon flying off and finding the female still on her perch, the male again hovered

briefly before the female, etc.; the sequence was repeated three times before the male lost interest. Female rejection-acceptance displays occur in the Zygoptera (e.g. Bick and Hornuff 1966, Waage 1973), but apparently do not occur in the Anisoptera. Increased visual acuity (cf. Sherk 1978) is probably responsible for rapid recognition in the Anisoptera, being supported by the taxonomic significance of thoracic color patterns in large genera such as *Aeshna* and *Somatochlora*. Therefore, the trend is apparently toward increased efficiency in male-female recognition achieved through increased male initiative.

Odonate male terminalia are variously developed for grasping the female following recognition and seizure. Zygopteran males use the feet to initially grasp the wings, thorax, or head of perched females, and then affix the cerci, or cerci and paraprocts to the thorax. Anisopteran males use the feet to grasp females in flight by either the abdomen, thorax, or head, and then affix the cerci and epiproct to the female head⁴. However, pairs of the Gomphidae and Cordulegastridae will at least occasionally fall to a surface before the tandem hold is established. The anisopteran method is apparently followed in *Epiophlebia* (cf. Asahina 1954). As previously stated the zygopteran method is here considered the more primitive. Throughout the Calopterygoidea the male cerci are used in the primitive forceplike manner and are relatively unspecialized. For example, the cerci of the polythorines are quite similar to those of Jurassic Tarsophlebiidae (cf. Hagen 1866). Similarity in cercal form is apparently related to reliable precontact

⁴Williamson (1918) concluded that in *Archaeogomphus* both the female head and thorax are engaged by only the dorsum of abdominal segment ten.

recognition, evidenced by the diversity of wing coloration, or male and female displays or both in the Calopterygoidea and Libellulidae. The diversity of cercal shapes in many Coenagrionoidea and Anisoptera indicate that female recognition (acceptance) has been shifted to this stage. This is indicated in several heterospecific pairings observed by the author. For example, a male *Enallagma aspersum* Hagen captured in tandem with a female *E. triviatum* Selys was found to have several eggs deposited in the genital fossa of abdominal segment two. In another instance a female *Boyeria grafiana* Williamson rejected and was freed by a male *B. vinosa* Say immediately following establishment of the tandem hold. Female rejection has also been observed as the male grasps the female head in attempted heterospecific pairings among *Macromia* and *Tetragoneuria*, indicating that the different lengths of tibial keels within these genera may enable females to recognize conspecific males at this time.

Sperm transfer to male secondary genitalia in the Zygoptera apparently occurs at rest only after establishment of the tandem hold (cf. Bick and Bick 1965a), but in the Anisoptera has been observed by the author only during flight and either before or after pairing. Also in all cases observed by the author establishment of the copulatory position has been at rest in the Zygoptera, and in flight in the Anisoptera. *Epiophlebia* probably achieve the copulatory position in flight, although the absence of auricles does not support this. The author's observations of *Gomphus descriptus* Banks and *Tetragoneuria cynosura* Say following pairing indicate that anisopteran hind tibiae are placed over the auricles as the male abdomen is flexed downward, thus accounting

for the wide gap between the auricles and the notched inner border of the hind wings. The female abdomen is grasped and guided to the male genital fossa by the male legs which are apparently pulled dorsally by an upward movement of the abdomen. Anisopteran males may also use the hind legs during intramale sperm transfer. In the more primitive "at rest" method of the Zygoptera the male only lifts the female upward and forward (e.g. Johnson 1961, Waage 1973) at which time the female effects genital contact. However, the use of the hind legs by male Zygoptera in a manner suggesting the apparent anisopteran method has been described (e.g. Bick and Bick 1965b, Miller and Miller 1981). If the zygopteran penis originally developed as a guide for the female genitalia, then it is likely that sperm removal via the zygopteran penis head was the original method of removal. The anisopteran penis would then have developed posterior to, and gradually functionally replaced the zygopteran penis in both sperm removal and transfer. The reduced condition of the homologue of the zygopteran penis in *Epiophlebia* is regarded as a specialization related to the peculiar function of the posterior hamuli which according to Asahina (1954) is to act as a sperm channel. Copulation generally occurs at rest in the Odonata and can last for several hours (e.g. Krieger and Krieger-Loibl 1958). However, many Libellulidae commonly complete the entire copulatory process in flight; for example in-flight copulation lasts for about 5 minutes in *Tetragoneuria cynosura* Say (Kormondy 1959), and only for about 3 seconds in *Plathemis lydia* Drury (Jacobs 1955).

Male guarding behavior has been described for several Zygoptera (e.g. Johnson 1961, Bick and Hornuff 1966, Bick and Sulzbach 1966,

Waage 1973) and probably represents the original odonate postcopulatory behavior. Fidelity to a single female is low in the Calopterygoidea and reaches a zenith in species which oviposit in tandem as in many Lestidae and Coenagrionidae. Fraser's (1939) erroneous generalization "throughout the whole of the more primitive suborder Zygoptera, the male accompanies the female during oviposition, firmly linked to her prothorax" has apparently led several authors to conclude that tandem oviposition represents the primitive odonate mode (e.g. Heymer 1974). Tandem oviposition has apparently evolved in response to changes in the nature of preferred oviposition sites which may, for example, expose females to predation if not held by an alert male. Tandem oviposition also ensures that the most recently deposited sperm will not be removed before oviposition and has apparently led to a decreased importance of *complete* sperm removal as evidenced by reductions in the penis head. Tandem oviposition is uncommon in the Anisoptera, but is found in species of *Anax* and several libelluline genera. In *Tramea* the male releases the female to briefly oviposit, and then reestablishes the tandem hold in flight without first grasping the female head with the feet. Guarding behavior with the male hovering near the female occurs in species of *Libellula*, *Plathemis*, *Perithemis*, *Belonia*, and *Orthetrum*; and in *L. flavida* (which inhabits seepage pools) the males will often guard a female from a nearby perch. However, Moore (1952) suggested that male dragonflies are only attracted by ovipositing females, and that their short pursuits after intruding males are aborted attempts at mating. Moore did not explain the increased defense of the female (male hovering much closer to the female) with the approach of conspe-

cific males. As in other segments of the odonate copulatory process the general trend seems to be toward increased male domination of the reproductive process.

Previous Scenarios

Three scenarios have been advanced explaining the evolution of the odonate copulatory process: the "sexual perversions" theory of Fraser (1939), the complete female immobilization theory of Moore (1960) and the vaguely described in-flight indirect transfer theory of Brinck (1962). Fraser's scenario (Fig. 1) begins as the male alights on the female thorax, "the female curling up her abdomen in strong dorsi-flexion to facilitate coitus". The primary genitalia of the two sexes "are brought into close association with the 2nd segment of the male" accompanied by a still greater dorsal flexion of the female abdomen. A genital fossa is formed beneath abdominal segment two of the male, and the primary genitalia of the male are eventually "quite unable to effect normal coitus with the female", so that "the male contracted the habit of masturbating in the genital fossa". The male being finally altogether excluded from the original mode of copulation grasped the base of the female abdomen, which was then followed by "tandem-flight with the male gripping the female by the base of the abdomen". After tandem oviposition, the female in attempting to copulate "found that by curling her abdomen downwards and forwards in ventri-flexion instead of dorsalwards as usual she was able to consummate the act of copulation". Eventually the male shifted his point of initial seizure from the base of the female abdomen to the constriction between the head and thorax to avoid "the fluttering wings of the female". Fraser's scenario can be expressed

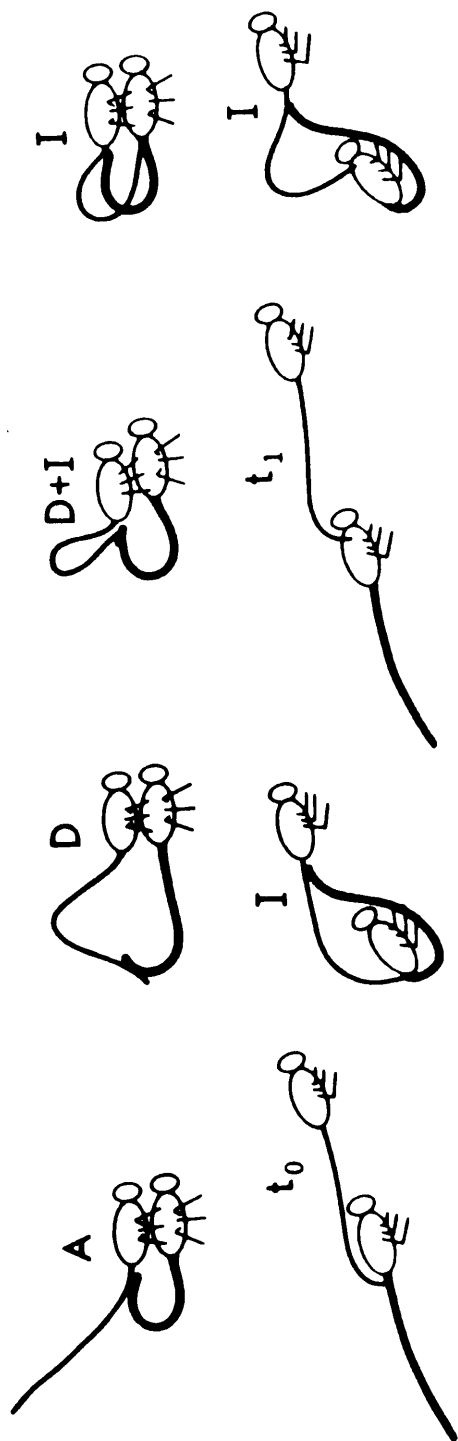


Fig. 1. Fraser's scenario illustrating the evolution of the odonate copulatory process: (A) male alighting upon female, (D) direct sperm transfer, (I) indirect sperm transfer, (t₀) tandem hold not currently existing, and (t₁) tandem hold currently existing; females designated by thicker abdomen, wings omitted for clarity, flight indicated by position of legs.

(D, I, t_0 , I, t_1 , I) where t_0 denotes a tandem hold not found in existing Odonata.

Moore's scenario (Fig. 2) assumes "that the rapacity of the female dragonfly was originally overcome by a male display" which puts the female in a state of catalepsy with the abdomen raised. The male grasps the apex of the female abdomen with his legs and flies off carrying her upside down and backwards. The pair lands with the female on her back and after the male bends his abdomen forward so that the primary genitalia are in close proximity at a point below his second abdominal segment, he "inserts sperm into the female's genital opening, being aided by the second and third abdominal segments and their respiratory movements". The male straightens his abdomen touching the legs of the female and "the reflex clutching movements evoked" in the female. The apex of the male abdomen is bent around the female head and "when he flies the female is carried off in the tandem position". Copulation is attempted in the tandem position and is successful because of sperm left on the abdomen by previous copulation, and copulation is "perfected by the original mating movement turning into the filling of the accessory genitalia" which precedes the new mode of copulation. Moore's scenario can be expressed (R, t_0 , D, t_1 , I).

Brinck (1962) suggested that direct sperm transfer between the primary genitalia was never developed in the Odonata. Because apparently all male Aterygota deposit spermatophores which are picked up by females, Brinck reasoned that this may have been the method employed by early Pterygota. After the evolution of wings Brinck postulated reduced population densities and the spending of a large portion of insect life

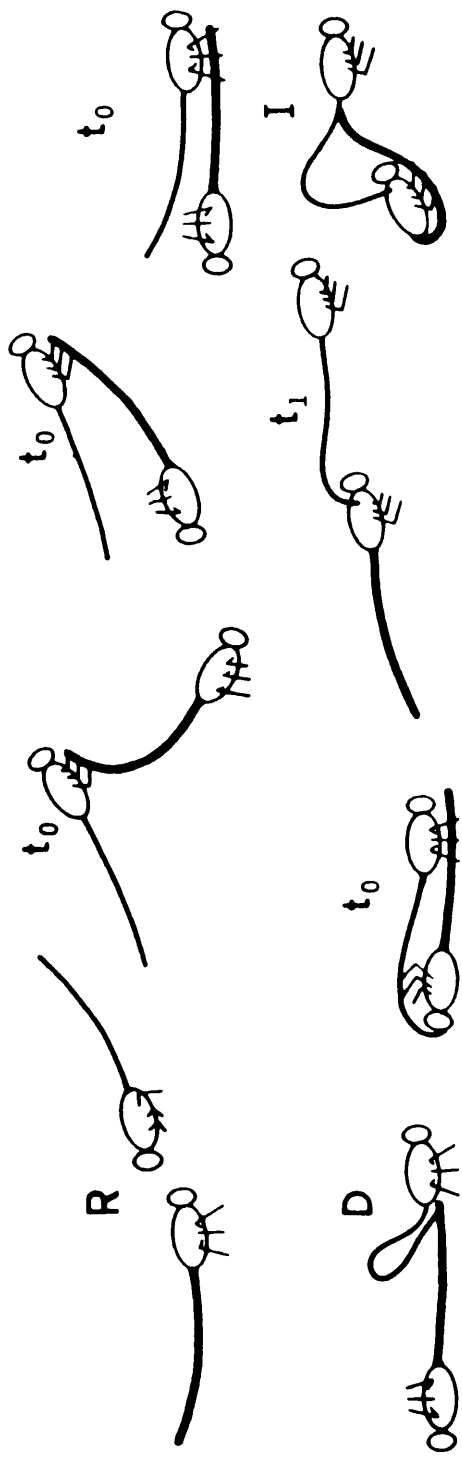


Fig. 2. Moore's scenario illustrating the evolution of the odonate copulatory process; (K) male courtship display, (t₀) tandem hold or tandem position not currently existing, (D) direct sperm transfer, (t₁) tandem hold currently existing, and (I) indirect sperm transfer; females designated by thicker abdomen, wings omitted for clarity, flight indicated by position of legs.

in flight, therefore necessitating a better contact between males and females to ensure sperm transfer. In most Pterygota this was accomplished by placing spermatophores on the female body which eventually led to the direct contact of the primary genitalia, whereas in the Odonata spermatophores were placed on abdominal sterna two and three of the male. In support of the postulated odonate method, Brinck called attention to the archaeonathan method of depositing spermatophores on a thread attached near the male genital opening. Body contact between males and females was supposedly enhanced to prevent the loss of spermatophores when the male abdomen was raised in enabling the male's feet to grasp the female prothorax. However, Brinck noted that it was possible that the male terminalia were already modified to grasp the female, and cited the grasping antennae of sminthurine Collembola as an example of grasping organs among early insects. Brinck's scenario was not illustrated or explained in detail, but it is evident that the establishment of the tandem hold and copulatory position were considered to have originally occurred in flight as in most Anisoptera.

Alternative Scenarios

Assuming as do Fraser and Moore that the primitive mode of odonate sperm transfer was direct, three variations of an additional scenario seem likely (Fig. 3). The basic scenario can be expressed (T, R, D, t_1 , I, t_2), and the variations involve three explanations for the initial transfer of sperm to the male anterior abdominal sterna. Transfer could have occurred in place of direct sperm transfer (Fig. 3a), during direct sperm transfer (Fig. 3b), or during the establishment of the tandem hold (Fig. 3c). The first possibility seems reasonable because

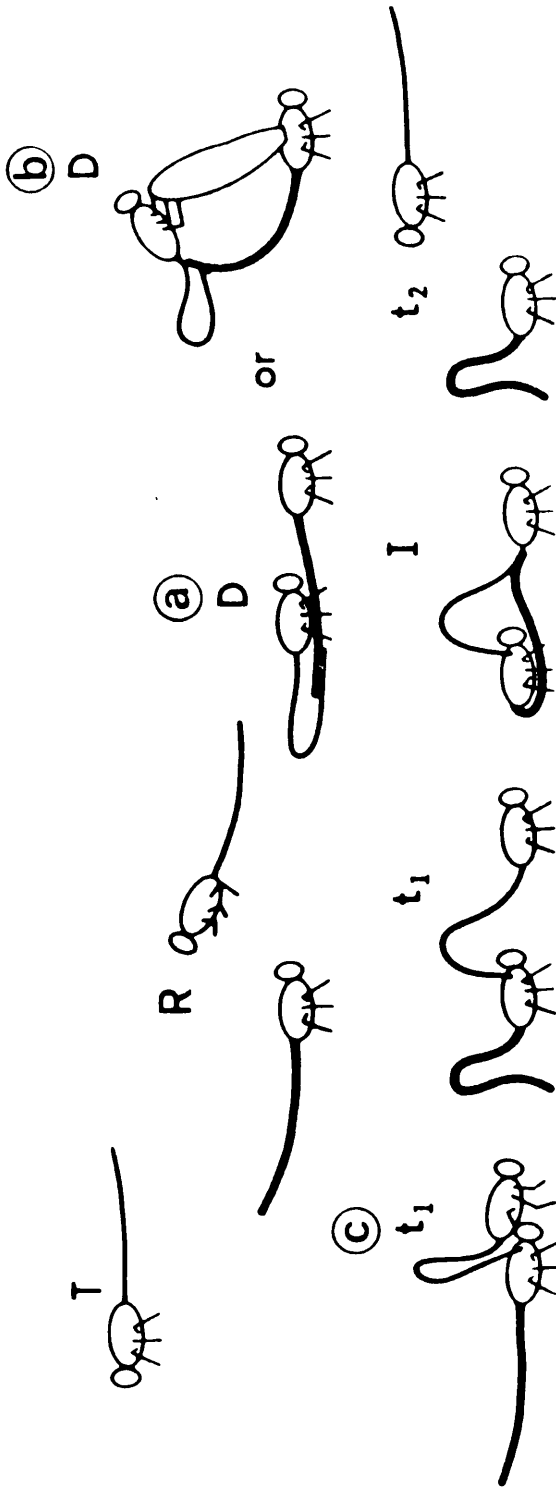
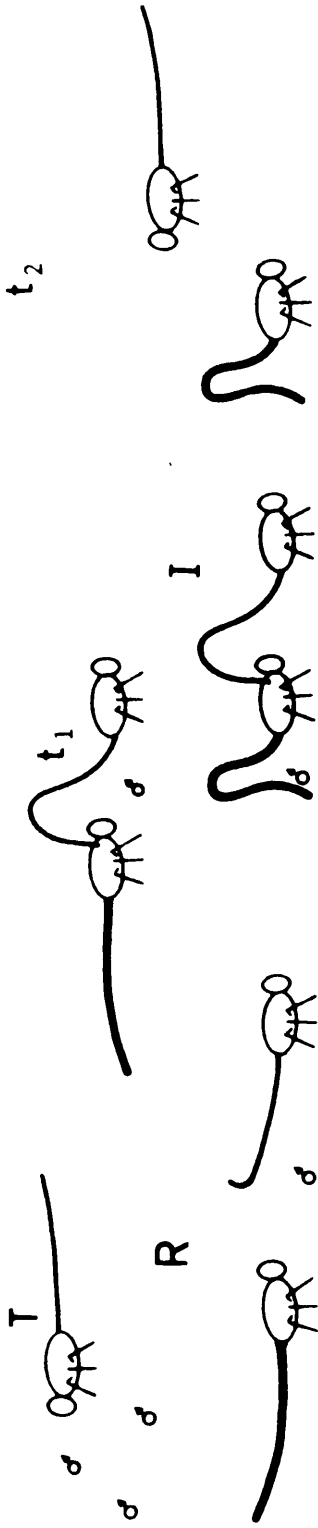


Fig. 3. Alternative scenario illustrating the evolution of the odonate copulatory process from direct sperm transfer, (T) establishment of a male territory near a suitable oviposition site, (R) male-female conspecific recognition, (D) direct sperm transfer, (t₁) existing tandem hold, (I) indirect sperm transfer, and (t₂) male guarding behavior: (a and b) possible positions during direct sperm transfer, (a-c) possible positions during which sperm is accidentally transferred to male anterior abdominal sterna; females designated by thicker abdomen, wings omitted for clarity, flight indicated by position of legs.

the male could mistake his own abdomen for that of the female. Fraser and Moore have envisioned extraordinary postures to accommodate the second possibility, but such explanations are unnecessary if the wings were held vertically at rest enabling the male to hold the female wing tips. In support of the third possibility Williamson and Calvert (1906) reported that males of *Calopteryx*, *Argia*, and *Enallagma* transfer sperm to the secondary genitalia immediately after the female is captured. Furthermore, Bick and Bick (1965a) concluded that sperm transfer in all Zygoptera probably occurs in tandem immediately prior to copulation. However, the abandonment of direct sperm transfer once established seems unlikely, and in each proposed scenario requires the original mode of odonate oviposition to be in tandem and for sperm transfer to and from the male anterior abdominal sterna to be accidental which also seems unlikely. Alexander (1964) commented that recognizing indirect rather than direct sperm transfer to be the forerunner of odonate copulation will lead to simpler and more reasonable hypotheses than the "fantastic schemes" proposed by Fraser and Moore.

Assuming as does Brinck that the original mode of odonate sperm transfer was indirect, an additional scenario seems likely (Fig. 4). The proposed original sequence is readily derived from that of the Apterygota. For example, Stürm (1952) reported that in the Machilidae males deposit sperm droplets on an anchored thread extending from the apex of the abdomen, and then use their antennae and cerci to guide the female genitalia in picking up the sperm droplets. The placement of the spermatophore on the male or female is probably related to feeding habits, and may reflect a primary ecologic and evolutionary dichotomy

Original Sequence



Modified Sequence

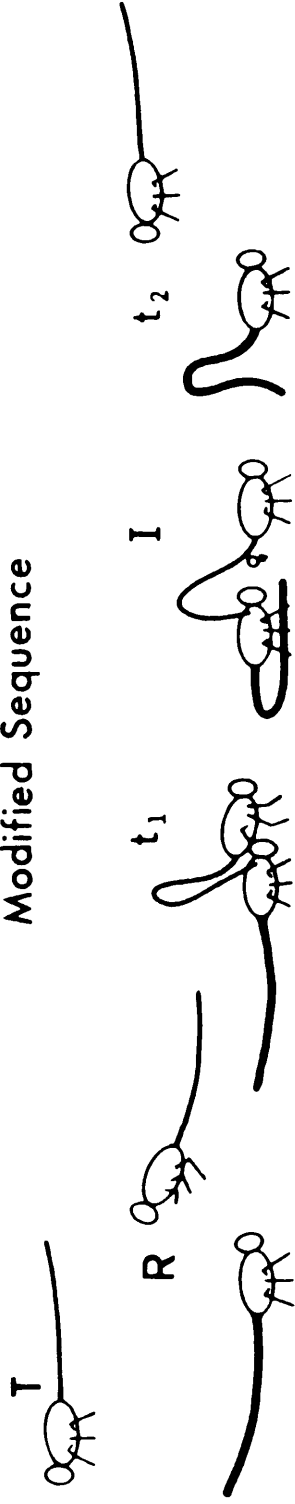


Fig. 4. A scenario illustrating the possible evolution of the odonate copulatory process without assuming an original direct transfer of sperm between the primary genitalia; (T) establishment of a male territory near a suitable oviposition site, (♂) spermatophore; (R) male-female contact specific recognition, (t₁ of original sequence) male guiding female with cerci, (t₁ of modified sequence) existing tandem hold and transfer of spermatophore to male secondary genitalia, (I) indirect sperm transfer, (t₂) male guarding behavior during oviposition; females designated by thicker abdomen, wings omitted for clarity, flight indicated by position of legs.

in the Pterygota. The odonatoids are obligate predators in contrast to other Palaeoptera⁵, and probably developed the cercal hold to prevent female predation while males guided them to spermatophores. Originally female Pterygota approached the male from behind leading to the original female above-male below copulatory position of the Neoptera (Alexander 1964). Ephemeroptera also utilize the female above position and have the male coxites and telopodites (leg homologs) of abdominal segment nine modified for grasping the female abdomen. These same organs are found in Paleozoic Ephemeroptera (*Proteronisma*, Carpenter 1933) and Palaeodictyoptera (*Stenodictya*, Kukalova 1970) supporting the female above copulatory position in all nonodonatoid Palaeoptera. It is also noted that the male odonate genital valves and anterior hamuli may represent modified coxites, again indicating the primary pterygote dichotomy to be between the Odonatoids and remaining Pterygota. Predacious habits would also require increased care in male-female conspecific recognition. This probably involved a display of the male terminalia and it is perhaps significant that both male *Calopteryx* and *Hemiphysalia* display this portion of the abdomen to the female. Male territories and guarding behavior were also probably included in early odonatoid reproductive behavior because of localized oviposition sites related to endophytic oviposition and the likely small stream habitats of early Odonatoids. Fundamental differences between this scenario and that vaguely described by Brinck (1962) involve the formation of the tandem hold before the

⁵The Palaeoptera (Protodonata, Odonata; Protephemerida, Ephemeroptera; Palaeodictyoptera, Megasecoptera) are likely paraphyletic, being primarily characterized by their inability to fold the wings over the abdomen in the specialized manner of the Neoptera.

placement of the spermatophore on the male, and the formation of the tandem hold and copulatory position at rest.

Modification of the original sequence would occur following the transformation of the male cerci into clasplike organs analogous to male ephemeropteran forceps. This would allow tandem flight and further male domination of the copulatory process by enabling males to sequester females, rather than simply attract them. It is possible that prior to tandem flight males improved their reproductive success by attracting females with displays similar at least in purpose to the "cross display" of *Calopteryx* (e.g. Buchholtz 1951, Zahner 1960, Johnson 1962, Pajunen 1966, Beatty and Beatty 1970, Waage 1973, and Heymer 1974). However, male seizure of the female would inevitably occur and if the wings were held dorsally at rest as in Ephemeroptera, most Zygoptera, and primitive Anisopteroids⁶, the male would probably seize the female wing tips, climb down along the costa, grasp the female head with his legs, and establish the tandem hold as is often the case in *Calopteryx*. It is possible that female wing spreading in order to discourage male seizure developed early, and formed the basis for both female and male threat displays in recent Zygoptera. The initial association of the spermatophore with the male anterior abdominal sterna probably occurred during step t_1 . Males unable to consistently return to their spermatophores, presumably because of interference from rival males, could transfer a spermatophore from the primary genitalia to the anterior abdominal sterna by backing toward the female. The spermatophore could then be

⁶Fossil Isophlebiidae are characteristically found with the wings at least partly folded dorsally, and Asahina and Eda (1956) reported that the wings of *Epiophlebia superstes* Selys gradually close at rest.

placed on the ground as in I of the original sequence (Fig. 4). The modified sequence requires that the male leave the spermatophore attached to abdominal sterna two and three, and that the female accept it from this location as illustrated in the modified step I. Fossil and recent morphological evidence indicate that the modified sequence was employed at least by the Permian, and considering the well developed clasping cerci of the Protodonata it was likely developed before the known fossil record of insects.

Summary

The Odonata are unique among pterygote orders in that the primary genitalia do not meet during copulation. Prior to copulation sperm is transferred from the male primary genitalia to a unique copulatory apparatus on abdominal sterna two and three, from which it is transferred to the female primary genitalia. Explanations concerning the evolution of the odonate copulatory process have been influenced by phylogenetic schemes which considered the narrow-winged damselflies the most generalized Odonata. However, fossil evidence and the comparative morphology of recent Odonata indicate the broad-winged damselflies (Calopterygoidea) to be the most generalized Odonata. If the reproductive behavior of the Calopterygoidea is also generalized, then evolutionary trends have been toward increased male initiative, and the completion of the copulatory process in flight. More specifically evolutionary trends within the Odonata have in general been away from: isolated male territories which are defended from a perch, precontact female rejection, establishment of the tandem hold at rest, unspecialized cerci which

clasp about the female thorax, establishment of the copulatory position at rest, female establishment of the copulatory position, oviposition at rest, and male guarding of several females. In general evolutionary trends have been toward: male patrol and search flight, establishment of the tandem hold in flight, postcontact female rejection, specialized cerci and paraprocts or epiproct which grasp the female thorax or head, establishment of the copulatory position in flight, male establishment of the copulatory position, copulation in flight, reduction of the male medial organ of abdominal sternum two, reduction of the penis head (when associated with tandem oviposition), and either tandem oviposition or oviposition away from the male.

Previous scenarios assuming an original direct transfer of sperm in the Odonata included extraordinary postures which are not actually necessary to explain the evolution of the process. In addition, assuming direct sperm transfer to be the original odonate mode requires that oviposition be in tandem, and the initial transfer of sperm to and from the male anterior abdominal sterna to be accidental, both of which seem unlikely in early Odonata. Assuming that the original mode of odonatoid sperm transfer was indirect as in the Apterygota avoids such problems, and leads to an original odonatoid copulatory sequence which when slightly modified is essentially equivalent to that of the Odonata, particularly to that of the Calopterygoidea. The proposed original sequence differs from other scenarios in that the process is completed at rest, and the tandem hold developed before the transfer of sperm to the male anterior abdominal sterna. Presumably the odonatoid tandem hold developed in order that the male could guide the female to his spermatophores

without being eaten by the female. The presence of clasping organs on abdominal sternum nine of ephemeropteroids and palaeodictyopteroids indicate that sperm transfer was direct in nonodonatoid Palaeoptera as in the Neoptera, suggesting along with morphological and ecological evidence, that the primary pterygote evolutionary dichotomy gave rise to the odonatoids.

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CHAPTER IV

The Anisoptera of Virginia and Vicinity

To the memory of Mary Davis-Ries
for her contribution to our knowledge
of the Odonata of Virginia

ABSTRACT

The morphology and phylogeny of the Anisoptera are reviewed and identification keys to Eastern North American families and genera provided. Identification keys to 174 anisopterous species occurring in Virginia and surrounding states are also provided, along with a brief synoptic description of each family, genus, and species. Information on the biology, behavior, and seasonal and geographical distribution of each species is also reported. Diagnostic characters are illustrated and a pictorial key to genera provided. A list of synonymy and a glossary are also included.

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LITERATURE REVIEW

During the eighteenth century six of the more common Anisoptera occurring in Virginia became known to science. Linnaeus (1763) described *Libellula carolina* and Drury (1770, 1773) illustrated *L. lydia*, *L. junius*, *L. berenice*, *L. pulchella*, and *L. eponina*; of these species only *L. berenice* was known to occur in Virginia. Rambur (1842) described *L. virginia* presumably from Virginia, in which case it would likely be the correct name for *Tramea lacerata* Hagen. However, Ris (1912-13) concluded that the locality label on Rambur's type was in error.

Eleven species of Odonata were reported from Virginia by Hagen (1861), but all possible new anisopteran records except *P. lydia* were collected by Osten Sacken at Berkley Springs, West Virginia. Hagen's Virginia record for *Gomphus fraternus* (Say) was collected by Osten Sacken presumably at what is now Berkley Springs, West Virginia; this "Virginia" record has been subsequently listed by Needham and Hart (1901), Muttkowski (1910), Needham and Heywood (1929), Needham and Westfall (1955), and Walker (1958). Hagen (1875) added *Gomphus ventriosus* Walsh, *Aeschna heros* Fabricius, *Celithemis eponina* (Drury), and *L. lustruosa* Burmeister (as *L. basalis* Say) to the Anisoptera known to occur in Virginia. The *L. auripennis* Burmeister reported from Virginia by Hagen (1875) and subsequently by Uhler (1879) and Kolbe (1888) was probably the then undescribed *L. needhami* Westfall; also the specimens reported as *L. auripennis* by Davis (1938) are *L. needhami*.

A list including twelve Anisoptera collected at Fort Wool, a small artificial island at the mouth of Hampton Roads, was published by Uhler

(1879). Among the species reported by Uhler, *Epithea filosa* (Hagen), *Tramea carolina* (Linnaeus), *L. cyanea* Fabricius (as *L. quadrupla* Say), *L. pulchella* Drury, *L. semifasciata* Burmeister, *Dythemis longipennis* (Burmeister), *Anax junius* (Drury), and *Aeschna clepsydra* Say were reported for the first time from Virginia. However, Uhler's *A. clepsydra* was probably the then undescribed *Aeshna umbrosa* Walker.

Cabot (1881) reported *Gomphaeschna furcillata* (Say) from Lee county Virginia on the basis of a small nymph with an apically cleft epiproct which he supposed represented the uniquely cleft epiproct of adult *Gomphaeschna*. However, it is now known that nymphal *Gomphaeschna* do not have the epiproct apically cleft although many other species of the Aeshnidae do; therefore, the record is invalid.

The nymphs of *Gomphus exilis* Selys and *Cordulegaster diastatops* (Selys) were reported from Virginia by Hagen (1885). However, the nymph reported as *C. diastatops* was almost certainly that of the then undescribed *Zoraena bilineata* Carle, as were the specimens reported by Byers (1951) and Donnelly (1961). Calvert (1890) reported five Anisoptera from Spotsylvania county Virginia of which *Diplax vicina* Hagen and *Celithemis elisa* (Hagen) were new to the state list. The distributions of many Anisoptera reported by Banks (1892) indicated that several additional species were likely to occur in Virginia; only three Anisoptera were specifically reported from Virginia, all previously known from the state. Six Anisoptera were reported from Virginia by Calvert (1893) with *Gomphaeschna furcillata* var. *antelope* (Hagen) and *Pantala flavescens* (Fabricius) new to the state list. Calvert's Virginia record for *G. furcillata antelope* was listed by Byers (1930) and Davis (1938), but

Gloyd (1940) eventually corrected Calvert's record to *G. antilope*.

Williamson (1900) listed five species which were previously reported from Virginia; surprisingly only 18 anisopteran species were undisputedly reported from Virginia by the turn of the century.

Williamson (1901 and 1903) added *Gomphus plagiatus* Selys, *Hagenius brevistylus* Selys (nymph), *Boyeria vinosa* (Say) (nymph), *Macromia illinoensis* Walsh, and *M. taeniolata* Rambur; and Banks (1907 and 1908) added *Neurocordulia obsoleta* (Say) and *Tachopteryx thoreyi* (Hagen) to the Virginia list. Williamson (1909) described *M. alleghaniensis* including Virginia specimens in the type series. In his revision of *Aeshna* Walker (1912) added only *A. umbrosa* Walker to the Virginia list. Calvert (1921) described *Gomphus lineatifrons* including Virginia specimens in the type series and also added *G. vastus* Walsh to the Anisoptera known from Virginia. In his study of the penis within the genus *Libellula* Kennedy (1922) utilized a specimen of *L. axilena* Westwood from Dunbrooke, Virginia. Davis (1922) reported *Epicordulia princeps* (Hagen) from Virginia, and later described *Neurocordulia virginiensis* from the state (Davis 1927). In his revision of *Somatochlora* Walker (1925) added *S. linearis* (Hagen) and *S. tenebrosa* (Say) to the Virginia list. Needham and Heywood (1929) reported *Cordulegaster sayi* (Selys) from Virginia, but this record was based on specimens of the then undescribed *Zoraena bilineata* Carle. Williamson (1932) described *Gomphus laurae* including specimens collected from Virginia in the type series.

In her Master's thesis Davis (1938) reported 30 Anisoptera from the York-James Peninsula. Anisoptera reported from the state for the first time were: *Cordulegaster maculata* Selys, *Gomphus lividus* Selys, *G.*

villosipes Selys, *Tetragoneuria cynosura* (Say), *Perithemis tenera* (Say), *Libellula incesta* Hagen, *L. quadrimaculata* Linnaeus, *L. vibrans* Fabricius, *Erythemis simplicicollis* (Say), and *Epicordulia regina* (Hagen). However, the specimen of *L. quadrimaculata* was found in the collection of William and Mary without a locality label, and the specimen of *E. regina* represents a form of *E. princeps* which has been subsequently reported from Virginia by Cuyler (1968) and again as *E. regina* by Carle (1979a). In addition Davis (1938) listed *G. furcillata* from Virginia, but examination of her specimens has shown them to be *G. antilope*.

During the following decade very little was published concerning the odonate fauna of Virginia, but this was offset during the 1950's. In his revision of *Erythrodiplax* Borror (1942) added *E. conata minuscula* (Rambur) to the growing number of Anisoptera known from Virginia, but Gloyd (1951) reported these specimens as *E. minuscula*. Westfall (1943) described *Libellula needhami* including Virginia specimens in the type series. Gloyd (1951) reported 29 Anisoptera from Virginia with the following species new to the state list: *Gomphus quadricolor* Walsh, *Basiaeschna janata* (Say), *Boyeria grajiana* Williamson, *T. lacerata* Hagen, *Sympetrum rubicundulum* (Say), and *S. semicinctum* (Say). Walker (1951) also reported *S. semicinctum* from Virginia. In his study of the Odonata of Mountain Lake, Virginia, Byers (1951) reported the nymphs of *Lanthus albistylus* (Hagen) and *Somatochlora elongata* (Scudder). These questionable records were first confirmed for Virginia by Donnelly (1961) and Carle (1978a), respectively. In their **Manual to the Dragonflies of North America**, Needham and Westfall (1955) reported 49 Anisoptera from Virginia with *Progomphus obscurus*

(Rambur), *Cordulegaster obliqua* (Say), *Celithemis ornata* (Rambur), and *Leucorrhinia frigida* Hagen new to the state list. Virginia was listed among the southern limits for *Gomphus fraternus*, *G. ventricosus*, and *C. obliqua* by Walker (1958); the *G. fraternus* record was probably based on the questionable record of Hagen (1875).

In response to the low diversity of the Virginia anisopteran fauna as reported by Needham and Westfall (1955) and Walker (1958) several new records were reported from the state. Kormondy (1960) reported six species from Virginia with *Dromogomphus spinosus* Selys, *Erpetogomphus designatus* Hagen (as *Dromogomphus designatus*), *Nasiaeschna pentacantha* (Rambur), *Didymops transversa* (Say), and *Celithemis monomelaena* Williamson new to the state list. In his study of the Odonata of Washington D.C. and vicinity, Donnelly (1961) reported 42 Anisoptera from Virginia but only *Cordulegaster erronea* Hagen, *Helocordulia uhleri* (Selys), *Libellula deplanata* Rambur, and *Pantala hymenae* (Say) were new to the state list. However, *P. hymenae* was mentioned as common around the Great Falls without specific reference to Virginia or Maryland; this species was later confirmed for Virginia by Carle (1978a) and Matta (1978). *Anax longipennis* Hagen was added to the Anisoptera known from Virginia by Ries and Cruden (1966). Roback and Westfall (1967) reported 17 Anisoptera from Virginia of which *Stylurus spiniceps* (Walsh) and *Neurocordulia yamaskanensis* (Provancher) were not previously known from the state. In the final volume of the Odonata of Canada and Alaska, Walker and Corbet (1975) reported Virginia to be among the southern limits for *Celithemis monomelaena* and *Leucorrhinia frigida*.

Recently populations of several additional anisopteran species have been discovered in Virginia. Voshell and Simmons (1978) reported 12 Anisoptera from Virginia among which *Macromia georgina* (Selys) had not been previously reported from the state. Carle (1978a) reported 114 Anisoptera from Virginia based on the discovery of new populations for all but two of the species previously known from the state, these were *N. virginiensis* and *L. quadrimaculata*. Of the 46 species reported from Virginia for the first time, *Gomphus fraternus*, *Zoraena diastatops*, *Somatochlora elongata*, *Libellula auripennis*, and *Pantala hymenea* had been previously known only questionably from the state. The remaining new state records were the following: Gomphidae- *Aphylla williamsoni* (Gloyd), *Arigomphus furcifer* Hagen, *Gomphus borealis* Needham, *G. descriptus* Banks, *G. abbreviatus* Hagen, *G. brevis* Hagen, *G. parvidens* Currie, *G. viridifrons* Hine, *Lanthus parvulus* (Selys), *Ophiogomphus aspersus* Morse, *O. carolus* Needham, *O. howei* Bromley, *O. mainensis* Packard, *O. rupinsulensis* (Walsh), *Stylurus amnicola* Walsh, *S. notatus* Rambur, *S. scudderi* Selys; Aeshnidae- *Aeshna canadensis* Walker, *A. constricta* Say, *A. mutata* Hagen, *A. tuberculifera* Walker, *A. verticalis* Hagen, *Coryphaeschna ingens* (Rambur), *Gomphaeschna furcillata* (Say); Corduliinae- *Helocordulia selysii* (Hagen), *Somatochlora georgiana* Walker, *S. provocans* Calvert, *S. williamsoni* Walker, *Tetragoneuria semiaquea* (Burmeister), *T. spinosa* (Hagen), *T. williamsoni* Muttkowski; Libellulinae- *Brachymesia gravida* (Calvert), *Celithemis martha* Williamson, *C. verna* Pritchard, *Ladona julia* (Uhler), *Leucorrhinia intacta* (Hagen), *Libellula flavida* Rambur, *Sympetrum ambiguum* Rambur, *S. obtrusum* (Hagen), *Tarnetrum corruptum* (Hagen), and *Tramea onusta* Hagen. Later Matta (1978) reported

41 Anisoptera from southeastern Virginia, including *N. pentacantha*, *P. hymenea*, and *T. onusta* which were new for this region of the state. However, an examination of the specimens reported as *T. onusta* has revealed that they are *T. carolina*. Carle (1979a) added eight Anisoptera to the Virginia list which were: *Gomphus consanguis* Selys, *G. rogersi* Gloyd, *Ophiogomphus carolinus* Hagen, *Cordulia shurtleffi* Scudder, *Tetragoneuria canis* McLachlan, *Ladona exusta* (Say), *Leucorrhinia hudsonica* (Selys), and *L. proxima* Calvert. Carle (1980) described *Lanthus vernalis* from Virginia, bringing the total number of Anisoptera known from the state to 123.

ZOOGEOGRAPHY

Continental drift, glaciation, and adult vagility have all played important roles in determining the composition of the Virginia anisopteran fauna. The earliest anisopteroid fossil known is the fragmentary *Mesophlebia* reported by Tillyard (1916) from the Upper Triassic beds of Queensland, Australia. Several anisopteroid genera are known from the Liassic beds of England and Germany (Tillyard 1925; Handlirsch 1906-08, 1939) with the Liassogomphidae (Cowley 1934, 1942) the most similar to true Anisoptera. Undisputed gomphine and petalurine genera are represented in the Upper Jurassic beds of Germany (Handlirsch 1906-08), although the current world-wide distributions of these families despite low vagility, supports their radiation during the Triassic before the dispersion of the pangaeon supercontinent (cf. Dietz and Holden 1970). Typical Aeshnidae and Libellulidae are not known before the Cenozoic, although the mutually exclusive Gondwanian and Laurasian distributions of the related annectant neopetalines and cordulegastrines, respectively, suggest a dichotomy coincident with the separation of Gondwanaland from Laurasia, which according to Dietz and Holden (1970) occurred about 180 million years ago.

The timing of more recent anisopteran evolutionary events is clouded by an increase in adult vagility, but the compilations of anisopteran generic geographical distributions provided by Kirby (1890), Calvert (1893), Tillyard (1917), Fraser (1957), and Davies (1981) coupled with phylogenetic evidence, suggest the origin of remaining anisopteran families during the Cretaceous in southern Asia and Australia. The

dispersion of Gondwanaland during the Jurassic and subsequent formation of the Indonesian island arc during the Cretaceous (Le Pichon 1968, Dietz and Holden 1970, Smith *et. al.* 1973) allowed the dispersal of the Aeschnidae from Australia where they had been derived from the neopeptelines. Later the Macromiinae and Synthemistinae arose, probably during the late Cretaceous in southern Asia and Australia, respectively, from the chlorogomphine Cordulegastridae. Finally the gomphomacromiine and corduliine Libellulidae arose in sequence from the Synthemistinae of Australia, probably during the Paleocene and Eocene as evidenced by the many Libelluline fossils listed by Handlirsch (1906-08) from the Oligocene of Europe. Closure of the Tethyan Sea during the early Cenozoic (cf. Dietz and Holden 1970, Smith *et. al.* 1973) allowed the migration of the Cordulegastridae, Aeshnidae, Macromiinae, Corduliinae, and Libellulinae into Africa. Occurrence of the gomphomacromines in South America supports the connection of Australia and South America via Antarctica during the early Cenozoic as suggested by Wegener (1966).

Formation of the Bering land bridge by the early Cenozoic (Dietz and Holden 1970, Dott and Batten 1971) allowed migration of the Aeshnidae, Macromiinae, Corduliinae, and Libellulinae to North America. The number of related temperate genera between Eurasia and North America suggest a much more southern position of the Bering land bridge during the early Cenozoic. This is consistent with paleomagnetic evidence (Irving 1964) which supports a clockwise rotation of North America and consequent northward displacement of Alaska during the Cenozoic. Affinities between the faunas of Virginia and Eurasia are apparent between the following genera: *Tachopteryx-Tanypteryx*, *Gomphaeschna-Oligoaeschna*,

Epiaeschna-Brachytron, *Didymops-Epophthalmia*, *Tetragoneuria-Epitheca*, *Nannothemis-Nannophya*, and *Plathemis-Platetrum*. In addition, *Hagenius*, *Stylogomphus*, and possibly *Lanthus*, *Libellula* and *Boyeria* were added to the Virginia fauna from Asia; *Gomphus*, *Ophiogomphus*, and *Stylurus* invaded Eurasia from North America; and *Aeshna*, *Cordulia*, *Somatochlora*, *Leucorrhinia*, and probably *Sympetrum* evolved simultaneously across northern Eurasia and North America. Pleistocene climatic cooling has subsequently allowed the range extension of several boreal representatives of the latter genera southward into Virginia. The ease with which certain Anisoptera continue to utilize the Bering crossing is demonstrated by the current circumpolar distributions of *Aeshna juncea* Linneaus, *A. subarctica* Walker, *Somatochlora shalbergi* Trybom, and *Libellula quadrimaculata* Linneaus (cf. Walker 1958, Walker and Corbet 1975).

The formation of the Panamanian land bridge (cf. Dietz and Holden 1970) has also increased the diversity of the Virginia fauna. However, the West Indian island arc has apparently been a more important anisopteran migration route between South and North America. South American genera which have apparently utilized both routes are: *Leptemis*, *Orthemis*, *Macrodiplax*, *Miathria*, *Dythemis*, *Perithemis*, *Erythrodiplax*, *Pantala*, *Tramea*, and *Anax*. However, the former five genera are not known from Virginia, and the latter three genera range throughout the tropical and temperate zones of the entire world. Actually land bridges are apparently of minor significance concerning the dispersion of *Pantala*, *Tramea*, and *Anax* as evidenced by the distribution of *Anax junius* which includes North America, Hawaii, and the eastern coast of Asia

(cf. Needham and Westfall 1955). Additional South American genera which have utilized the West Indian route to the southeastern United States are: *Coryphaeschna*, *Gynacantha*, *Triacanthagyna*, *Brachymesia*, *Tauriphila*, and *Idiataphe*; only *Coryphaeschna* and *Brachymesia* are known from Virginia. Additional genera which migrated north through Mexico to reach Virginia include *Aphylla*, *Progomphus*, *Erpetogomphus*, and *Erythemis*. However, *Erpetogomphus* is unique in its Central American origin. The unintentional transport of anisopteran nymphs in aquatic plant material has apparently led to the recent establishment of the Old World genus *Crocothemis* in Florida, and it is apparently extending its range northward.

Eastern North America is one of at least six anisopteran refugial regions of the world (cf. Calvert 1893, Tillyard 1917). When compared to the anisopteran fauna of Australia (Fraser 1960), for example, Eastern North America is found to have more species and genera of which a nearly comparable number are endemic. Despite relatively high adult vagility the following anisopteran genera remain endemic to Eastern North America: *Tachopteryx*, *Arigomphus*, *Dromogomphus*, *Gomphaeschna*, *Basiaeschna*, *Epiaeschna*, *Nasiaeschna*, *Zoraena*, *Taeniogaster*, *Didymops*, *Williamsonia*, *Helocordulia*, *Neurocordulia*, *Dorocordulia*, *Epicordulia*, *Nannothemis*, and *Celithemis*; *Tetragoneuria*, *Plathemis*, *Ladona*, and *Pachydiplax* are limited to eastern and western North America. Of these only *Williamsonia* and *Dorocordulia* are not reported from Virginia, although *Dorocordulia* undoubtedly occurs in the state. The subgenus *Stenogomphus* is restricted to Eastern North America and the subgenera *Gomphurus*, *Phanogomphus*, *Schizuraeschna*, *Eolibellula*, *Neotetrum*, and

Holotania are limited to eastern and western North America. *Tachopteryx*, *Zoraena*, *Taeniogaster*, and possibly *Arigomphus*, *Dromogomphus*, and *Stenogomphurus* have apparently inhabited eastern North America since the Jurassic and may be considered paleoendemic. Holarctic paleoendemic genera inhabiting Virginia include: *Gomphus*, *Hagenius*, *Lanthus*, and *Cordulegaster*. This diversity seems unusual in light of Pleistocene glaciation, but actually glaciation may have increased diversity. Since the origin of the Anisoptera the climate of eastern North America has been predominantly tropical or subtropical and only recently during the Pleistocene have tropical climates been restricted to Florida (Dott and Batten 1971). The north-south orientation of the Appalachian mountains have enabled tropical species to retreat southward during periods of climatic cooling, while simultaneously providing refugia for northern species south of the glacial advance. However, *Eocalopteryx*, *Zacalites*, *Protamphipteryx*, *Dysagrion*, and *Protothore* reported from the Eocene of western North America by Scudder (1890) and Cockerell (1920, 1930) are now extinct and show their closest affinity to *Mnais* and *Epallage* of Asia, and *Amphipteryx*, *Thaumatoneura*, and *Euthore* of the Neotropics, respectively. In contrast to the situation in eastern North America, the east-west orientation of the southern European mountains coupled with Pleistocene climatic cooling have apparently led to the extinction of a large portion of the European anisopteran fauna.

Anisopteran speciation has apparently proceeded at a relatively high rate in eastern North America as evidenced by the high proportion of closely related species-pairs. Recently geographic isolation has apparently been achieved through climatic and sea level changes associ-

ated with glaciation. An important geographic isolating mechanism in terms of Virginia's anisopteran diversity involves the physiography of the Appalachian mountains. From Pennsylvania southward the mountains increase in elevation so that during interglacial periods the southern portion forms "islands" of cooler climate. Currently four northern species (*Gomphus brevis*, *G. borealis*, *Aeshna verticalis*, and *Somatochlora williamsoni*) exhibit isolated populations south of Virginia. Unfortunately the Laurel Bed, a 300-acre spring bog at an elevation of 1100 m in Russell county, Virginia was inundated during the 1960's and nothing is known of its former Odonate fauna, but it probably represented an important connecting link between boreal populations in northwestern Virginia and western North Carolina. It is difficult to determine what species have originated on these mountain "islands" because climatic changes following speciation may lead to extensive changes in distribution patterns. However, it appears that both *Gomphus consanguis* and *Macromia margarita* have been derived in this region from *G. rogersi* and *M. alleghaniensis*, respectively. The first mentioned species in the following pairs have possibly also differentiated in the southern Appalachians: *Lanthus vernalis*-*L. parvulus*, *Ophiogomphus edmundo*-*O. carolus*, *O. incurvatus*-*O. mainensis*, *Zoraena bilineata*-*Z. diastatops*, *Boyeria vinosa*-*B. grafiana*, *Helocordulia selysii*-*H. uhleri*, and *Tetragoneuria spinosa*-*T. canis*. All except *M. margarita* and *O. edmundo* have been reported from Virginia.

The Rocky Mountains and Great Plains have divided the distributions of many Anisoptera, which has in many cases led to speciation; currently *Tetragoneuria canis* and *Aeshna tuberculifera* exhibit east-west disjunct

distributions. The first mentioned species in each of the following east-west species pairs occur in Virginia: *Aeshna mutata*-*A. multicolor*, *Erythemis simplicicollis*-*E. collocata*, *Libellula cyanea*-*L. commanche*, *L. pulchella*-*L. forensis*, and *Plathemis lydia*-*P. subornata*, the latter two pairs are currently sympatric in western North America.

Sea level changes related to glaciation (e.g. Dott and Batten 1970) have also enhanced geographic isolation in several regions. The number of species-pairs with one member exhibiting a northeast costal distribution indicate that low sea levels during glacial maxima created a refugial region possibly in the area now referred to as the Grand Banks. Species which presumably inhabited bog ponds of the refugium are placed first in the following pairs: *Aeshna clepsydra*-*A. canadensis*, *Williamsonia lintneri*-*W. fletcheri*, *Dorocordulia lepida*-*D. libera*, *Ladona exusta*-*L. deplanata*, *Celithemis martha*-*C. amanda*, and *Sympetrum janeae*-*S. rubicundulum*; four of these species currently reach their southern distribution limit in Virginia.

Five species now occurring in Virginia have been apparently derived from Floridian isolates of West Indian congeners, this isolation has been enhanced by the postglacial rise in sea level. The apparent Floridian isolates are placed first in the following species pairs: *Anax longipes*-*A. concolor*, *Coryphaeschna ingens*-*C. viriditas*, *Erythrodiplax berenice*-*E. naevae*, *E. minuscula*-*E. connata*, and *Brachymesia gravida*-*B. herbida*. Similarly *Aphylla williamsoni* may have been derived from the Antillean *A. caraiba*. However, morphological similarities indicate that it was derived from a Floridian isolate of the Mexican *A. protracta* which had invaded Florida from along the gulf coast. The Bering

Straight has also brought about geographic isolation, but since the Pleistocene apparently only arctic species have been involved. However, surprising morphological similarities exist between some Virginia and Old World Anisoptera such as between *Hagenius brevistylus* and *H. deflexus*.

Virginia is characterized by considerable physiographic and biographic diversity (cf. Fenneman 1938, Hoffman 1969) affording a superb opportunity for analyzing the environmental factors influencing anisopteran biogeography. More than half of the anisopteran species of eastern North America are known to occur in Virginia with an additional twenty percent likely to be reported from the state. Distribution maps for both Virginia and North America were prepared for 175 species which occur in Virginia and neighboring states. Virginia locality records were each separately indicated on distribution maps, while North American distributions were indicated in more general terms. To determine North American species distributions the records reported by Needham and Westfall (1955) were augmented by several new published records (Ahrens and Beatty 1968; Beatty *et. al.* 1969, 1970; Bick 1957; Carle 1978a, 1979a, 1980; Maklin and Cook 1967; Cuyler 1968; Daigle 1978; Donnelly 1966, 1970; Goodwin 1968; Johnson *et. al.* 1980; Kormondy 1958, 1960; Molnar and Lavigne 1979; Paulson 1966; Resener 1970; Ries 1967, 1969; Roback and Westfall 1967; Shiffer 1970; Tennesen 1979; Trogdon 1961; Voshell and Simmons 1978; Walker 1958; Walker and Corbet 1975; Westfall 1956, 1965; Westfall and Tennesen 1979; Westfall and Trogdon 1966; White and Morse 1973; White *et. al.* 1974). Additional new distribution records were obtained from the following collections: Florida State Collection of Arthropods; U.S. National Museum of Natural History; E.B. Williamson

Collection, University of Michigan; Entomology Department Collection, University of Massachusetts; Entomology Department Collection, Virginia Polytechnic Institute and State University; and Academy of Natural Sciences of Philadelphia Entomology Collection. Many new records for northern Quebec, Vermont, New Jersey, and Oregon have been utilized from the author's collection. The compilation of North American records has shown the following species to have their southern distribution limit in Virginia: *Arigomphus furcifer*, *Gomphus fraternus*, *Lanthus parvulus*, *Ophiogomphus carolus*, *Aeshna canadensis*, *A. mutata*, *A. tuberculifera*, *Zoraena diastatops*, *Cordulia shurtleffi*, *Tetragoneuria canis*, *Celithemis martha*, *Ladona julia*, *L. exusta*, *Leucorrhinia hudsonica*, *L. frigida*, *L. proxima*, and *Sympetrum janeae*; and the following species to have their northern distribution limit in Virginia: *Aphylla williamsoni*, *Gomphus consanguis*, *Coryphaeschna ingens*, *Helocordulia selysii*, *Neurocordulia virginensis*, *Tetragoneuria spinosa*, and *Celithemis verna*.

Attempts to fit known anisopteran distributions to the life zones of Merriam (1898), climatic zones of Koppen (1936), biotic provinces of Dice (1943), or biotic regions of Hoffman (1969) were unsuccessful. Physiographic provinces, forest types, and river systems also did not correspond with anisopteran distributions. For example, typical distributional limits parallel the distributions of *Gomphus parvidens*, *G. rogersi*, and *Ophiogomphus incurvatus* which extend from the coastal plain of Maryland across the Piedmont of Virginia to the Blue Ridge Mountains of North Carolina. However, certain minimum monthly isotherms (cf. Nelson and Zillgitt 1969) show some correlation with anisopteran distributions, and the patterns of growing season isophenes (cf. Kinser 1941,

Hoffman 1969, Nelson and Zillgitt 1969) seem to parallel anisopteran distributional limits rather well. Growing season or the mean number of frost-free days per annum apparently coincides with many factors which affect anisopteran life history. Several factors such as latitude, elevation, and distance from the ocean obviously affect growing season and explain the varied species composition of the ridge and valley region. Also, yearly variation of growing season suggests a relationship to the highly dynamic aspect of some anisopteran distributions. The preferred length of growing season for Virginia Anisoptera determined from data for the entire continent of North America is reported in Table 1. However, it should be noted that in the midwest anisopteran distribution limits largely correspond to annual runoff isophenes of less than five inches (cf. Nelson and Zillgitt 1969).

Anisopteran distribution patterns indicate that the mutually exclusive life zones of Merriam (1898) and biotic provinces of Dice (1943) are an oversimplification of reality, as is apparently also the thermophytic or thermophilis classification of organisms proposed by Bradley (1956). In contrast the concept of overlapping biotic regions proposed by Hoffman (1969) is more compatible with the high degree of overlap characterizing anisopteran distributions. For example, fifteen percent of Virginia Anisoptera are known throughout the range of growing seasons found in Virginia. However, the tabulation of preferred growing seasons reveals a nonuniform array of distribution limits. A peak of both minimum and maximum preferred growing season limits occurs at about 155 days of frost-free period, with 20 percent of the species reaching their minimum limit and 15 percent reaching their maximum limit. In Virginia

Table 1. Distribution of Anisoptera in Relation to Growing Season and Virginia Physiography; N-northern section, S-southern section, U-upper section, L-lower section, ?-possible occurrence.

Family and Species	Preferred length of frost-free period in days	Appalachian Plateau	Alleghany Highlands	Ridge and Valley	Blue Ridge	Piedmont	Coastal Plain
Gomphidae							
1. <i>Aphylla williamsoni</i>	250-360						C
2. <i>Arigomphus furcifer</i>	130-160		AH				
3. <i>Arigomphus pallidus</i>	240-360						C?
4. <i>Arigomphus villosipes</i>	120-200		AH	R		P	C
5. <i>Dromogomphus armatus</i>	230-320						C?
6. <i>Dromogomphus spinosus</i>	120-320	AP	AH	R	B	P	C
7. <i>Dromogomphus spoliatus</i>	210-300	AP?		RS?			
8. <i>Erpetogomphus designatus</i>	170-310			R		P	C
9. <i>Gomphus crassus</i>	170-210	AP?		RS?			
10. <i>Gomphus dilatatus</i>	200-310					PL?	
11. <i>Gomphus externus</i>	160-250	AP?		RS?			
12. <i>Gomphus fraternus</i>	160-190	AP				P	
13. <i>Gomphus hybridus</i>	190-270	AP?		RS?			
14. <i>Gomphus lineatifrons</i>	160-180			R	BS		
15. <i>Gomphus septima</i>	190-200					P?	
16. <i>Gomphus vastus</i>	160-240			R		P	
17. <i>Gomphus ventricosus</i>	160-190			R		P	
18. <i>Gomphus abbreviatus</i>	160-190			R			
19. <i>Gomphus apomyius</i>	190-270						C?
20. <i>Gomphus brevis</i>	100-160			R			
21. <i>Gomphus carolinus</i>	205-240						C?
22. <i>Gomphus geminatus</i>	230-270						C?
23. <i>Gomphus parvidens</i>	170-200					P	
24. <i>Gomphus viridifrons</i>	150-170			R	BS		
25. <i>Gomphus consanguis</i>	190-200			RS			
26. <i>Gomphus rogersi</i>	130-190			RS		P	
27. <i>Gomphus australis</i>	240-330						C?
28. <i>Gomphus borealis</i>	110-160		AH				
29. <i>Gomphus cavillaris</i>	240-330						C?
30. <i>Gomphus descriptus</i>	120-170			R			
31. <i>Gomphus diminutus</i>	240-330						C?
32. <i>Gomphus exilis</i>	150-250			R		P	C
33. <i>Gomphus graslinellus</i>	150-180	AP?					
34. <i>Gomphus lividus</i>	120-270			R	BS	P	C
35. <i>Gomphus hodgesi</i>	250-310						C?
36. <i>Gomphus minutus</i>	260-330						C?

Table 1 (cont.). Distribution of Anisoptera in Relation to Growing Season and Virginia Physiography.

Family and Species	Preferred length of frost-free period in days	Appalachian Plateau	Alleghany Highlands	Ridge and Valley	Blue Ridge	Piedmont	Coastal Plain
37. <i>Gomphus quadricolor</i>	120-200			R			
38. <i>Gomphus spicatus</i>	110-160		AH?				
39. <i>Hagenius brevistylus</i>	140-310			R	BS	P	C
40. <i>Lanthus parvulus</i>	100-150		AH	R			
41. <i>Lanthus vernalis</i>	110-180			R	B	PU	
42. <i>Ophiogomphus anomalus</i>	120-160		AH?				
43. <i>Ophiogomphus aspersus</i>	110-170				BS		
44. <i>Ophiogomphus carolus</i>	110-160			R			
45. <i>Ophiogomphus howei</i>	140-170				BS		
46. <i>Ophiogomphus incurvatus</i>	180-200					P	
47. <i>O. incurvatus alleghaniensis</i>	160-180	AP					
48. <i>Ophiogomphus mainensis</i>	120-170			R			
49. <i>Ophiogomphus rupinsulensis</i>	130-180			R			
50. <i>Progomphus bellei</i>	230-270						C?
51. <i>Progomphus obscurus</i>	160-330	AP		R	BS	P	C
52. <i>Stylogomphus albistylus</i>	120-220			R		P	
53. <i>Stylurus amnicola</i>	160-180				BS	PU	
54. <i>Stylurus ivae</i>	240-270						C?
55. <i>Stylurus laurae</i>	170-270			R		P	C
56. <i>Stylurus notatus</i>	150-210					PU	
57. <i>Stylurus plagiatus</i>	200-320					P	C
58. <i>Stylurus scudderi</i>	100-160			R			
59. <i>Stylurus spiniceps</i>	130-220			R	BS	P	C
60. <i>Stylurus townesi</i>	240-270						C?
Petaluridae							
61. <i>Tachopteryx thoreyi</i>	160-300			R	B	P	C
Aeshnidae							
62. <i>Aeshna canadensis</i>	90-160		AH				
63. <i>Aeshna clepsydra</i>	160-180					P?	
64. <i>Aeshna constricta</i>	140-190			RN	BN		
65. <i>Aeshna interrupta</i>	100-160		AH?				
66. <i>Aeshna mutata</i>	150-170			R	BN		
67. <i>Aeshna tuberculifera</i>	130-180		AH	R	BN		
68. <i>Aeshna umbrosa</i>	100-250		AH	R	BN	P	C
69. <i>Aeshna verticalis</i>	120-180		AH				
70. <i>Anax junius</i>	100-360	AP	AH	R	BN	P	C

Table 1. (cont.) Distribution of Anisoptera in Relation to Growing Season and Virginia Physiography.

Family and Species	Preferred length of frost-free period in days	Appalachian Plateau	Alleghany Highlands	Ridge and Valley	Blue Ridge	Piedmont	Coastal Plain
71. <i>Anax longipes</i>	150-360	AP		R			
72. <i>Basiaeschna janata</i>	100-270			R	BS	P	C
73. <i>Boyeria grafiana</i>	100-180	AP	AH	R		PU	
74. <i>Boyeria vinosa</i>	100-310		AH	R	B	P	C
75. <i>Coryphaeschna ingens</i>	240-360						C
76. <i>Epiaeschna heros</i>	150-360			R		P	C
77. <i>Gomphaeschna antilope</i>	150-310			R		P	C
78. <i>Gomphaeschna furcillata</i>	160-270			R			C
79. <i>Gynacantha nervosa</i>	240-360						C?
80. <i>Nasiaeschna pentacantha</i>	160-340					P	C
81. <i>Triacanthagyna trifida</i>	240-360						C?
Cordulegastridae							
82. <i>Cordulegaster erronea</i>	150-180			R	BN	PU	
83. <i>Cordulegaster maculata</i>	100-270			R	BS	P	C
84. <i>Taenioaster obliqua</i>	150-200		AH	R	BN	PU	
85. <i>T. obliqua fasciatus</i>	200-270						C
86. <i>Zoraena bilineata</i> n. sp.	130-220		AH	R	B	P	C
87. <i>Zoraena diastatops</i>	100-150		AH				
88. <i>Zoraena sayi</i>	240-270						C?
Macromiidae							
89. <i>Didymops transversa</i>	100-270	AP		R	BS	P	C
90. <i>Macromia alleghaniensis</i>	160-260			R		P	C
91. <i>Macromia georgina</i>	170-300			R		P	C
92. <i>Macromia illinoensis</i>	140-200			R	BS	P	
93. <i>Macromia margarita</i>	150-180			RS?	BS?		
94. <i>Macromia taeniolata</i>	180-340			RS		P	C
Libellulidae, Corduliinae							
95. <i>Cordulia shurtleffi</i>	100-160		AH	R			
96. <i>Dorocordulia lepida</i>	140-190					P?	
97. <i>Dorocordulia libera</i>	110-160		AH?				
98. <i>Epicordulia princeps</i>	150-260	AP		R	B	P	C
99. <i>Helocordulia selysi</i>	210-270					PL	C
100. <i>Helocordulia uhleri</i>	110-240			R	BS	P	
101. <i>Neurocordulia alabamensis</i>	220-330						C?
102. <i>Neurocordulia clara</i>	240-270						C?

Table 1. (cont.) Distribution of Anisoptera in Relation to Growing Season and Virginia Physiography.

Family and Species	Preferred length of frost-free period in days	Appalachian Plateau	Alleghany Highlands	Ridge and Valley	Blue Ridge	Piedmont	Coastal Plain
103. <i>Neurocordulia molesta</i>	200-270						C?
104. <i>Neurocordulia obsoleta</i>	160-270			R		P	
105. <i>Neurocordulia virginensis</i>	180-270					P	
106. <i>Neurocordulia yamaskanensis</i>	150-180			R	BS		
107. <i>Somatochlora elongata</i>	110-160		AH	R			
108. <i>Somatochlora filosa</i>	200-330						C
109. <i>Somatochlora forcipata</i>	100-150		AH?				
110. <i>Somatochlora georgiana</i>	180-270					P	
111. <i>Somatochlora incurvata</i>	120-180		AH?				
112. <i>Somatochlora linearis</i>	160-270			R		P	C
113. <i>Somatochlora provocans</i>	180-270					PL	C
114. <i>Somatochlora tenebrosa</i>	130-270		AH	R		P	C
115. <i>Somatochlora walshii</i>	110-160		AH?				
116. <i>Somatochlora williamsoni</i>	110-160		AH				
117. <i>Tetragoneuria canis</i>	110-160		AH				
118. <i>Tetragoneuria costalis</i>	200-270					PL	C
119. <i>Tetragoneuria cynosura</i>	120-270	AP		R	B	P	C
120. <i>Tetragoneuria semiaquea</i>	230-270						C
121. <i>Tetragoneuria spinigeria</i>	110-160		AH?				
122. <i>Tetragoneuria spinosa</i>	220-270						C
Libellulidae, Libellulinae							
123. <i>Brachymesia gravida</i>	230-360						C
124. <i>Celithemis amanda</i>	230-340						C?
125. <i>Celithemis berthia</i>	230-340						C?
126. <i>Celithemis elisa</i>	130-280	AP		R	BN	P	C
127. <i>Celithemis eponina</i>	170-360			R		P	C
128. <i>Celithemis fasciata</i>	180-340					P	C
129. <i>Celithemis martha</i>	170-200					P	
130. <i>Celithemis ornata</i>	190-340						C
131. <i>Celithemis verna</i>	190-300					P	
132. <i>Dythemis velox</i>	210-290					P?	
133. <i>Erythemis simplicicollis</i>	130-360			R	B	P	C
134. <i>Erythrodiplax berenice</i>	200-360					PL	C
135. <i>Erythrodiplax minuscula</i>	180-360			R			C
136. <i>Ladona deplanata</i>	170-340					P	C
137. <i>Ladona exusta</i>	150-200					P	
138. <i>Ladona julia</i>	110-170		AH				

Table 1. (cont.) Distribution of Anisoptera in Relation to Growing Season and Virginia Physiography.

Family and Species	Preferred length of frost-free period in days	Appalachian Plateau	Alleghany Highlands	Ridge and Valley	Blue Ridge	Piedmont	Coastal Plain
139. <i>Leucorrhinia frigida</i>	110-180		AH				
140. <i>Leucorrhinia glacialis</i>	100-160		AH?				
141. <i>Leucorrhinia hudsonica</i>	100-160		AH				
142. <i>Leucorrhinia intacta</i>	120-210		AH	R	BN		
143. <i>Leucorrhinia proxima</i>	100-150		AH				
144. <i>Libellula auripennis</i>	180-340						C
145. <i>Libellula axilena</i>	190-340			R			C
146. <i>Libellula cyanea</i>	130-260	AP	AH	R	B	P	C
147. <i>Libellula flavida</i>	160-270			R	B	P	C
148. <i>Libellula incesta</i>	140-340	AP	AH	R	BN	P	C
149. <i>Libellula luctuosa</i>	120-310	AP	AH	R	B	P	C
150. <i>Libellula needhami</i>	200-360						C
151. <i>Libellula pulchella</i>	130-280	AP	AH	R	B	P	C
152. <i>Libellula semifasciata</i>	130-320			R	B	P	C
153. <i>Libellula vibrans</i>	180-330					P	C
154. <i>Libellula quadrimaculata</i>	100-170						C?
155. <i>Macrodiplex balteata</i>	260-360						C?
156. <i>Nannothemis bella</i>	160-270						C
157. <i>Orthemis ferruginea</i>	250-360						C?
158. <i>Pachydiplax longipennis</i>	140-360	AP	AH	R	B	P	C
159. <i>Pantala flavescens</i>	150-360			R		P	C
160. <i>Pantala hymenaea</i>	170-360			R		P	C
161. <i>Perithemis tenera</i>	130-360	AP	AH	R	BN	P	C
162. <i>Plathemis lydia</i>	130-270	AP	AH	R	B	P	C
163. <i>Sympetrum ambiguum</i>	170-340					P	C
164. <i>Sympetrum costiferum</i>	100-150		AH?				
165. <i>Sympetrum internum</i>	100-160		AH?				
166. <i>Sympetrum janae</i>	100-220						C
167. <i>Sympetrum obtrusum</i>	100-160		AH	R			
168. <i>Sympetrum rubicundulum</i>	140-220		AH	R	B	P	
169. <i>Sympetrum semicinctum</i>	130-200		AH	R	B	P	
170. <i>Sympetrum vicinum</i>	130-270	AP	AH	R	BN	P	C
171. <i>Tarnetrum corruptum</i>	160-360			R			
172. <i>Tramea calverti</i>	240-360						C?
173. <i>Tramea carolina</i>	160-360			R	BN	P	C
174. <i>Tramea lacerata</i>	140-360	AP		R		P	C
175. <i>Tramea onusta</i>	170-360			R			C

the 150-day isophene roughly corresponds to an elevation of approximately 1000 m, which shows obvious similarities to the limits of the Canadian zone as delineated by Hoffman (1969). However, the total cluster encompasses approximately 40 percent of minimum and 40 percent of maximum preferred growing season limits, and extends from about 150-200 days. The 200-day isophene in Virginia has been variously and irregularly depicted, but it is here considered to roughly parallel the boundary between Braun's (1950) oak-chestnut and oak-pine forest types. The included area of species transition roughly encompasses that portion of Virginia west of the piedmont plus the northern piedmont which shows some similarity to Merriam's Transition zone and Hoffman's Alleghanian region. The range of growing season isophenes between 200 and 230 days coincide with relatively few distributional limits; in Virginia this area encompasses much of the southern piedmont and northern coastal plain. Northern distributional limits of many tropical species coincide with approximately the 235-day isophene. In Virginia isophenes near this magnitude have been variously and irregularly depicted (e.g. Kinser 1941, Hoffman 1969, Nelson and Zillgitt 1969) and here considered roughly to extend across the southern half of Southampton county, then north at the Nottoway River to Reedville in Northumberland county, and then across southern Accomack county. Southern distributional limits for many northern species approximately coincide with the 270-day isophene; this isophene apparently has its northern limit near Bodie Island in Dare county, North Carolina.

Growing season also may in part explain the distribution of species limited to either east or west of the Appalachian mountains. The 170-

day isophene extends as far south as northern Georgia, but as far north as Newfoundland and Wisconsin east and west of the Appalachians, respectively (cf. Kinser 1941, Nelson and Zillgitt 1969). In addition, the range of growing season lengths between 170 and 230 days forms a narrow corridor in northern Georgia, but covers extensive regions east and west of the Appalachians. Species which are apparently restricted to west of the Appalachians as a consequence of preferred growing season (Table 2) include: *Gomphus consanguis* Selys, *G. crassus* Hagen, and possibly *G. externus* Hagen, *G. graslinellus* Walsh, and *G. hybridus* Williamson. Species apparently limited to east of the Appalachians by preferred growing season limits include *Dorocordulia lepida* Hagen, *Ladona exusta* Say, and *Celithemis martha* Williamson. In addition, growing season isophenes are generally attenuated upstream along river valleys, supporting the migration of Odonata up river valleys such as the Ohio, Kanawha, and Tennessee in eventually reaching the east coast. The pattern of growing season isophenes in eastern North America may have also led to the subspeciation of *Ophiogomphus incurvatus* Carle and *Enallagma travium* Selys, which are both represented by a subspecies on each side of the Appalachians.

The distribution of each species is also given in terms of Virginia physiography (Table 1). The boundaries of physiographic provinces are indicated by dotted lines on the distribution maps for each species. The least well known anisopteran fauna in Virginia is that of the Appalachian Plateau, only 20 species are known from this region which in Virginia is primarily defined by the Big Sandy drainage system. The apparent low diversity is no doubt related to the disturbance of coal

Table 2. Average Preferred Growing Season of Anisoptera Listed by Species Number from Table 1.

Average preferred growing season in days	Family	Species number from Table 1
125-150	Gomphidae	2, 20, 28, 30, 38, 40, 41, 42, 43, 44, 48, 58
	Aeshnidae	62, 65, 73
	Cordulegastridae	87
	Libellulidae	95, 97, 107, 109, 111, 115, 116, 117, 121, 138, 139, 140, 141, 143, 154, 164, 165, 167
151-175	Gomphidae	4, 12, 14, 17, 18, 24, 26, 33, 37, 45, 47, 49, 52, 53, 59
	Aeshnidae	63, 64, 66, 67, 68, 69
	Cordulegastridae	82, 84, 86
	Macromiidae	92, 93
	Libellulidae	96, 100, 106, 137, 142, 160, 169
176-200	Gomphidae	9, 15, 16, 23, 25, 32, 34, 46, 56
	Aeshnidae	72
	Cordulegastridae	83
	Macromiidae	89
	Libellulidae	114, 119, 129, 146, 162, 168, 170
201-225	Gomphidae	6, 11, 21, 39, 55
	Aeshnidae	74, 78
	Macromiidae	90
	Libellulidae	98, 104, 105, 110, 112, 113, 126, 147, 149, 151, 152, 156
226-250	Gomphidae	8, 13, 19, 22, 50, 51
	Petaluridae	61
	Aeshnidae	70, 77, 80
	Cordulegastridae	85
	Macromiidae	91
	Libellulidae	99, 103, 118, 120, 122, 131, 132, 133, 148, 158, 161, 174
251-275	Gomphidae	5, 7, 10, 54, 57, 60
	Aeshnidae	71, 76
	Cordulegastridae	88
	Macromiidae	94
	Libellulidae	101, 102, 108, 127, 128, 130, 135, 136, 144, 145, 153, 159, 160, 163, 171, 173, 175
276-310	Gomphidae	1, 3, 27, 29, 31, 35, 36
	Aeshnidae	75, 79, 81
	Libellulidae	123, 124, 125, 134, 150, 155, 157, 172

mining operations, but in general collecting has been light in the region. This is unfortunate because species largely restricted to west of the Appalachians may occur in this region. The Alleghany Highlands are here recognized as a distinct physiographic province based on the intermediate folding of the basement rocks as compared to the Appalachian Plateau and the Ridge and Valley Provinces. This has resulted in drainage patterns intermediate between the trellis type of the Ridge and Valley and the dendritic type of the Appalachian Plateau. Consequently the average elevation of the region is higher than in other areas and aquatic habitats more stable. The province is limited by the Alleghany front in the east (Lantz Mountain in Highland county, Virginia) and by Yew, Gauley, Rich, Laurel, and Chestnut mountains in the west. As noted by Braun (1950) and Hoffman (1969) the fauna of this region is distinctly Canadian and somewhat distinct from that of the southern Blue Ridge. Of the 36 Anisoptera known from the Alleghany Highlands of northwestern Highland county, eleven species are not known to occur elsewhere in Virginia. Eighty-two Anisoptera are known from the Ridge and Valley Province, three species are limited to the southern portion delineated by the Tennessee River drainage, and one species to the northern portion. Only seven species are unique to the region in Virginia. Forty-five Anisoptera are known from the Blue Ridge with thirteen species limited to the section north of the Roanoke River, fifteen species are limited to the southern section and two of these are not reported from elsewhere in the state. Seventy-six Anisoptera are known from the Piedmont with six species limited to the upper or foothill section and four species limited to the lower section, only

six species are restricted to the Virginia Piedmont. Seventy Anisoptera are known to occur on the coastal plain with eleven of these not occurring elsewhere in Virginia. Although many species of Anisoptera are known from Virginia several may be considered rare or possibly endangered. These species are listed in Table 3 along with the number of Virginia populations known for each.

Table 3. Rare and Endangered Anisoptera of Virginia and Vicinity: (A) Austral Species, (B) Boreal Species, (C) Apparently Common but Infrequently Captured Species, (M) Mississippian Species, (L) Locally Distributed Species, (R) Rare Species, and (E) Possibly Endangered Species; Each Followed by the Number of Known Virginia Populations.

Taxa	Status	Taxa	Status
Gomphidae			
<i>Aphylla williamsoni</i>	A 1	<i>Ophiogomphus carolus</i>	B 2
<i>Arigomphus furcifer</i>	B 1	<i>Ophiogomphus edmunro</i>	E 0
<i>Arigomphus pallidus</i>	A 0	<i>Ophiogomphus howei</i>	E 2
<i>Arigomphus villosipes</i>	C 6	<i>Ophiogomphus mainensis</i>	B 1
<i>Dromogomphus armatus</i>	A 0	<i>Ophiogomphus rupinsulensis</i>	C 3
<i>Dromogomphus spoliatus</i>	A 0	<i>Progomphus alachuensis</i>	A 0
<i>Erpetogomphus designatus</i>	A 10	<i>Progomphus bellei</i>	A 0
<i>Gomphus abbreviatus</i>	L 6	<i>Stylurus ammicola</i>	R 2
<i>Gomphus apomyius</i>	R 0	<i>Stylurus ivae</i>	A 0
<i>Gomphus australis</i>	A 0	<i>Stylurus laurae</i>	L 6
<i>Gomphus brevis</i>	B 1	<i>Stylurus notatus</i>	B 1
<i>Gomphus carolinus</i>	R 0	<i>Stylurus plagiatus</i>	C 8
<i>Gomphus cavillaris</i>	A 0	<i>Stylurus scudderi</i>	B 2
<i>Gomphus consanguis</i>	E 1	<i>Stylurus spiniceps</i>	C 9
<i>Gomphus crassus</i>	M 0	Petaluridae	
<i>Gomphus descriptus</i>	L 2	<i>Tachopteryx thoreyi</i>	L 15
<i>Gomphus dilatatus</i>	A 0	Aeshnidae	
<i>Gomphus diminutus</i>	A 0	<i>Aeshna canadensis</i>	B 2
<i>Gomphus externus</i>	M 0	<i>Aeshna clepsydra</i>	B 0
<i>Gomphus fraternus</i>	B 2	<i>Aeshna constricta</i>	B 2
<i>Gomphus geminatus</i>	E 0	<i>Aeshna mutata</i>	R 3
<i>Gomphus graslinellus</i>	M 0	<i>Aeshna tuberculifera</i>	L 7
<i>Gomphus hodgesi</i>	A 0	<i>Aeshna verticalis</i>	B 1
<i>Gomphus hybridus</i>	A 0	<i>Anax longipes</i>	A 3
<i>Gomphus lineatifrons</i>	L 14	<i>Boyeria grafiana</i>	B 15
<i>Gomphus minutus</i>	A 0	<i>Coryphaeschna ingens</i>	A 1
<i>Gomphus parvidens</i>	R 1	<i>Gomphaeschna antilope</i>	A 9
<i>Gomphus quadricolor</i>	B 3	<i>Gomphaeschna furcillata</i>	L 12
<i>Gomphus rogersi</i>	R 3	<i>Gynacantha nervosa</i>	A 0
<i>Gomphus spicatus</i>	B 0	<i>Nasiaeschna pentacantha</i>	L 4
<i>Gomphus septima</i>	E 0	<i>Triacanthagyna trifida</i>	A 0
<i>Gomphus vastus</i>	L 11	Cordulegastridae	
<i>Gomphus ventricosus</i>	R 2	<i>Cordulegaster erronea</i>	R 9
<i>Gomphus viridifrons</i>	L 3	<i>Taeniogaster obliqua</i>	L 9
<i>Lanthus parvulus</i>	B 3	<i>Zoraena diastatops</i>	B 1
<i>Lanthus vernalis</i>	L 16	<i>Zoraena sayi</i>	A 0
<i>Ophiogomphus acuminatus</i>	A 0	Libellulidae (Macromiinae)	
<i>Ophiogomphus anomalus</i>	B 0	<i>Macromia alleghaniensis</i>	L 9
<i>Ophiogomphus aspersus</i>	B 3	<i>Macromia georgina</i>	A 6
<i>Ophiogomphus incurvatus</i>	R 3	<i>Macromia margarita</i>	E 0

Table 3 (cont.). Rare and Endangered Anisoptera of Virginia and Vicinity: (A) Austral Species, (B) Boreal Species, (C) Apparently Common but Infrequently Captured Species, (M) Mississippian Species, (L) Locally Distributed Species, (R) Rare Species, and (E) Possibly Endangered Species; Each Followed by the Number of Known Virginia Populations.

<i>Macromia taeniolata</i>	A 12	Libellulidae (Libellulinae)	
Libellulidae (Corduliinae)		<i>Brachymesia gravida</i>	A 3
<i>Cordulia shurtleffi</i>	B 3	<i>Celithemis fasciata</i>	A 12
<i>Dorocordulia lepida</i>	B 0	<i>Celithemis martha</i>	L 1
<i>Dorocordulia libera</i>	B 0	<i>Celithemis ornata</i>	A 1
<i>Helocordulia selysii</i>	L 7	<i>Celithemis verna</i>	A 2
<i>Neurocordulia alabamensis</i>	A 0	<i>Dythemis velox</i>	A 0
<i>Neurocordulia clara</i>	E 0	<i>Erythrodiplax minuscula</i>	A 7
<i>Neurocordulia molesta</i>	L 0	<i>Ladona exusta</i>	B 1
<i>Neurocordulia obsoleta</i>	A 6	<i>Ladona julia</i>	B 1
<i>Neurocordulia virginiensis</i>	A 1	<i>Leucorrhinia frigida</i>	B 1
<i>Neurocordulia yamaskanensis</i>	B 5	<i>Leucorrhinia glacialis</i>	B 0
<i>Somatochlora elongata</i>	B 3	<i>Leucorrhinia hudsonica</i>	B 1
<i>Somatochlora filosa</i>	A 4	<i>Leucorrhinia intacta</i>	B 6
<i>Somatochlora forcipata</i>	B 0	<i>Leucorrhinia proxima</i>	B 1
<i>Somatochlora georgiana</i>	R 1	<i>Libellula auripennis</i>	A 6
<i>Somatochlora incurvata</i>	B 0	<i>Libellula axilena</i>	A 10
<i>Somatochlora linearis</i>	C 11	<i>Libellula flavida</i>	L 13
<i>Somatochlora provocans</i>	R 2	<i>Libellula quadrimaculata</i>	B 1
<i>Somatochlora walshii</i>	B 0	<i>Macrodiplax balteata</i>	A 0
<i>Somatochlora williamsoni</i>	B 1	<i>Nannothemis bella</i>	L 1
<i>Tetragoneuria canis</i>	B 1	<i>Orthemis ferruginea</i>	A 0
<i>Tetragoneuria costalis</i>	A 3	<i>Sympetrum costiferum</i>	B 0
<i>Tetragoneuria semiaquea</i>	A 1	<i>Sympetrum janeae</i>	B 1
<i>Tetragoneuria spinigera</i>	B 0	<i>Sympetrum obtrusum</i>	B 3
<i>Tetragoneuria spinosa</i>	L 2	<i>Tarnetrum corruptum</i>	A 1
		<i>Tramea calverti</i>	A 0
		<i>Tramea onusta</i>	A 2

METHODOLOGY

Collecting

Collecting was planned to supplement the work of previous workers by directing collecting effort toward the establishment of new seasonal and county records, and toward the establishment of new state records for species expected to occur in Virginia. The former objective was achieved by collecting from March through November; and by collecting nymphs, exuviae, and teneral adults in addition to mature individuals. The latter objective was achieved by studying locality data for species likely to occur in Virginia and directing collecting effort toward promising localities. This resulted in a concentration of collecting effort in the southern Piedmont and Coastal Plain, and in the western Mountains.

Many techniques have been successfully used to capture dragonflies ranging from the standard insect net to the use of dust shot (cf. Needham and Heywood 1929, Needham and Westfall 1955). However, the author's net design and capture technique developed over the past 15 years was more efficient and versatile than standard techniques. The net was constructed by attaching a handle of aluminum tubing (ca. 2.5 cm in diameter) 1 to 1.5 m long to a hoop of aluminum tubing (ca. 1 cm in diameter) forming an opening of 50 cm to which was attached a dome of 1.6 mesh/cm clear plastic netting. The hoop was attached to the handle by partially flattening the distal 3 cm of the handle to accept the recurved ends of the hoop. Then a 2.5 X 10 cm piece of sheet metal was bent over the connection, and a hole drilled through the sheet metal and handle between the inserted ends of the hoop. A small bolt and two

nuts, the second a lock nut, were used to secure the assembly. The hoop was set at ca. 15° from the handle and the netting attached with 10-pound test monofilament fishing line. Finally a durable rubber tube was split and attached over the distal half of the hoop and secured with twisted loops of stove pipe wire.

The author's net had several advantages over the typical dragonfly net; it was light, durable, waterproof, practically invisible, easy to repair, and was used effectively to collect both nymphs and adults. If torn the netting was repaired with spare monofilament or temporarily repaired by weaving a vine or stick through the mesh. The netting itself was rather stiff and formed a cylinder ca. 40 cm deep. Unlike standard nets in which insects are trapped by flipping the net over the rim, dragonflies were trapped by holding the open end of the net over either the surface of the ground, water, or vegetation. Air pressure created by the swing held the dragonfly in the net before the opening was sealed against a surface. A perfect rim to surface seal was unnecessary because most dragonflies flew upward to escape. However, primitive dragonflies such as the cordulegastrines or gomphines often flew down to escape. Once captured, dragonflies were confined to a corner of the net by compressing the net. The wings were then folded back and held through the net from where the specimen was easily transferred to the other hand. However, small Zygoptera were captured as they were allowed to climb through the netting. Specimens were then placed live in paper triangles with the wings folded over the back to be transported to the lab. To prevent crushing, triangles were made of pliable paper (either of notebook paper or newspaper) and specimens were transported

in cigar boxes.

The various behaviors and habitats of dragonflies required different netting techniques in different situations. It was generally more effective to net specimens flying above shoulder height from the side and to net those flying below the shoulder from above. Although often recommended, netting from behind was less effective. Many of the larger Anisoptera patrol low above the water surface and were easily captured by waiting at a place which afforded both good visibility of the approaching dragonfly and ample room to swing the net. Cordulegastrines typically fly low along small streams in a manner such that the net could be held at about 1 m above the stream and practically dropped on the passing dragonfly. Many gomphines rest on rocks or on banks and were approached slowly from behind, the net was then slowly lowered to ca. 50 cm above them before the final downward thrust of the net. Helpful techniques included waiting within netting distance of a favored perch site, allowing the shadow of the net to pass over a perched dragonfly slowly, hesitating when perched dragonflies tensed their wings, and centering the net about 10 cm in front of perched dragonflies for they generally flew forward from their perch. Petalurines typically rest against the trunks of trees and were easily captured by slowly placing the net over them, moving it up the tree until the rim touched the terminalia, and as they flew down and away from the tree trunk, the net was slid off the tree to the ground. Dragonflies which perch on vegetation were swept off with a quick swing of the net, but considerable care was often needed in maneuvering the net within striking distance while insuring it would not snag on its path to the ground. When

hanging from branches dragonflies were easily netted by a similar sweep along the limb; the author has taken three resting *Aeshna mutata* in this manner with a single sweep. A final point is that dragonflies were more easily captured when distracted by other dragonflies, when ovipositing, or when eating or pursuing prey. The latter case was perhaps the only time that many cordulines were vulnerable to capture.

The author's net was also used to collect nymphs. Dragonfly nymphs may be grouped into those that climb, sprawl, cling, or burrow. In riffle areas and rapids where most species are either clingers or burrowers, nymphs were easily captured by placing the net perpendicular to the current and disturbing the substrate upstream from the net with the feet. Nymphs found in aquatic vegetation and on roots are primarily climbers and were captured by thrusting the net into stems or roots and lifting it or by simply pulling the net through these habitats. Nymphs which burrow in or sprawl on the bottoms of pools, ponds, and lakes were captured by pulling the net across the bottom in such a manner as to remove the top 3 to 5 cm of substrate. Afterward, much of the excess material was washed through the net by repeatedly dipping it in water. Also, species which burrow into soft muds were often located by following the trails of disturbed mud created by the apex of the abdomen as the nymph moves. In pools the most productive areas were generally the areas in which detrital material had accumulated. Among the most difficult species to collect were those which clung to large roots or trees. This group apparently includes many species of *Neurocordulia* and the most practical method for collecting them was to pull branches and logs out of the water and carefully search their surfaces for nymphs.

The nymphs were transported to the lab in cellophane or paper envelopes, but nymphs to be reared were transported in wet moss, or in the case of burrowers in water-filled containers with ca. 1 cm of sand in the bottom.

The exuviae or cast skins of dragonfly larvae were also collected and were of great value particularly when the adult was associated with them. The site selected for transformation varied somewhat throughout the Odonata, but two basic groups existed. The seemingly more primitive group exemplified by the gomphines generally transformed horizontally on a bank, sometimes with the apex of the abdomen in the water. Practically all other Anisoptera transformed in a vertical position while clinging to vegetation, with some individuals traveling several meters up and away from the water's edge. Exuviae located in inaccessible sites were often reached, dislodged, and netted with the author's net. In cases where the exuviae of rare species were found they were wetted before being dislodged to prevent breakage. Efficiency in collecting exuviae was greatly increased by studying the flight seasons of the species concerned and determining the various times and places of emergence; the actual site of transformation was easily determined by flushing teneral adults. The water surface along the shoreline was also checked for exuviae because exuviae will float when blown or washed into the water. Exuviae were transported to the lab in paper triangles.

It is generally recommended that teneral adults not be collected, but many rare species were often particularly vulnerable to capture at this time. Nymphs collected in emergence, or teneral adults were placed and transported in inflated paper bags which were sealed with a twist tie. In the lab, tenerals were held in a cage in a cool place and fed

dipterans and water using tweezers for about one week before preservation. This procedure allowed the cuticle to harden, the full development of color and color pattern, and prevented distortion during preservation.

Preservation

Living dragonflies are among the most colorful insects. Color and color patterns are frequently of taxonomic value, but often fade and are lost after death. Color loss may vary from a mere fading of abdominal color, to a loss of all color patterns. Coincident with color loss is an associated reduction in specimen durability. It has long been known (Tillyard 1917) that the excretion of alimentary canal contents during slow death reduces the fading of abdominal color patterns. Methods of preservation which have shown promise include: degutting (Longfield 1960), vacuum drying (Moore 1951), low temperature vacuum drying (Davies 1954), alcohol (Young 1966), and acetone (White and Morse 1973). The author has had exceptionally good results with freeze drying and acetone techniques; his oldest freeze dried and acetoned specimens retaining their natural color after ten years (Carle 1978b).

Specimens in this study were preserved in paper triangles in which they were transported from the field. However, in order to produce higher quality specimens they were killed in acetone or by freezing, and then carefully aligned by straightening the abdomen and either spreading the wings vertically or horizontally over the dorsum. If preserved in the lateral position the head was turned to the side and the legs were often pushed forward. This was accomplished after first placing the specimen in a 10 x 5 cm paper folded in half (venter toward

fold) and arranging the fore and hind wings so that they did not overlap. A hair pin was pushed across the paper and consequently over the wings. A lead pencil was used to transfer lot numbers to the folded papers because it was not affected when specimens were preserved in acetone. Also the plastic end coverings of the hair pins were loosened with acetone and removed before use in preservation. Small Anisoptera and Zygoptera were aligned easier if placed in a shallow pan or lid in a depth of ca. 2 mm of acetone. Tweezers were used to manipulate specimens and the area was well ventilated to prevent inhalation of acetone vapors. When the specimens were to be spread horizontally for pinning in a Cornell drawer or display case the alignment procedure was more complicated. The materials used were a piece of corrugated cardboard about 15 x 30 cm, hair pins, and 2 x 4 cm rectangles cut from index cards. Specimens were held dorsal side down with the head nearest the edge of the cardboard while two hair pins were inserted over the wings (the lower portion of each hair pin was inserted between the corrugations in the cardboard, while the upper portion was bent upward to avoid damage to the wings). A piece of index card was then slid under the wings on that side of the body released by raising the distal end of the hair pin. The wings were then easily arranged, first on one side and then on the other. The small paper rectangles were then fastened over the wings with hair pins to flatten and protect the wings. Actual pinning was done after preservation to avoid the escape of fluids through the pin hole to the surface of the specimen.

Freeze drying is a process in which water is removed from a frozen object in the form of water vapor, and can be divided into a freezing

and a drying phase. Specimens previously killed and stored by freezing were partially thawed to allow straightening of the abdomen, positioning of the head and wings, and adjustment of the legs. Specimens were placed in the Virtis USM-15 freeze dryer (Virtis Co., Gardiner, N.Y.) and the shelf temperature lowered to ca. -50° C. After specimens had frozen, the vacuum pump was switched on and the pressure of the chamber reduced to 10 microns Hg. The temperature of the condenser was lowered to less than -50° C and the temperature of the shelf allowed to rise to -20° C. Care was exercised when setting the shelf temperature to insure that specimen temperature remained below 0.098° C. Higher temperatures allowed frozen water in specimens to melt and resulted in the alteration of colors. Drying was considered completed when the vacuum reached its maximum low, this generally occurred within 48 hours. The freeze dryer used was able to dry ca. 1000 papered specimens or 100 spread specimens per run.

Acetone treatment is a process in which water, lipids, and other substances are extracted from the body. The extraction of water inhibits bacterial and fungal growth and apparently prevents oxidation (cf. White and Morse 1973). In addition the extraction of lipids removes barriers to rapid evaporation of water. Containers used for extraction were a 4-pound size peanut butter jar (ca. 12 cm in diameter x 16 cm high) and a square 5-pound size honey jar (ca. 12 cm square x 14 cm high). The diameter of the jar openings were 10 cm and the lids used incorporated soft washers which did not dissolve in acetone. A stand of folded cardboard ca. 3 cm high was placed at the bottom of each jar since extraction was poorest and occasionally greatly inhibited

at this level. Fresh acetone was slowly poured into the jar as it was gradually filled with papered specimens by using long tweezers to place specimens neatly four per layer. The hair pin weighed each specimen down, but when the acetone was allowed to be much higher than the specimens during filling the neatly arranged layers tended to become disturbed and capacity was reduced. The jar was filled with acetone and a crumpled piece of paper used to keep the top specimens immersed. Then the lid was tightened and the extraction allowed to proceed for 24 hours. Acetone was only used once when used on several large-bodied specimens, but was reused several times for small specimens such as Zygoptera. Extraction was considered complete when the legs had become stiff at the joints. A problem encountered with the method was the delamination of pigments apparently caused by differences in osmotic pressure. This was avoided by using a more dilute acetone solution or by injecting each specimen with acetone (through the venter) before the extraction process. Nymphs and exuviae which were to be stored dry were placed in small paper triangles during extraction. Because of the volatile and flammable characteristics of acetone, the process was carried out in well ventilated areas.

After extraction the specimens were air dried and slid into cellophane envelopes with 3 X 5 inch locality cards (Beatty and Beatty 1963). The enveloped specimens were in turn stored in paperboard boxes in a cool dry place; a small container of naphthalene was put in each box. These precautions prevented dermestids from eating specimens and mold from developing. In this study 4 X 6 inch file cards were used to store collection information, one for each specimen studied. Abbrevia-

tions used for collectors and institutions are listed in Table 4.

Rearing Nymphs

The rearing of nymphs was often required to verify occurrence records based on nymphal determinations. Association of nymphal and adult stages was most efficiently accomplished by collecting nymphs while they congregated near shore just prior to emergence. However, smaller nymphs or eggs were reared with the advantage that the cast skins of each instar were obtained for possible life history and identification purposes. Eggs of endophytic species were obtained by collecting plant material in which eggs had been laid, or by setting out suitable substrates to obtain dated eggs. Eggs of exophytic species such as gomphines and libellulines were obtained by capturing ovipositing females and dipping the apex of their abdomens in a small container of water. Petalurine females oviposited in wet moss spread across the bottom of a large container, but the author was not successful in obtaining eggs from either the cordulegastrines or macromines. Rearing was accomplished by putting the eggs or nymphs in a net-covered aquarium with a sand bottom, aquatic vegetation, and a ramp for emergence. However, to increase survival and allow the collection of cast skins most nymphs were reared in separate containers. In this study cardboard containers 15 cm high and 12 cm in diameter lined with plastic bags were used. Three cm of sand covered the bottom of each container and a 5 X 20 cm strip of plastic netting was used for an emergence ramp. Plastic screening also covered the top of the containers and water was periodically added to maintain water levels at about half full.

Nymphs were fed a few worms of the genus *Enchytraeus* each morning

Table 4. Abbreviations of Collectors and Institutions.

BCK	Boris C. Kondratieff
BPC	Bertha P. Currie
CA	Carston Ahrens
CC	Compton Crook
FLC	Frank Louis Carle
JFM	James F. Matta
JRV	J. Reese Voshell
MDR	Mary E. Davis Ries
MED	Mary E. Davis
OSF	Oliver S. Flint
RLH	Richard L. Hoffman
RPC	Rolla P. Currie
RRM	Richard R. Mills
SWB	Steve W. Bullington
SWD	Sidney W. Dunkle
TWD	Thomas W. Donnelly
WR	W. Robinson
WTD	William T. Davis
ANSP	Academy of Natural Sciences of Philadelphia
CUC	Cornell University Collection
FSCA	Florida State Collection of Arthropods
MCZ	Museum of Comparative Zoology
MZUM	Museum of Zoology at the University of Michigan
ODU	Old Dominion University
USNM	United States National Museum
VCU	Virginia Commonwealth University
VPI&SU	Virginia Polytechnic Institute and State University
VSEC	Virginia State Entomology Collection
W&M	William and Mary

at which time emerging individuals were removed to paper bags with their exuviae. Teneral adults were not moved until the wings and abdomen had fully expanded. When moved, teneral adults were not touched, but either removed with the substrate they were holding, or if necessary picked up carefully by the legs or wings. Newly emerged adults were kept alive for at least a week as previously described.

Field Observations

Many people have observed dragonflies at one time or another, but relatively few have made careful observations as evidenced by common names such as snake doctor, stinger, and devil's darning needle. Precise observations were facilitated by the use of a field note book, stopwatch, and the collecting net previously described. Many valuable observations were made while collecting. For example, the author has observed the establishment of the tandem hold in *Zoraena sayi* Selys and oviposition in both *Tachopteryx thoreyi* Selys and *Tanypteryx huajeni* Selys while they were unaware of being trapped within the see-through dome of the author's net. It was particularly useful to review the literature to become acquainted with the various habitats and behaviors of the dragonflies to be collected and observed. However, the mature males of several species typically patrol and were captured at the head of riffle areas and near the inlets and outlets of lakes. Other than this all that was required was patience and a certain proficiency in stalking. The latter was aided by the use of clothing which blended with the surroundings and by approaching dragonflies from a direction in which their vision was obscured.

Photography and Drawings

The photographing of dragonflies in their natural environments can be a very rewarding pursuit, and the photography of taxonomically important characteristics extremely valuable. Thirty-five mm, single-lens reflex equipment is versatile and was used for both indoor and outdoor work. A macro lens which permitted close-up photography was used, but a telephoto lens and extension tubes were necessary to photograph wary species in their natural environment. For outdoor work a fast color film was used, but indoor a fine-grained black and white film was used for close-up taxonomic photographs, and high contrast black and white film used for taking photographs of wings. Wing photographs in this study were taken with a Myranda Sensorex SLR camera and a ring light mounted on the base of a dissecting microscope. Shadows and glare were further reduced by placing the wings on tracing paper which was back lighted. The photographs of terminalia and secondary genitalia were taken with a Wild Photomakroskop M400. Glare was reduced by illuminating specimens with light reflected from wrinkled aluminum foil.

Drawings were traced from photographs or from projected images. In either case materials used included vellum drawing paper, a number 2 pencil, waterproof black ink, and a fine point ink pen. Images were projected using the lens from a slide projector which was mounted on the frame of a dissecting microscope to allow focusing. A cork board was then taped to the microscope table to allow the pinning of specimens in various positions. The microscope frame was then laid on its back and the image projected on a wall while illuminating the specimen with a high intensity light source. After achieving the desired magnification

and focusing, the image was traced onto the drawing paper. The specimens were then observed under magnification and compared to the tracing; minor corrections and shading were then added in pencil. The drawings were then lined and stippled in black ink.

Identification

Species identification in this study was accomplished by comparison with type specimens and original descriptions. In cases where type material could not be examined and original descriptions are inadequate the identity of species as determined from the keys and descriptions of Needham and Westfall (1955) and Walker (1958) were accepted. Additional verification was achieved through studying specimens determined by Edmond de Selys Longchamps, Hermann Hagen, P. P. Calvert, J. G. Needham, E. B. Williamson, E. M. Walker, L. K. Gloyd, M. J. Westfall, Jr., and other Odonatologists.

THE ORDER ODONATA

Adult Odonata may be distinguished from all other insects by wing mechanisms responsible for the controlled twisting and bending of the wings during flight. The most conspicuous of these include the nodus located at the point where the costal vein joins the subcostal vein, and the discal nodus which lies on the posterior cubitus at the discal brace. In addition, the mesothoracic and metathoracic terga of adult Odonata are unique among insects in the absence of anterior or posterior connections to the pleura, which allows the terga to move up and down during flight without distortion. This occurs because the downstroke of the wings is achieved by the contraction of muscles connected directly to the basalars and subalars, rather than contraction of longitudinal dorsal muscles which restore curvature to momentarily flattened pterothoracic terga. Adult male Odonata are also unique among insects by possessing a secondary copulatory apparatus beneath the second abdominal segment. Other external features which characterize adult Odonata include: biting mouthparts, setaceous antennae, large compound eyes, mesothorax and metathorax fused into a pterothorax, mesanepisterna meeting at a dorsal carina, mesopleural and metapleural sulci aslant, wings displaced backward on the pterothorax, three segmented tarsi, two pairs of wings with abundant venation, a relatively long abdomen, and one segmented cerci.

Living Odonata are divided into three suborders, the Zygoptera, the Anisozygoptera, and the Anisoptera. The Anisozygoptera (*Epiophlebia*) and Anisoptera apparently comprise a monophyletic group, whereas the

suborder Zygoptera appears monophyletic. The suborder Anisozygoptera was established by Handlirsch (1906-08) to include several Mesozoic fossils and the living genus *Epiophlebia* Calvert, which in many respects are intermediate between Zygoptera and Anisoptera. The genus *Epiophlebia* includes only *E. superstes* Selys from Japan, and *E. laidlawi* Tillyard from India and Nepal. The Zygoptera and Anisoptera are of world wide distribution and are easily distinguished from each other. In general Zygoptera are characterized by a slender abdomen, transverse head, and similarly shaped wings; the Anisoptera by a robust abdomen, globular head, and dissimilarly shaped fore and hind wings. In life the Anisoptera hold the wings horizontally while at rest, whereas the Zygoptera hold the wings vertically in all our genera except *Archilestes* Selys, *Lestes* Leach, and *Chromagrion* Needham, in which the wings are held approximately half open at rest. Venational differences include the presence of supratrangles and triangles in the Anisoptera, and generally the presence of numerous straight intercaleries in the Zygoptera. The ventral coupling mechanism of the male terminalia when developed is derived from the epiproct in the Anisoptera, and from the paraprocts in the Zygoptera.

Key to the Suborders of Odonata

1. Head transverse, antefrons not elevated, vertex (postfrons) without transverse ridge, occiput not elevated dorsally; thorax and legs generally not robust, male terminalia placed about female thorax to form tandem hold, mesanepisternal collar carina neither elevated nor transverse; basal half of fore and hind wings similar

in shape, discal brace similarly oriented in fore and hind wings, numerous intercalated wing veins generally present, hexagonal cells generally absent; abdomen slender, abdominal sterna without posterior processes, anterior hamuli platelike and fused to anterior lamina, lamina batiliformis well developed, posterior hamuli smaller than anterior hamuli, medial organ of abdominal sternum 2 developed into penis with well-developed head, medial organ of abdominal segment 3 not extended anteriorly to base of posterior hamuli; and epiproct vestigial Zygoptera

Head not transverse, antefrons elevated, vertex (postfrons) generally with transverse ridge, occiput elevated dorsally; thorax and legs robust, male terminalia placed about female head to form tandem hold, mesanepisternal collar carina elevated and transverse; basal half of fore and hind wings not similar in shape, discal brace generally not similarly oriented in fore and hind wings, intercalated veins absent or vestigial, hexagonal cells generally present; abdomen robust, abdominal sterna with posterior processes, anterior hamuli neither platelike nor fused to anterior lamina, lamina batiliformis absent or vestigial, posterior hamuli larger than anterior hamuli, medial organ of abdominal segment 2 not developed into penis, medial organ of abdominal segment 3 extended anteriorly to base of posterior hamuli, and epiproct well developed 2

2. Labrum laterally protruding to form an angulate margin, genae with lateral protrusions, anteclypeus membranous, frontoclypeal suture

not deeply invaginated, antennae 5-segmented, pedicel dorsoventrally depressed, interocellar ridge hyperdeveloped, mesanepisternal collar carina not extended laterally to mesokatepisterna, dorsal surface of femora with round tubercles; arculus located ca. midway between costal braces, quadrangle not divided by crossvein into supratriangle and triangle; anterior frame not fused medially, posterior hamuli extended posteriorly beyond medial organ of segment 3, medial organ of segment 2 vestigial, medial organ of segment 3 one-segmented, auricles absent, abdominal sterna without medial carina, posterior margin of female sternum 8 with median process Anisozygoptera (*Epiophlebia*)

Labrum laterally rounded, genae without lateral protrusions, anteclypeus sclerotized, frontoclypeal suture deeply invaginated, antennae 3, 4, 6, or 7-segmented, pedicel cylindrical, interocellar ridge not hyperdeveloped, mesanepisternal collar carina extended laterally to mesokatepisterna, dorsal surface of femora without round tubercles; arculus located ca. 1/3 distance between proximal and distal costal braces, quadrangle divided by crossvein into supratriangle and triangle; anterior frame fused medially, posterior hamuli not extended posteriorly beyond medial organ of segment 3, medial organ of segment 2 well developed, medial organ of segment 3 four-segmented, auricles generally present, abdominal sterna with median carina, posterior margin of female sternum 8 without median process Anisoptera

General Morphology of Adult Anisoptera

Although primitive in many respects and specialized in others, the body of all Anisoptera follows the general insect plan. The body is divided into three principal regions or tagmata (Fig. 1): the head which functions in ingestion and as the sensory and neural integration center, the thorax which functions as the locomotory center, and the abdomen which functions as the digestive and reproductive centers. The head is apparently composed of six or seven primary body segments, the posterior two segments bearing the segmented maxillae and labium. The thorax is composed of three segments, each originally bearing two wings and legs (e.g. Kukalova 1970). The wings remain only on the meso- and metathorax which are fused to form a pterothorax. Fusion of the meso- and metathorax is so complete in the Anisoptera that the intersegmental suture is absent above the metathoracic spiracle. The abdomen was primitively composed of twelve tubular segments which had fused at their ends and become secondarily articulated near the middle to allow the flexing of the abdomen by the primary longitudinal muscles. Original segmental boundaries are represented by a transverse groove on most abdominal segments which is the remnant of the antecostal suture; the portion of each terga anterior to the antecostal suture is termed the acrotergite. Abdominal segment eleven is apparently represented by the appendages of segment ten other than the cerci, the tergum represented by the epiproct, and two sternites (coxites) represented by the paraprocts (the cerci are apparently remnants of the coxites and appendages of segment 10). Segment twelve is apparently represented by internal laminae representing remnants of the

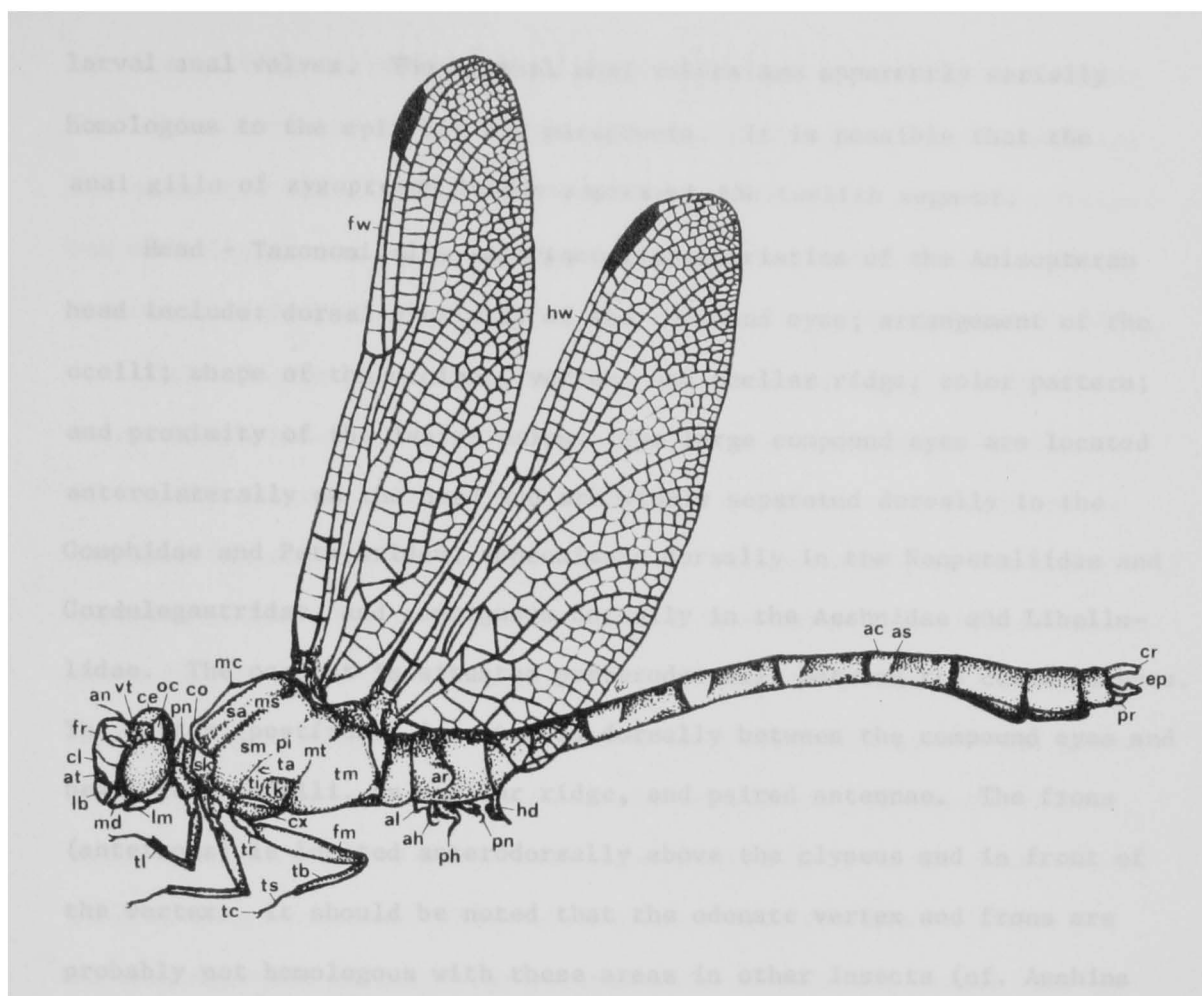


Figure 1. General morphology of *Ophiogomphus rupinsulensis*: (ac) acrotergite; (ah) anterior hamuli; (al) anterior lamina; (an) antenna; (ar) auricle; (as) antecostal suture; (at) anteclypeus; (ce) compound eye; (cl) postclypeus; (co) collar; (cr) cerci; (cx) coxa; (ep) epiproct; (fm) femur; (fr) frons (antefrons); (fw) fore wings; (hd) hood of penis; (hw) hind wings; (lb) labrum; (lm) labium; (mc) middorsal carina; (md) mandible; (ms) mesopleural sulcus; (mt) metapleural sulcus; (oc) occiput; (ph) posterior hamuli; (pi) pterothoracic intersegmental interface; (pn) penis; (pr) paraproct; (pt) pronotum; (sa) mesanepisternum; (sk) mesokatepisternum; (sm) mesoanepimeron; (ta) metanepisternum; (tb) tibia; (tc) tarsal claws; (ti) metinfraepisternum; (tk) metakatepisternum; (tl) tibial keel; (tm) metanepimeron; (tr) trochanter; (ts) tarsi; (vt) vertex (postfrons).

larval anal valves. The nymphal anal valves are apparently serially homologous to the epiproct and paraprocts. It is possible that the anal gills of zygopteran larvae represent the twelfth segment.

Head - Taxonomically important characteristics of the Anisopteran head include: dorsal proximity of the compound eyes; arrangement of the ocelli; shape of the occiput, vertex, and ocellar ridge; color pattern; and proximity of the labial palps. The large compound eyes are located anterolaterally on the head and are widely separated dorsally in the Gomphidae and Petaluridae, approximate dorsally in the Neopetaliidae and Cordulegastridae, and contiguous dorsally in the Aeshnidae and Libellulidae. The occiput is situated posterodorsally between the compound eyes. The vertex (postfrons) is situated dorsally between the compound eyes and bears three ocelli, an ocellar ridge, and paired antennae. The frons (antefrons) is located anterodorsally above the clypeus and in front of the vertex. It should be noted that the odonate vertex and frons are probably not homologous with these areas in other insects (cf. Asahina 1954). The occiput and vertex vary in size and shape corresponding to the dorsal development of the compound eyes. In general, specializations of the female occiput such as the development of spines and ridges serve as reliable specific characters. These specializations relate to the form of the male epiproct which holds the female head during tandem flight, oviposition, and copulation. The clypeus is located anteriorly ventral to the epistomal suture which separates it from the frons. The clypeus is divided into a dorsal sclerotized postclypeus and a ventral anteclypeus which is less sclerotized. Ventral to the clypeus is the labrum which lies just anterior to the mandibles. Posterior to the mandibles

are the maxillae of which only the apical spines are visible ventrally. The labium is located posteroventrally on the head behind the maxillae. Two segmented labial palps are present with the basal segments contiguous medially in the Libellulidae, and widely separated medially in the Gomphidae, Petaluridae, Neopetaliidae, Aeshnidae, and Cordulegastridae.

Thorax - Taxonomically important characteristics of the adult Anisopteran thorax include: shape of the posterior pronotum, straightness of the mesopleural sulci, color, and color pattern. The prothorax is the anterior segment of the thorax and is characterized by its relatively expanded notum. The pronotum is divided into three lobes by two transverse furrows; the posterior lobe is sometimes erect and occasionally bilobed and is of taxonomic importance in the Libellulidae. The pterothorax is formed from the fusion of the mesothorax and the metathorax, which are each divided by pleural sulci extending from the coxae to the pleural wing processes. Many Libellulidae have the mesopleural sulci sinuous near the middle. The pleural sulci divide the pleura into anterior episterna and posterior epimera. The episterna are further divided by oblique sulci into dorsal anepisterna and ventral katepisterna. Anterior to the wings, the mesanepisterna are confluent dorsally along a middorsal carina. At the anterior end of the dorsal carina lies a transverse ridge or collar. Posteriorly, the dorsal carina divides into the antealar carinae. The areas of the anepisterna medial to the antealar carinae are termed the antealars. Anterior to and partially between the anepisterna and katepisterna lies the infraepisterna which bear the spiracles; infraepisterna and anepisterna are not completely separated by sulci in the Anisoptera. Posterior to the metacoxae the metepimera

are expanded ventrally and confluent medially. The base color of the thorax is dark brown or black and when pale stripes are present they are generally centered on the pleural sclerites. Taxonomically important pale stripes of the thorax include: middorsal mesanepisternal, dorsal mesanepisternal, anterior mesanepisternal or collar, lateral mesanepisternal, mesanepimeral, metanepisternal, and metanepimeral.

Legs - The segments of the leg in the order of their proximity to the thorax are the short coxae and trochanters (the trochanters constricted near the middle), the long femora and tibiae, and the three-segmented tarsi. The patellae of fossil Palaeoptera are apparently fused to the proximal ends of the tibiae, the distal tarsal segments each bear two tarsal claws with a ventral spine, the length and position of which is often of taxonomic importance. The femora and tibiae are variously spined with at least two ventrolateral rows, however the spines of the hind tibiae are reduced in males. The spines of the legs function in the capture of prey and the hind legs are rotated posteriorly to the long axis of the body to improve this function, although this greatly reduces the efficiency of walking. The tibiae of many Anisoptera bear ventral keels distally, the lengths of which often serve as reliable generic and specific characters. The prothoracic tibiae also have the distal spines modified into a comb used to clean the compound eyes.

Wings - The Anisoptera are among the most agile fliers, an ability largely related to a substantial modification of the primitive wing venation. The primitive insect wing apparently possessed at least five pairs of main veins, the anterior vein of each pair convex or positive, and the posterior vein of each pair concave or negative. The vein pairs

beginning with the most anterior are the following: costal, radial, medial, cubital, and anal. The Selysian system of naming wing veins used by early odonatologists consisted of descriptive names for the veins without a notation; there was no attempt to homologize the veins with those of other insects. Two methods for determining wing vein homologies have emerged, each leading to different conclusions and consequently different notations. The Comstock-Needham system is based on nymphal wing tracheation and although modified by various workers has remained essentially unchanged. However, the Adolf-Lameere system which is based on wing fluting has been superseded by the systems of several workers including those of Tillyard (1917, 1926) Martynov (1924), Tillyard and Fraser (1938-1940), Forbes (1943), Fraser (1948), Hamilton (1972), and the system proposed in chapter II of this dissertation. The numerous interpretations of wing vein homologies based on corrugation are related to the loss and fusion of basal, costal, and anal wing veins. The system proposed in chapter II is followed herein.

The two-dimensional array of wing veins and crossveins encompasses the most important taxonomic characteristics of the Odonata, enabling rapid and reliable identification to at least the category of genus. In addition, the third dimension of wing fluting aids in the rapid identification of veins. The principal longitudinal veins at the base of the odonate wing have been reduced to two concave or low veins between three convex or high veins (Fig. 2). However, beyond the arculus the primitive vein complement and fluting of the central veins still persists. The anterior wing margin and anterior costa (CA) form the double-barreled anterior margin of the wing or *costa* (C). Basally these veins remain

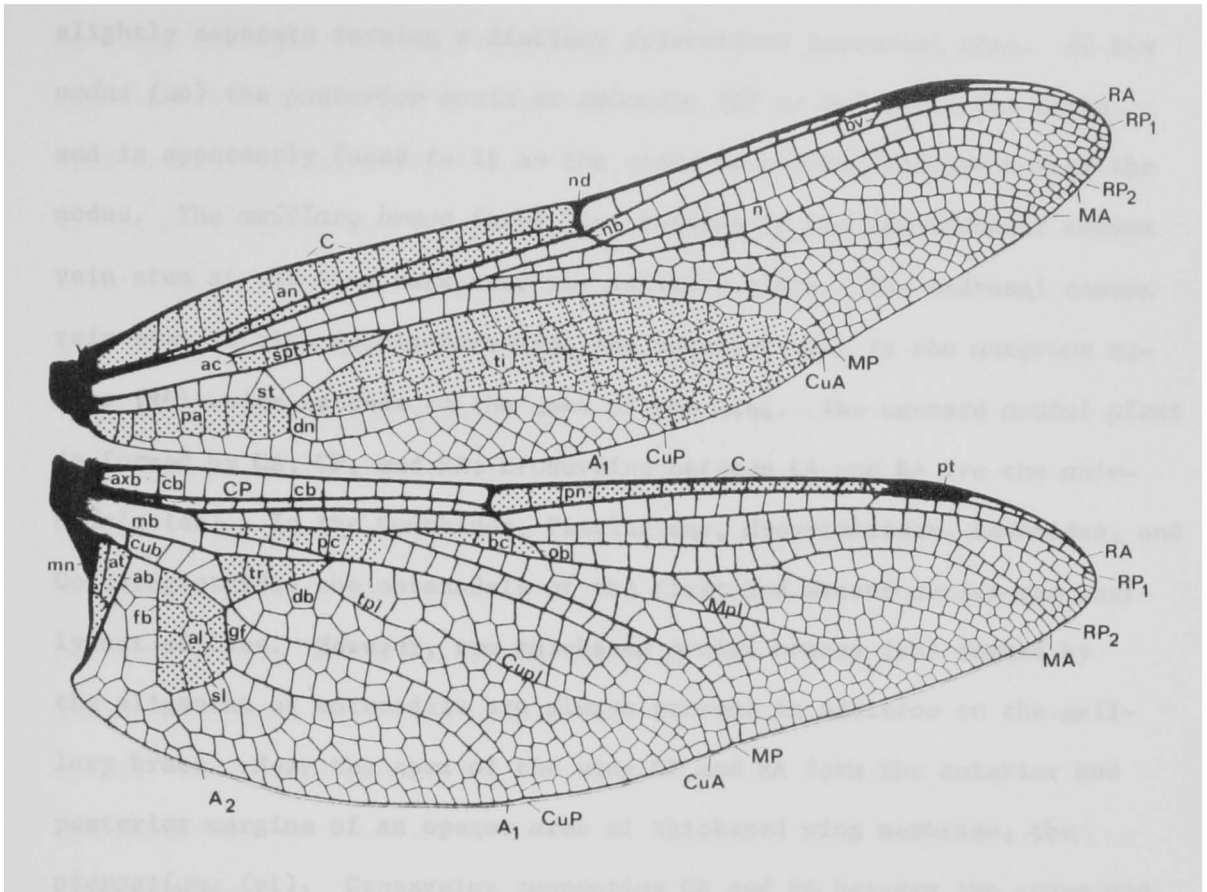


Figure 2. Wings of *Aeshna mutata* illustrating taxonomically important characteristics of anisopteran wings: (ab) anal brace; (ac) arculus; (al) anal loop; (an) antenodals; (A₁) first branch of anterior anal; (A₂) second branch of anterior anal; (at) anal triangle; (axb) axillary brace; (bc) bridge crossveins; (bv) brace vein; (CA or C) costa anterior or costa; (cb) costal braces; (CP or Sc) posterior costa or subcosta; (CuA) anterior cubitus; (cub) cubital brace; (CuP) posterior cubitus; (Cupl) cubital planate; (db) discal brace; (dn) discal nodus; (fb) fibulum; (gf) gaff; (MA) anterior media; (mb) midbasal space; (mn) membranule; (MP) posterior media; (Mpl) median planate; (nb) nodal brace; (nd) nodus; (ob) oblique vein; (pa) paranals; (pc) postmedian crossveins; (pn) post-nodals; (pt) pterostigma; (RA) anterior radius; (RP₁) anterior branch of posterior radius; (RP₂) posterior branch of posterior radius; (sl) solum; (spt) supratriangle; (st) subtriangle; (ti) trigonal interspace; (tpl) trigonal planate; (tr) triangle.

slightly separate forming a distinct sclerotized precostal area. At the *nodus* (nd) the *posterior costa* or *subcosta* (CP or Sc) meets the costa and is apparently fused to it as the costa is neutral-concave beyond the nodus. The *axillary brace* (axb) lies between CA and the midbasal convex vein stem at the wing base near the axillary plate. The midbasal convex vein stem is also double-barreled, the anterior vein is the *anterior radius* (RA) which extends to the apex of the wing. The concave *costal pleat* is formed by CA, CP, and RA; crossveins between CA and RA are the *antenodals* (an). In the Gomphidae, Petaluridae, Neopetaliidae, Aeshnidae, and Cordulegastridae the antenodals of the first and second series are mostly out of line. However, two thickened *costal braces* (cb) formed by the alignment of antenodals are always present in addition to the axillary brace. Near the apex of the wing CP and RA form the anterior and posterior margins of an opaque area of thickened wing membrane, the *pterostigma* (pt). Crossveins connecting CA and RA between the nodus and pterostigma are called *postnodals* (pn). The posterior vein of the midbasal convex vein stem turns rearward to form the upper portion of the *arculus* (ac). The interspace proximal to the arculus is the *midbasal space* (mb) which may contain several crossveins as in the genus *Boyeria* of the Aeshnidae. The arculus gives rise to a concave anterior branch representing the fused *posterior radius* (RP), *anterior media* (MA), and *posterior media* (MP); and a posterior convex branch representing the *anterior cubitus* (CuA). The crossvein forming the lower portion of the arculus may represent a detached segment of CuA. The anterior branch of the arculus gives off a posterior branch MP which parallels CuA to the wing margin. The anterior branch is again branched into the convex

MA which diverges from MP, and the concave RP. The convex *distal pleat* is formed by RP, MA, and MP. RP is connected to the nodus by a thickened crossvein, the *nodal brace* (nb), at a point where RP divides into two branches (RP₁) and (RP₂); RP₁ parallels RA to the apex of the wing. A thickened *brace vein* (bv) connects the proximal end of the pterostigmata to RP in the Gomphidae (absent in some exotic genera), Petaluridae, Neopetaliidae, and Aeshnidae. An intercalated posterior branch of RP₁ is often well developed below the stigma in the Libellulidae. An intercalated vein formed parallel to and behind RP₁, a *radial planate* (Rpl), is also often well developed in the Libellulidae. RP₂ parallels MA to the wing margin and is characteristically undulate in the Libellulini. The *oblique vein* (ob) lies between RP₂ and MA just distal to the subnodus. Crossveins connecting RP and MA proximal to the oblique vein are called *bridge crossveins* (bc). An intercalated posterior branch of MA rising near the oblique vein and paralleling MP to the wing margin is characteristic of the Cordulegastrinae, and an intercalated anterior branch of MA is often present in the Aeshnidae. A *median planate* (Mpl) is present behind MA in the Aeshnidae and Libellulidae. Crossveins connecting CuA to the anterior branch of the arculus proximal to the branching of MP are *postmedian crossveins* (pc), the number of which are taxonomically important in the Gomphidae. Behind the midbasal positive vein (RA+RP+MA+MP) lies the *posterior cubitus* (CuP) which bends sharply rearward toward the *discal nodus* (dn) forming the inner side of the *triangle* (tr). At the discal nodus CuP has lost much of its concavity to enhance flexing of the wing. The upper side of the triangle is a realigned crossvein between CuA and CuP, which divides the space homol-

ogous with the Zygopteran quadrangle into the triangle and a *supratriangle* (spt). The outer side of the triangle is homologous with the outer side of the Zygopteran quadrangle, and is formed by the upper portion of the *discal brace* (db). The inner side of the hind wing triangle is retracted proximally to the arculus in many Libellulidae. CuP regains its concavity after turning distally at the hind angle of the triangle from which it extends in an arc to the wing margin. The interspace between CuA and CuP distal to the triangle is called the *trigonal interspace* (ti). A *trigonal planate* (tpl) arising from the outer side of the triangle is present in most Aeshnidae and in the genus *Hagenius* of the Gomphidae. A *cubital planate* (Cupl) is also present in the Aeshnidae and Libellulidae. The *anterior anal* (A), CuP, and CuA form the concave discal pleat. The *basal nodus* is located at the divergence of A from the posterior wing margin ("AP"). Proximal to the basal nodus the anal vein becomes concave. The thickened crossvein between CuP and A is referred to as the *cubital brace* (cub). The anterior anal extends distally toward the hind angle of the triangle to which it is connected by a short crossvein representing the lower portion of the discal brace. A second crossvein is often present between CuP and A forming the inner side of the *subtriangle* (st). Turning rearward at the discal brace A then branches, the distal branch (A₁) parallels CuP to the wing margin, and the proximal branch (A₂) forms the outer side of the *anal loop* (al) when present in the hind wing and then extends to the wing margin. The portion of A between the discal brace and the branching of A₁ and A₂ is termed the *gaff* (gf). The portion of A₂ beyond the gaff bordering the anal loop is referred to as the *solum* (sl). The inner side

of the anal loop is formed by a secondarily formed vein referred to as the *fibulum* (fb), and the anal loop is bisected by a *midrib* (mr) in most Libellulidae. Males of most Anisoptera also have a thickened *anal brace* (ab) which supports the hind angle of the hind wing while forming the distal side of the *anal triangle* (at). The cells immediately posterior to the anal vein between the wing base and the discal brace are called the *paranals* (pa). An opaque tissuelike flap along the basal anal margin of the wing is known as the *membranule* (mn).

Abdomen - Taxonomically important characteristics of the Anisopteran abdomen include: general shape, presence and location of carinae, color and color pattern, differences in the male secondary genitalia, presence and shape of auricles, shape of the male epiproct and cerci, length of the female cerci, and development of the female ovipositor. Ten abdominal segments can be distinguished, although the first segment is very short and easily overlooked. The acrotergite of segment one is fused to the sternum making segment one somewhat ringlike. The terga of segments two to nine comprise the dorsal and lateral surfaces of the abdomen and are not fused to the sterna, although the lateral tergal margins are almost contiguous midventrally on segments three to six. The tergum and sternum of segment ten are fused so that it also appears ringlike. Paired spiracles are present on segments one to eight, but the spiracles of segments two to eight are concealed along with the pleural membranes between the terga and sterna. The abdomen is characteristically constricted on segments one and three, particularly in the male, and the lateral margins of terga seven to nine are noticeably expanded in male Gomphidae and in male *Dorocordulia* of the Corduliinae. Ventral and

posterior submarginal carinae are present on the abdominal terga of all Anisoptera, and lateral, middorsal, and transverse carinae variously developed at the family level. Aeshnidae and Libellulidae have lateral abdominal carinae in addition to possessing a well-developed middorsal carina. Supplementary lateral carinae are developed to varying degrees in the genus *Anax* of the Aeshnidae. When developed, supplementary transverse carinae follow the paths of the antecostal sutures, and are taxonomically important in the Libellulidae. The color of the abdomen is typically dark brown or black with pale markings. Markings of the abdominal segments are generally arranged in a dorsal and a lateral series of three spots that may be variously conjoined or totally obscure. In its more diverse form the dorsal series consists of an anterodorsal, paired middorsal, and paired posterodorsal spots; the lateral series consists of paired anterolateral, midlateral, and posterolateral spots. The male abdomen, in addition to being much narrower than that of the female, has lateral auricles and a ventral copulatory apparatus on segment two, and has the epiproct and cerci specialized for grasping the female head. Auricles are lateral outgrowths of segment two that may be denticulate or spinose posteriorly. They are absent or reduced in all females, and are absent in male Libellulinae and male *Anax* of the Aeshnidae. Male secondary genitalia often supply the definitive characteristics for species determination and are therefore described in detail in the following section. Appearing to be appendages of the tenth abdominal segment, the epiproct, paraprocts, and cerci are actually remnants of the tenth and eleventh segments, the cerci having migrated dorsally to oppose the dorsal surface of the epiproct. While in tandem the male

epiproct is applied to the dorsal surface of the female head, and the cerci applied to the posterior surface to hold the female firmly during copulation and in many species also during oviposition. The male epiproct is forked in the Gomphidae and in such distantly related genera as *Tachopteryx*, *Gomphaeschna*, and *Cordulia*; in other Anisoptera it is generally triangle-shaped, but may be truncate as in the Neopetaliidae, or long and narrow as in *Phenes* of the Petaluridae. Male *Aphylla* of the Gomphidae have forceplike cerci and lack a functional epiproct. Ventral specializations of the male cerci are also useful in species determinations, reaching an unusual variety of shapes in the species of *Gomphus*, *Aeshna*, and *Somatochlora*. Length of the cerci is useful for the determination of female *Boyeria*, *Neurocordulia*, and *Tetragoneuria*.

In its unreduced form the Anisopteran ovipositor consists of paired progonocoxae and progonapophyses of segment eight, and paired metagonocoxae, metagonapophyses, and metagonostyli of segment nine. Oviposition is generally endophytic in the Petaluridae, Neopetaliidae, and Aeshnidae, which have stylelike gonapophyses (except *Neopetalia*) for piercing plant material. Stylelike gonapophyses are not developed in the remaining Anisopteran families; oviposition is generally achieved by tapping the apex of the abdomen to the water surface. The reduced structure, referred to as the vulvar lamina, varies in size and shape, and is often of taxonomic importance. In the Gomphidae the progonocoxae and progonapophyses are fused to form the vulvar lamina, with other parts of the primitive ovipositor absent. Cordulegastridae have the progonocoxae and progonapophyses (vulvar lamina) greatly lengthened for oviposition in wet substrates. The metagonapophyses are of moderate length, but

the metagonocoxae and metagonostyles are represented only by a small setose sclerite near the base of the metagonapophyses. The condition of the ovipositor in the Libellulidae varies from a reduced condition resembling that of the Cordulegastridae to the total loss of the vulvar lamina with the metagonapophyses represented by nipplelike structures of sternum nine or absent.

Secondary genitalia - Situated beneath abdominal segment two of the male is the secondary genitalia or copulatory apparatus. It consists of several taxonomically useful parts including the anterior lamina, the anterior and posterior hamules, and the penis. A membranous depression of sternum two, the genital fossa, is surrounded by the anterior lamina, lateral sclerites, and the posterior lamina. The anterior lamina is occasionally armed with lateral spines as in *Epiaeschna* of the Aeshnidae. Attached between the anterior lamina and the lateral sclerites are the anterior hamules. Often reduced or absent as in the Libellulidae, the anterior hamules are unusually diverse in size and shape in the Gomphidae; for example they are often sicklelike in *Ophiogomphus*, clenched fistlike in many *Gomphurus*, or vestigial and rodlike in *Stylurus*. Posterior hamules are attached between the posterior lamina and the lateral sclerites; they are generally large and conspicuous and vary in size and shape from small lanceolate structures in the Aeshnidae to shouldered and apically attenuate forms found in *Ophiogomphus*. Projecting anteriorly from the anterior margin of sternum three is the penis which rests between the posterior hamules in the genital fossa. Anteriorly the penis is shielded and held in the retracted position by a sclerotized sheath arising medially from the genital fossa. The penis

is four-segmented, although in the Libellulidae the fourth segment is largely membranous and difficult to distinguish from segment three. The first segment of the penis or penile vesicle is often produced ventrally to form a hood which serves to protect the delicate apex of the penis and is typically conspicuous in the Gomphidae where it is often taxonomically important. The anterior portion of the hood in which rests the apical penile segment is termed the penile receiver. Arising from the dorsal membranous area of segment one and then bending distally is the second segment or stem which is somewhat L-shaped. A median spine is often present anteriorly on the second segment which engages the sheath to help hold the penis in the retracted position. Directed posteriorly the third or median segment lies at a right angle to the second segment; it is generally swollen distally having a dorsal apical lobe called the prepuce, and paired lateral or ventral lobes. The fourth segment or glans projects from the apex of the third segment below the prepuce; it is bilobed and ends in paired flagella which may be fused or entirely absent.

The Anisoptera

The name Anisoptera is derived from the Greek words for unequal wing, referring to unequally shaped fore and hind wings. It is the conspicuous expansion of the hind wings posterior to the anal vein which readily distinguishes most Anisoptera from other Odonata. Six families of Anisoptera are here recognized, the Gomphidae, Petaluridae, Neopetal-liidae, Aeschnidae, Cordulegastridae, and Libellulidae. The Corduliidae, Synthemistidae, and Macromiidae of various authors are here included in the Libellulidae. A cladogram including the extant families of Anisoptera is presented in Fig. 3a. The morphology of the Anisozygoptera and ancestral Zygoptera establish the following readily observed Anisopteran characteristics as primitive: compound eyes widely separated dorsally; frons about as high as the clypeus; first segments of the labial palps ending in a long spine and not approximate distally; second segment of the labial palps well developed; ligula cleft apically; abdomen without longitudinal carinae; female ovipositor composed of paired progonocoxae, progonapophyses, metagonocoxae, metagonapophyses, and metagonostyles; antenodals not in line, costal braces present; male epiproct forked; triangles of the fore and hind wings equidistant from the arculus; brace vein of the pterostigma well developed; veins arising from the arculus not fused basally; planates to the main veins absent; anal loop absent; pterostigma convex posteriorly; and in the nymph: ligula cleft apically, prementum flat with the first palpal segments cyclelike; mandibles two-segmented; antennae seven or eight-segmented; tarsi three-segmented; and abdomen with posterolateral spines.

The ancient Anisoptera probably inhabited small streams, the nymphs stalking their prey amidst debris and the relatively poor flying adults perching much of the time at streamside. The Gomphidae are worldwide in distribution, and represent the descendants of perhaps the most ancient anisopteran adaptive radiation. Adult Gomphidae are little changed from the early Anisoptera; conspicuous adult derived characteristics include the apical margin of the labium entire, and the reduction of the female ovipositor to fused progonocoxae and progonapophyses. The anal loop of the hind wings is formed in various Gomphidae and in later Anisoptera. The fossorial habits of nymphal Gomphidae have led to a reduction to two segments of the nymphal fore and mesotarsi (also hind tarsi in ictinogomphines), and a reduction of the antennae to four segments. However, unlike the partial fusion and reduction of the second mandibular segment found in other Anisopteran nymphs, the nymphal mandibles of the Gomphidae have remained distinctly two-segmented, the freely articulating second segment long with four to seven teeth along the expanded apical margin.

The Petaluridae were apparently abundant during the Jurassic period, but are now only represented by five isolated archaic genera persisting in seepage areas of the United States, Japan, Chile, New Zealand, and Australia. Derived characteristics of the adults include long narrow pterostigmata with concave posterior borders, and expanded or greatly lengthened male cerci. The habit of later Anisoptera to perch vertically is well developed in the Petaluridae, the Gomphidae in contrast preferring to perch horizontally like their immediate predecessors. A conspicuous primitive characteristic of adult Petaluridae and Gomphidae

is the wide dorsal separation of the compound eyes which are contiguous or barely meet at a point in the later Anisoptera. Petalurine nymphs are greatly modified for a semiaquatic mode of life in burrows or in small retreats about rocks, sticks, and leaves. Dorsally the abdominal segments are beset with submedian setal tufts which are positively thigomotactic. The jet propulsion so characteristic of anisopteran nymphs is lost in the Petaluridae, although they retain the ability to squirt water from the anal opening apparently to maintain a thin water layer on the rectal gills and allow ejection of fecal pellets. Other derived characteristics of the nymphs include the distal expansion of the first segment of the labial palps and the presence of a small spine near the base of the second palpal segments.

The Neopetaliidae are a little-known family of ancient stream-inhabiting Anisoptera found in Chile, Australia, and Tasmania. Conspicuous derived characteristics of the adults include the dorsal proximity of the compound eyes and the large reddish brown or blood red wing spots. The adults are an unexpected combination of cordulegasterine, gomphine, and aeshnine characteristics; the nymphs are distinctly aeshnine, but possess lateral abdominal lobes that Tillyard (1917) believed helped to conceal them amid fern leaflets.

The adaptive radiation of the Aeshnidae has produced a dominant anisopteran family of world-wide distribution with representatives in almost all types of freshwater environments. Within the Aeshnidae several lines of specialization are apparent, but the following derived characteristics of the adults are possessed by all: compound eyes meeting dorsally forming an eye seam; face laterally compressed; ligula with a

shallow apical cleft, abdomen with lateral carinae; radial, medial, and cubital planates well developed; and vein RP_2 arching toward the pterostigma. Conspicuous derived characteristics of the nymph include a long prementum with a slight apical cleft, and the large compound eyes. A prominent primitive characteristic of the female is the well-developed zygopteran ovipositor.

The Cordulegastridae are ancient stream-inhabiting Anisoptera represented by six genera distributed throughout the Northern Hemisphere. An ancient division between the Cordulegastridae and Neopetaliidae is suggested by their mutually exclusive geographical distributions, and shared derived characteristics such as the dorsal development of the compound eyes. Other derived characteristics of the Cordulegastridae include: distal margins of the first segment of the labial palps close and with irregular toothlike spines apically; ligula triangular; female metagonapophyses reduced, metagonocoxae and gonostyles absent, and progonocoxae and progonapophyses greatly enlarged; brace vein of the stigma absent; and a posterior branch of MA arising near the oblique vein (except in Chlorogomphinae). The nymphal labium is also derived in possessing enlarged raptorial setae of the prementum and first palpal segments, and in the development of the first palpal segments into scooplike structures.

The family Libellulidae contains over half of the anisopteran genera occurring in Virginia. The "Synthemistidae", "Macromiidae", and certain "Corduliidae" together may comprise a monophyletic group deserving the rank of family, but for convenience while studying the North American fauna they are here considered separate subfamilies of the

Libellulidae pending further study. The Synthemistinae are represented by four Australian genera, whereas the Macromiinae are represented by six genera which are distributed throughout the world except in South America. The Corduliinae encompass a diverse group worldwide in distribution. These groups along with the Libellulinae have undergone considerable change in relation to the Cordulegastridae. Derived characteristics of the adults held in common by all four subfamilies include: compound eyes generally meeting dorsally along an eye seam, first segments of the labial palpi meeting distally and not ending in a long incurved hook, second segment of the labial palpi absent, ligula entire apically and much wider than long, veins arising from the arculus fused basally, first and second series of antenodal crossveins mostly in line and the costal braces not greatly developed, triangles further from the arculus in the fore wings than in the hind wings; and in the nymphs, first segments of the labial palpi generally evenly scalloped to level and with marginal setae distally, second palpal segments similar to the lateral premental setae, and ligula apparently absent. The Synthemistinae and Macromiinae differ from the Libellulinae primarily in the possession of primitive characteristics including: absence of longitudinal abdominal carinae, triangle distal to the arculus in the hind wings, anal loop rounded without a midrib, and anterior hamuli of the male relatively well developed; and in nymphs of the Synthemistinae, first segments of the labial palps with large regular teeth. The Corduliinae are morphologically intermediate between the Macromiinae-Synthemistinae and Libellulinae.

Derived characteristics which distinguish adult North American

Libellulinae and Corduliinae include: abdomen with lateral and middorsal carinae, gaff and inner side of the hind wing triangle in line with the arculus, anal loop elongated with a midrib, and anterior male hamuli vestigial or absent. The following characteristics are derived in the Libellulinae: posterior margin of the compound eyes not sinuate, anal loop with a well-developed "toe"; males without auricles, tibial keels, anterior hamuli, or an anal angulation of the hind wings (also absent in *Hemicordulia* of the Corduliinae); and in the nymph, the first segments of the labial palpi usually only slightly crenulate mesally if at all.

The families of Anisoptera are here placed in four superfamilies, the Gomphoidea, the Petaluroidea, the Aeshnoidea, and the Libelluloidea (Table 5). Tillyard and Fraser (1938-40) have separated the Cordulegastriidae from the Libelluloidea to form its own superfamily, a division which is not recognized herein as the remaining Libelluloidea are apparently not of sufficient geologic age to receive the rank of superfamily. A phylogeny of the Anisoptera is presented in Fig. 3b.

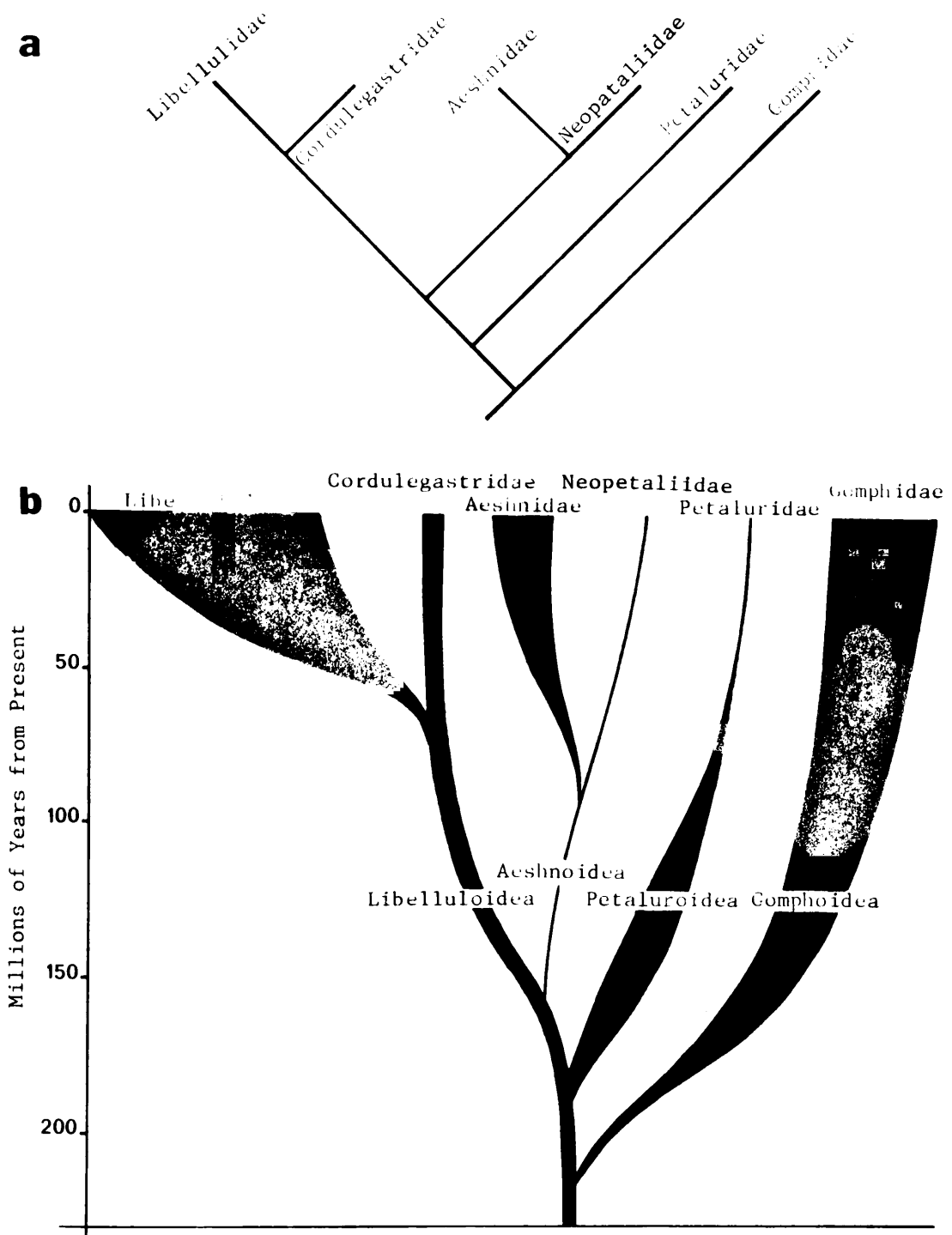


Figure 3. Evolution of the Anisoptera: (a) cladogram illustrating relationship between anisopteran families; (b) phylogeny of the Anisoptera.

Table 5. The Superfamilies and Families of Anisoptera.

Group	Type genus	Type species
Gomphoidea		
Gomphidae	<i>Gomphus</i> Leach 1815	<i>G. vulgatissimus</i> (Linnaeus)
Petaluroidea		
Petaluridae	<i>Petalura</i> Leach 1815	<i>P. gigantea</i> Leach
Aeshnoidea		
Neopetaliidae	<i>Neopetalia</i> Cowley 1934	<i>N. punctata</i> (Selys)
Aeshnidae	<i>Aeshna</i> Fabricius 1775	<i>A. grandis</i> (Linnaeus)
Libelluloidea		
Cordulegastridae	<i>Cordulegaster</i> Leach 1815	<i>C. annulatus</i> (Latreille)
Libellulidae	<i>Libellula</i> Linnaeus 1758	<i>L. quadrimaculata</i> Linnaeus

Key to the Families of Adult Dragonflies
(Odonata:Anisoptera) of North America

1. Costal and subcostal antenodal crossveins in alignment, costal braces not noticeably thickened; triangles further from arculus in fore wings than in hind wings; first segments of labial palps meeting medially Libellulidae p. 538
 Costal and subcostal antenodal crossveins not in alignment, costal braces noticeably thickened; triangles ca. equidistant from arculus in fore and hind wings; first segments of labial palps not meeting medially 2

2. Compound eyes contiguous along middorsal seam; wings each with Rpl and Mpl; abdominal segments 3-9 with ventrolateral carinae Aeshnidae p. 415
 Compound eyes not contiguous along middorsal seam; wings each without Rpl and Mpl; abdominal segments 3-9 without ventrolateral carinae 3

3. Compound eyes closely approximated dorsally; wings each with posterior branch of MA arising near oblique vein, and pterostigma without thickened brace vein Cordulegastridae p. 511
 Compound eyes widely separated dorsally; wings each without posterior branch of MA arising near oblique vein, and pterostigma with thickened brace vein 4

4. Distal margin of labium with medial cleft; wings each with pterostigma longer than distance between costal braces, pterostigma concave posteriorly, and anterior margin of supratriangle straight Petaluridae p. 408
- Distal margin of labium without medial cleft; wings each with pterostigma shorter than or as long as distance between costal braces, pterostigma convex posteriorly, and anterior margin of supratrangles convex Gomphidae p. 208

Family GOMPHIDAE Rambur

Diagnosis.--Distal margin of labium not cleft; first segments of labial palpi not approximate distally and each with incurved apical spine, second segments present; face (frons and clypeus) wider than high; vertex trapezoidal, ocellar ridge transverse, posterior to lateral ocelli; compound eyes widely separated dorsally; occiput transverse; color of pterothorax variable; wings each with antenodals mostly not in alignment, pterostigma as long as or shorter than distance between costal braces and convex posteriorly, brace vein present (absent in some exotic genera), veins arising from arculus separate at base, planates to main veins absent, anterior margin of supertriangle curved, and intercalated branch of MA not extended from near oblique vein to wing margin; triangles equidistant from arculus in fore and hind wings; hind wings each with anal loop absent or present and rounded; male auricles present; anterior hamuli stalklike; posterior hamuli robust with apical hook; longitudinal abdominal carinae absent; ovipositor reduced to fused progonocoxae and progonapophyses.

Generic Key to Adult Gomphidae of Eastern North America

1. Wings each with basal subcostal vein; fore wing subtriangles 2-celled; hind wings each with 4-9 postmedian crossveins 2
- Wings each without basal subcostal vein; fore wing subtriangles 1-celled; hind wings each with 1-3 postmedian crossveins 3

2. Supratriangles 2-celled; fore wings each with 10-12 postmedian crossveins; male epiproct vestigial *Aphylla* p. 212
- Supratriangles 1-celled; fore wings each with 6-8 postmedian crossveins; male epiproct not vestigial *Progomphus* p. 370
3. Triangles 2-celled; trigonal planate present in all wings; fore wings each with 4-7 postmedian crossveins . . . *Hagenius* p. 336
- Triangles 1-celled; trigonal planate absent in all wings; fore wings each with 2 or 3 postmedian crossveins 4
4. Hind femora each bearing row of 4-8 long ventral spines alongside usual short spines; length of hind femora more than 1.5 times width of head *Dromogomphus* p. 225
- Hind femora each without row of 4-8 long ventral spines alongside usual short spines; length of hind femora less than 1.5 times width of head 5
5. Hind femora ca. 3/4 as long as width of head; hind wings each with fibulum arising nearer cubital brace than to hind angle of triangle 6
- Hind femora as long or longer than width of head; hind wings each with fibulum arising nearer hind angle of triangle than to cubital brace 7

6. Hind wings each with anal loop 1-celled, and solum shorter than inner side of triangle; CuA and CuP of each fore wing not divergent to wing margin *Erpetogomphus* p. 237
- Hind wings each with anal loop 2-4-celled, and solum longer than inner side of triangle; CuA and CuP of each fore wing divergent to wing margin *Ophiogomphus* p. 350
7. Occipital crest absent, occiput without transverse hair fringe; hind wings each with distance between costal braces ca. equal to distance between second costal brace and nodus; sternum 9 of female membranous with 2 laterobasal sclerites 8
- Occipital crest present, or transverse hair fringe present; hind wings each with distance between costal braces less than distance between second costal brace and nodus; sternum 9 of female not membranous with 2 laterobasal sclerites 9
8. Anteclypeus and cerci dark brown; fore wings each with outer side of triangle not angulate; male cerci straight, penile hood higher than long, anterior hamuli stublike *Lanthus* p. 342
- Anteclypeus and cerci white; fore wings each with outer side of triangle angulate; male cerci sigmoid, penile hood longer than high, anterior hamuli cyclelike *Stylogomphus* p. 379

9. Dorsal surface of frons ca. 4 times as wide as long; anterior hamuli vestigial without apical spines or denticles, anterior lamina without posterior invagination *Stylurus* p. 385

Dorsal surface of frons ca. 3 times as wide as long; anterior hamuli not vestigial and with apical spines or denticles, anterior lamina with posterior invagination 10

10. Dorsal mesanepisternal dark area divided by pale middorsal stripe; penile receiver extended through posterior margin of hood; cerci yellow *Arigomphus* p. 216

Dorsal mesanepisternal dark area not divided by pale middorsal stripe; penile receiver not extended through posterior margin of hood; cerci not yellow *Gomphus* p. 242

Genus *Aphylla* Selys 1854

Selys 1854. Bull. Acad. Belg. 21:78.

Type Species.--*Gomphoides brevipes* Selys.

Diagnosis.--Occipital carina present, with occipital hair fringe; mesanepisterna brown with dorsal yellow stripes divergent ventrad; length of hind femora $\frac{4}{5}$ width of head, each without 4-7 long ventral spines alongside usual row of short spines; wings each with basal subcostal vein present, supratriangle 2-celled, triangle 2 or 3-celled, subtriangle 1 or 2-celled, and trigonal planate absent; fore wings each with 10-12 postmedian crossveins, and CuA and CuP divergent to wing margin; hind wings each with distal costal brace located at ca. 0.36 distance between proximal costal brace and nodus, 7-9 postmedian crossveins, CuP and AnA₁ separated by one cell row for ca. $\frac{2}{3}$ their length, solum ca. $\frac{7}{10}$ length of inner side of triangle, A₂ slightly angulated at distal end of solum, anal loop 2 or 3-celled, and fibulum originating at ca. $\frac{3}{8}$ distance between cubital brace and discal brace; anterior hamuli cyclelike; hood of penile vesicle small, apical margin thin-bilobate, receiver flat; vulvar lamina bilobate with wide apical notch, ca. $\frac{1}{10}$ length of sternum 9; male cerci brown, forcepslike; male epiproct vestigial.

Aphylla williamsoni (Gloyd)

(Figures 4, 5)

Gloyd 1936. Occ. Pap. Mus. Zool. Univ. Mich. 326:9 (in *Gomphoides*).

Length 71-81 mm; abdomen 52-62 mm; hind wings 37-46 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AL, FL, LA, MS, NC, and VA. Known from the Virginia county of Southampton. Known distribution among the counties of neighboring states include: North Carolina- Beaufort, Camden, Gates, Hertford, and New Hanover.

Virginia Records.--Southampton Co.; Nottoway R. at Rt. 753, 11 June 1975, 1 nymph, FLC; Nottoway R. at Rt. 753, 10 Oct. 1978, (observation), FLC.

Flight Season.--Apr. 14 (FL) to Nov. 2 (FL); in Virginia Oct. 10. Known season in neighboring states are: North Carolina- July 22 to Aug. 11.

Biology.--*Aphylla williamsoni* inhabits lakes and river embayments with thick muddy bottoms. Adults are often observed hovering about cypress shallows.

Remarks.--Although known in Virginia from only a small nymph and one observation of an adult, this species is probably locally abundant along coastal rivers.

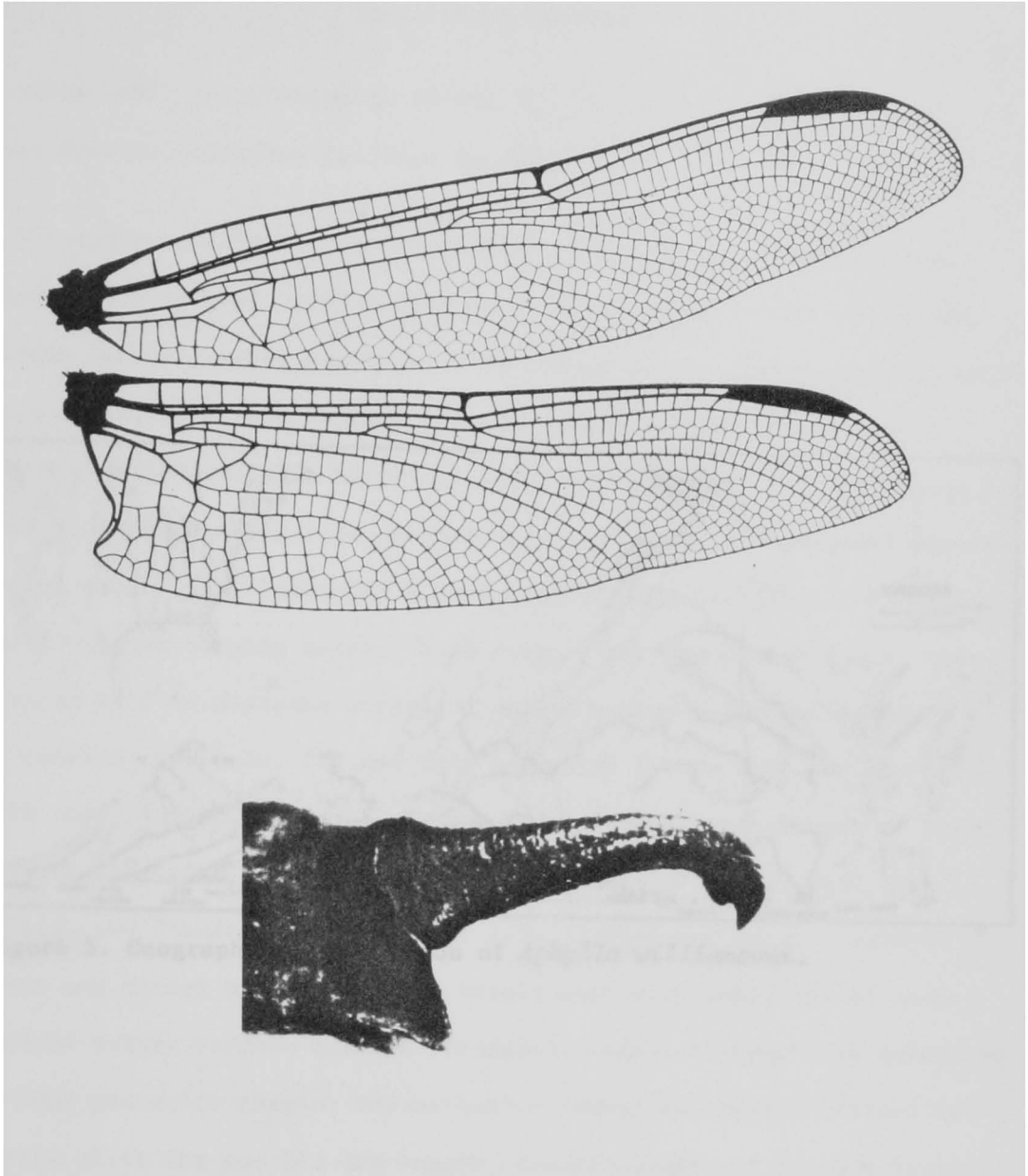


Figure 4. Wings x3 and male terminalia in lateral view x35 of *Aphylla williamsoni*.

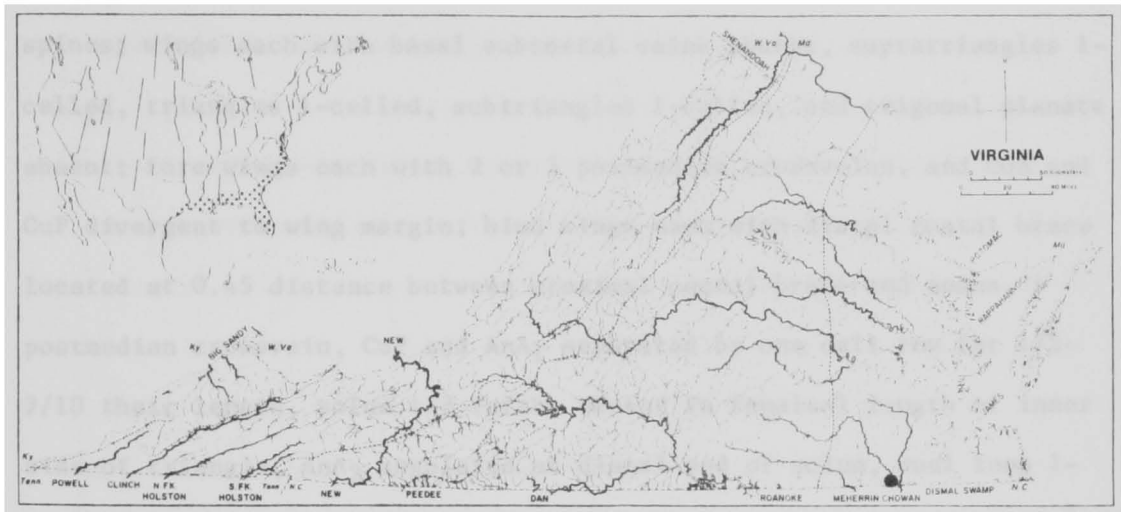


Figure 5. Geographic distribution of *Aphylla williamsoni*.

Genus *Arigomphus* Needham 1897Syn.: *Orcus*: Needham

Needham 1897. Can. Entomol. 29:181.

Type Species.--*Gomphus pallidus* Rambur.

Diagnosis.--Occipital carina present, with occipital hair fringe; mesanepisterna green with narrow brown bands along medial carina and narrow lateral bands; length of hind femora ca. 1.1 times width of head, each without 4-7 long ventral spines alongside usual row of short spines; wings each with basal subcostal veins absent, supratrangles 1-celled, triangles 1-celled, subtriangles 1-celled, and trigonal planate absent; fore wings each with 2 or 3 postmedian crossveins, and CuA and CuP divergent to wing margin; hind wings each with distal costal brace located at 0.45 distance between proximal costal brace and nodus, 1 postmedian crossvein, CuP and AnA₁ separated by one cell row for 1/2-7/10 their length, solum 1/2 (often absent in females) length of inner side of triangle, AnA₂ angulated at distal end of solum, anal loop 1-celled, and fibulum originating at 1/2-3/5 distance between cubital brace and discal brace; anterior hamuli each with small apical hook; hood of penile vesicle stalked-pyramidal, receiver troughlike extending through posterior margin; vulvar lamina convex laterally, divided by narrow cleft for ca. 2/5 its length, 1/4-2/5 length of sternum 9; male cerci yellow, each strongly acuminate posterior to lateral projection; male epiproct divaricate, apical "U"-shaped notch flat-bottomed.

Key to Adult *Arigomphus* of Virginia

1. Tibiae each without external yellow stripe; male cerci each abruptly narrowed to 1/5 width beyond midlength; lobes of vulvar lamina not contiguous apically, inner margins convex... *A. furcifer* p. 217
- Tibiae each with external yellow stripes; male cerci each not abruptly narrowed to 1/5 width beyond midlength; lobes of vulvar lamina contiguous apically, inner margins straight 2
2. Abdomen yellow and brown; occipital crest not elevated medially; posterior hamuli each with apical hook keellike
 *A. pallidus* p. 218
- Abdomen yellow and black; occipital crest elevated medially; posterior hamuli each with apical hook spine-like
 *A. villosipes* p. 219

Arigomphus furcifer (Hagen)

(Figures 6a, 7a, 8)

Hagen 1878. In Selys, Bull. Acad. Belg. 46:458 (in *Gomphus*).

Length 46-54 mm; abdomen 34-39 mm; hind wings 27-32 mm.

Diagnosis.--Face yellowish-green with black markings; vertex without spines or horns; occipital ridge of male slightly convex and of female convex; mesanepisternal middorsal pale stripe narrower than bordering brown bands; femora black apically, tibiae black externally; posterior hamuli each with shoulder visible in lateral view, apical hook spine-like; abdomen black with yellow markings; vulvar lamina ca. 3/8 length

of sternum 9, lateral lobes not contiguous apically, inner margins convex; male cerci each abruptly narrowed distal to lateral spine.

Distribution.--Known from the states of CT, IN, IA, MA, MI, NH, NJ, NY, OH, PA, VT, VA, and WI, and the provinces of Ont. and Que. Known from the Virginia county of Highland. Known distribution among the counties of neighboring states include: Pennsylvania- Crawford and Luzerne.

Virginia Records.--Highland Co.; Buck Run beaver pds., 5 July 1973, 1 male, FLC.

Flight Season.--May 18 (NY) to Aug. 1 (MI); in Virginia July 5.

Biology.--*Arigomphus furcifer* inhabits marsh-bordered ponds, lakes, and occasionally slow-flowing streams. Males frequently alight upon lily pads and algal mats near shore. The female oviposits while hovering just above the water. The abdomen is tapped on the water in about the same place amongst algal mats or lily pads.

Remarks.--The Virginia record for this species represents the southernmost record for *Arigomphus furcifer*. It is often overlooked by collectors and therefore is probably more widespread than previous records suggest.

Arigomphus pallidus (Rambur)

Syn.: *pilipes* Hagen

(Figures 6b, 7b, 8b)

Rambur 1842. Ins. Neur., p. 163 (in *Gomphus*).

Length 54-62 mm; abdomen 38-47 mm; hind wings 30-38 mm.

Diagnosis.--Face yellowish-green with black markings; vertex without spines or horns; occipital ridge of male convex and of female emarginate; mesanepisternal middorsal pale stripe wider than bordering brown bands; femora brown apically, tibiae yellow externally; posterior hamuli each with shoulder not visible in lateral view, apical hood keellike; abdomen brown with yellow markings; vulvar lamina ca. 3/10 length of sternum 9, lateral lobes contiguous apically, inner margins straight; male cerci each gradually tapered to apex distal to lateral lobe.

Distribution.--Known from the states of AL, FL, GA, KY, LA, SC, and TN. Known distribution among the counties of neighboring states include: Kentucky- Fulton, Monroe, Pulaski, and Trigg; Tennessee- Obion.

Flight Season.--Mar. 20 (FL) to July 23 (KY). Known season in neighboring states are: Kentucky- June to July 23; Tennessee- July to Aug.

Biology.--*Arigomphus pallidus* inhabits ponds, lakes, and slow-flowing streams. Males alight in open areas near shore where they are considerably wary.

Remarks.--This is a southern species which doubtfully occurs in Virginia.

Arigomphus villosipes (Selys)

(Figures 6c, 7c, 8c)

Selys 1854. Bull. Acad. Belg. 21:53 (in *Gomphus*).

Length 50-58 mm; abdomen 36-41 mm; hind wings 29-36 mm.

Diagnosis.--Face yellowish-green with black markings; vertex without spines or horns; occipital ridge of male with medial elevation and of

female with medial spinous process; mesanepisternal middorsal pale stripe narrower than bordering brown bands; femora black apically, tibiae yellow externally; posterior hamuli each with shoulder not visible in lateral view, apical hook spinelike; abdomen black with yellow markings; vulvar lamina ca. 1/3 length of sternum 9, lateral lobes contiguous apically, inner margins straight; male cerci each gradually tapered to apex distal to lateral lobe.

Distribution.--Known from the states of CT, IL, IN, KY, MD, MA, MI, MN, NH, NJ, NY, NC, OH, PA, TN, VA, and WV, and the province of Ont. Known from the Virginia counties of Charlotte, Highland, Isle of Wight, James City, Montgomery, and Powhatan. Known distribution among the counties of neighboring states include: Kentucky- Breckinridge, Bullitt, Edmonson, Fayette, Floyd, Green, Hardin, Hart, Metcalfe, and Trigg; Maryland- Garrett; North Carolina- Henderson and Transylvania; Pennsylvania- Allegheny, Beaver, Bucks, Cambria, Centre, Chester, Clearfield, Clinton, Columbia, Crawford, Cumberland, Dauphin, Delaware, Elk, Fayette, Franklin, Greene, Huntingdon, Indiana, Luzerne, McKean, Perry, Potter, Sullivan, Union, Wayne, Warren, Washington, Westmoreland, Wyoming, and York; Tennessee- Coffee, Cumberland, and Overton. West Virginia- Hampshire, Pendleton, Preston, and Randolph.

Virginia Records.--Charlotte Co.; Twittys Cr. at Rt. 642, 23 May 1977, 1 female, FLC. Highland Co.; Buck Run beaver pds., 12 June 1980, 3 nymphal exuviae, FLC; Buck Run beaver pds., 8 Aug. 1978, 1 male, FLC. Isle of Wight Co.; locality unknown, 1 June 1975, 2 males, JFM and J. Hancock, ODU. James City Co.; Jamestown Island, 12 June 1937, 1 male, CC, (Det. CC, MDR notes), W&M. Montgomery Co.; Pandapas Pd., 14

June 1974, 1 male, FLC. Powhatan Co.; locality unknown, 27 June 1975, 1 male, D. Custer, VCU.

Flight Season.--May 7 (MD) to Aug. 28 (WV); in Virginia May 23 to Aug. 8. Known season in neighboring states are: Kentucky- May 20 to June 5; Maryland- May 7 to June 20; North Carolina- June 13 to July 7; Pennsylvania- May 16 to Aug. 7; Tennessee- June 14 to 20; West Virginia- June 12 to Aug. 28.

Biology.--*Arigomphus villosipes* inhabits ponds, lakes, and slow-flowing streams. Males alight in open areas near shore where they are considerably wary.

Remarks.--This species is the most common *Arigomphus* in Virginia.

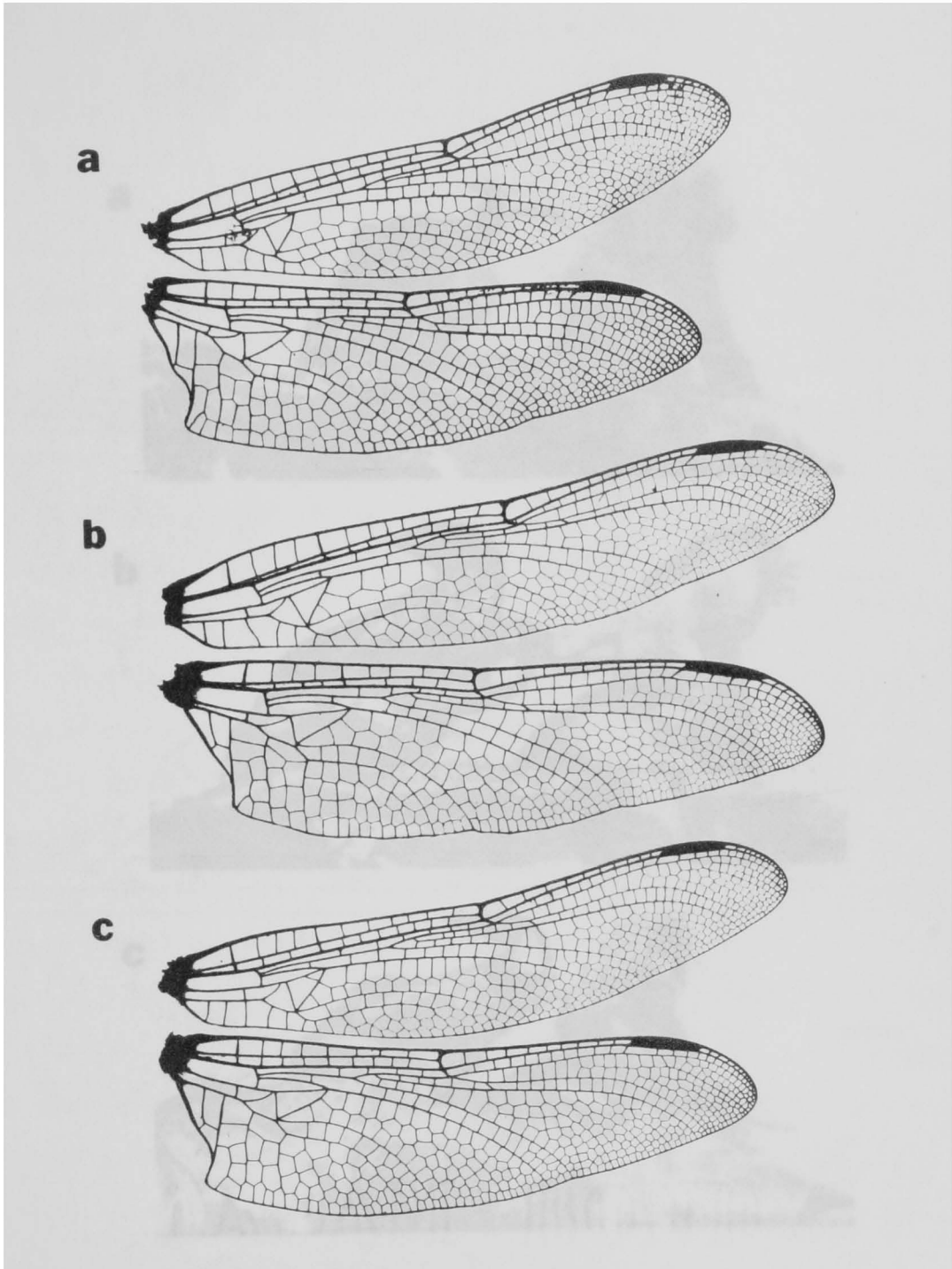


Figure 6. Wings of *Arigomphus* x3: (a) *A. fuscifer*; (b) *A. pallidus*; (c) *A. villosipes*.

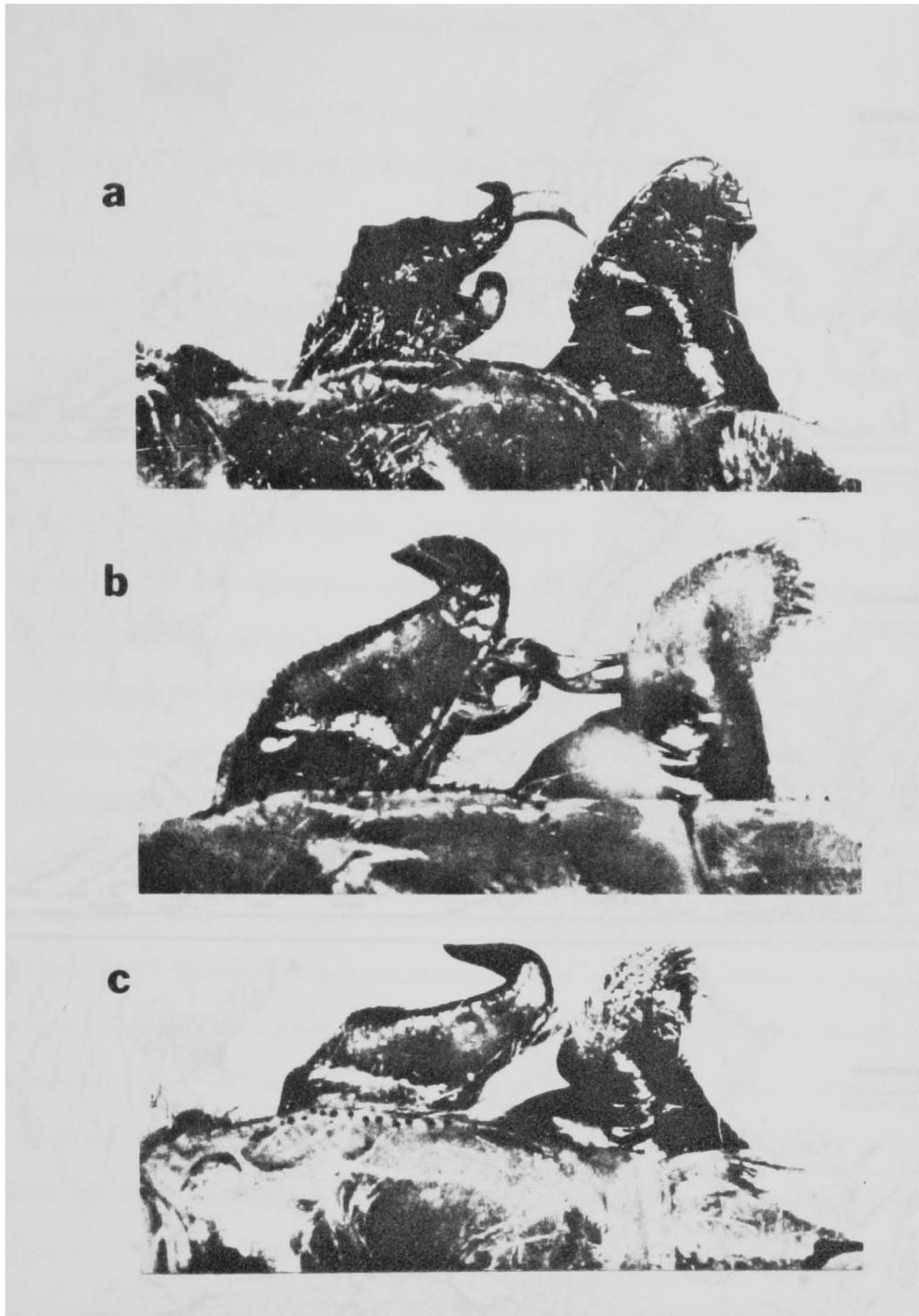


Figure 7. Secondary genitalia in lateral view of *Arigomphus* x23: (a) *A. fuscifer*; (b) *A. pallidus*; (c) *A. villosipes*.

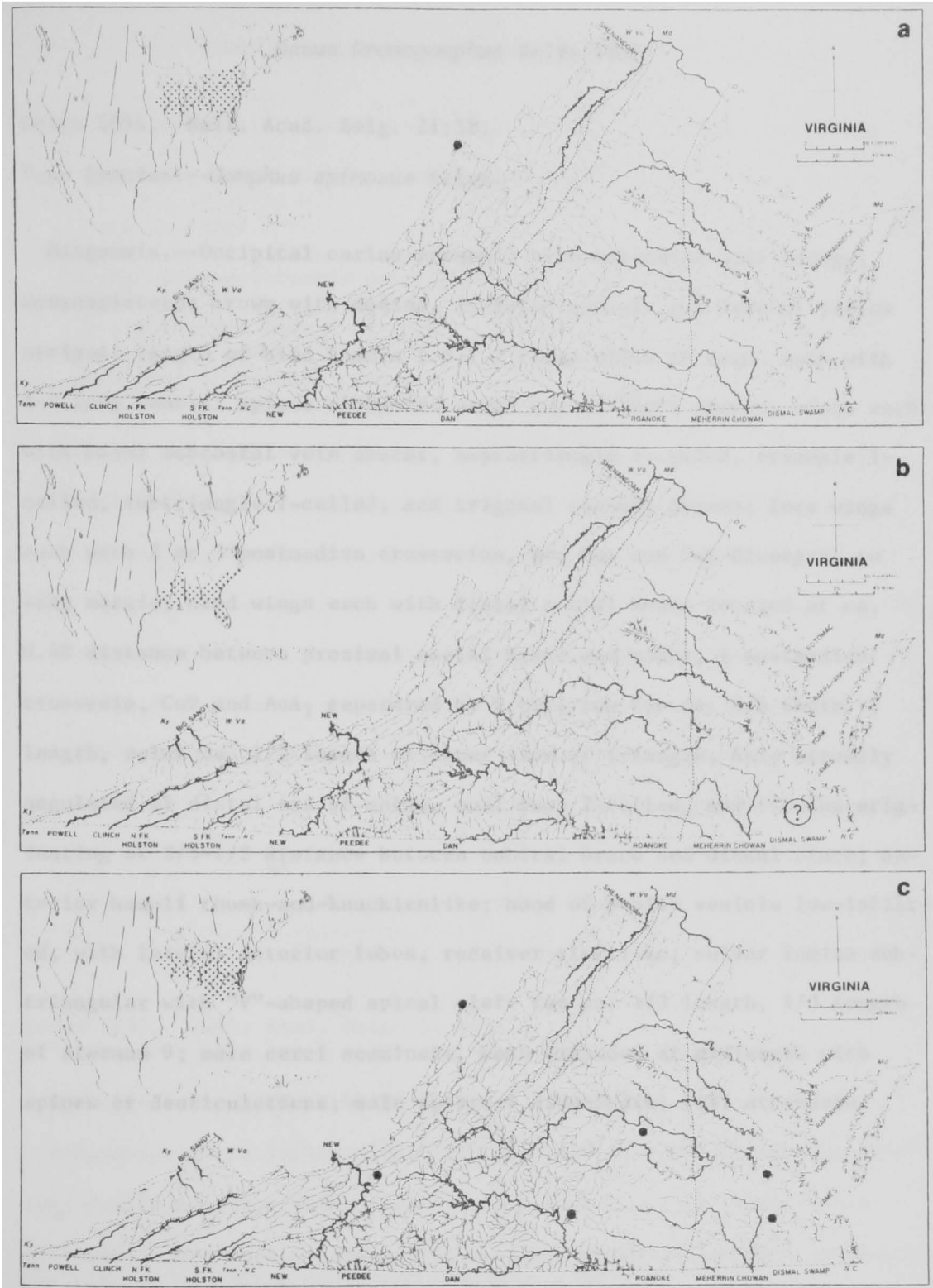


Figure 8. Geographic distribution of *Arigomphus*: (a) *A. furcifer*; (b) *A. pallidus*; (c) *A. villosipes*.

Genus *Dromogomphus* Selys 1854

Selys 1854. Bull. Acad. Belg. 21:58.

Type Species.--*Gomphus spinosus* Selys.

Diagnosis.--Occipital carina present, with occipital hair fringe; mesanepisterna brown with medial, isolated dorsal, and lateral yellow stripes; length of hind femora 1.6-1.7 times width of head, each with 4-7 long ventral spines alongside usual row of short spines; wings each with basal subcostal vein absent, supratriangle 1-celled, triangle 1-celled, subtriangle 1-celled, and trigonal planate absent; fore wings each with 2 or 3 postmedian crossveins, and CuA and CuP divergent to wing margin; hind wings each with distal costal brace located at ca. 0.40 distance between proximal costal brace and nodus, 1 postmedian crossvein, CuP and AnA₁ separated by 1 cell row for ca. 4/5 their length, solum ca. 1/2 length of inner side of triangle, AnA₂ strongly angulated at distal end of solum, anal loop 2-celled, and fibulum originating at 2/5-1/2 distance between cubital brace and discal brace; anterior hamuli thumb-and-knuckleslike; hood of penile vesicle low-inflated, with lateral anterior lobes, receiver cleftlike; vulvar lamina subtriangular with "V"-shaped apical cleft for ca. 1/3 length, 1/3 length of sternum 9; male cerci acuminate, each expanded at midlength with spines or denticulations; male epiproct divaricate, rami attenuate.

Key to Adult *Dromogomphus* of Virginia

1. Lateral mesanepisternal pale stripes vestigial; costa, cerci, and posterior hamuli black; female vertex with spine at each end of ocellar ridge *D. spinosus* p. 227
- Lateral mesanepisternal pale stripes not vestigial; costa, cerci, and posterior hamuli not black; female vertex without spine at each end of ocellar ridge 2
2. Mesanepimeral pale stripes not confluent with metanepisternal pale stripes above metathoracic spiracles; male cerci evenly convex ventrally; female occipital crest slightly emarginate medially *D. armatus* p. 226
- Mesanepimeral pale stripes narrowly confluent with metanepisternal pale stripes above metathoracic spiracles; male cerci obtusangulate ventrally; female occipital crest convexly raised medially *D. spoilatus* p. 231

Dromogomphus armatus Selys

(Figures 9a, 10a, 11a, 12a)

Selys 1854. Bull. Acad. Belg. 21:59.

Length 64-74 mm; abdomen 48-55 mm; hind wings 36-41 mm.

Diagnosis.--Face yellow with wide dark band along frontoclypeal sulcus; female vertex without spine at each end of ocellar ridge; male occipital crest evenly convex, female crest slightly notched; mesanepisternal middorsal pale stripe narrower than bordering brown areas;

lateral mesanepisternal pale stripes well developed; mesanepimeral pale stripes not confluent with metanepisternal pale stripes above metathoracic spiracles; anterior edge of costa yellow; each inner apical edge of anterior hamuli spinose; each posterior hamuli yellow with shoulder well developed; vulvar lamina ca. 1/4 length of sternum 9, cleft for ca. 1/3 its length; cerci brown and yellow, ventrally evenly convex in male.

Distribution.--Known from the states of AL, FL, GA, LA, NC, and SC. Known distribution among the counties of neighboring states include: North Carolina- Bladen, Columbus, Moore, Richmond, Robeson, and Sampson.

Flight Season.--June 7 (GA) to Oct. 16 (NC). Known season in neighboring states are: North Carolina- July 29 to Oct. 16.

Biology.--*Dromogomphus armatus* inhabits pools of slow-flowing rivers.

Remarks.--Although not previously reported from Virginia, this species may occur along rivers of the coastal plain.

Dromogomphus spinosus Selys

(Figures 9b, 10b, 11b, 12b)

Selys 1854. Bull. Acad. Belg. 21:59.

Length 53-68 mm; abdomen 40-50 mm; hind wings 32-40 mm.

Diagnosis.--Face green with dark line along frontoclypeal sulcus; female vertex with spine at each end of ocellar ridge; male occipital crest evenly convex, female crest with medial eminence; mesanepisternal middorsal pale stripe wider than bordering brown areas; lateral mesanepisternal pale stripes vestigial; mesanepimeral pale stripes broadly confluent with metanepisternal pale stripes above metathoracic spiracles;

anterior edge of costa black; each inner apical edge of anterior hamuli spinose; each posterior hamuli black with shoulder well developed; vulvar lamina ca. 3/10 length of sternum 9, cleft for ca. 1/3 its length, cerci black, ventrally evenly convex in male.

Distribution.--Known from the states of AL, AR, CT, FL, GA, IL, IN, KS, KY, LA, ME, MD, MA, MI, MN, MS, MO, NH, NJ, NY, NC, OH, OK, PA, SC, TN, TX, VT, VA, WV, and WI, and the provinces of Ont. and Que. Known from the Virginia counties of Alleghany, Bath, Bedford, Botetourt, Charlotte, Chesterfield, Clarke, Craig, Dickenson, Fauquier, Giles, Hanover, Highland, Louisa, Madison, Montgomery, Nelson, Orange, Prince William, Roanoke, Rockbridge, Southampton, Stafford, Sussex, and Wythe. Known distribution among the counties of neighboring states include: Kentucky-- Allen, Barren, Bell, Breckinridge, Bullitt, Butler, Carter, Cumberland, Fayette, Fulton, Green, Hardin, Harrison, Hart, Henderson, Letcher, Marion, McCreary, Metcalfe, Monroe, Pike, Pulaski, Russell, Taylor, Todd, Trigg, Warren, Washington, and Wayne; Maryland-- Frederick, Montgomery, and Prince Georges; North Carolina-- Moore and Wake; Pennsylvania-- Allegheny, Bucks, Chester, Cumberland, Dauphin, Delaware, Fayette, Forest, Franklin, Fulton, Jefferson, Juniata, Lycoming, Monroe, Montgomery, Northumberland, Perry, Philadelphia, Union, Wayne, and York; Tennessee-- Blount, Campbell, Cheatham, Coffee, Davidson, Giles, Hawkins, Lewis, Monroe, Roane, Sequatchie, Sevier, Sullivan, and Wilson; West Virginia-- Doddridge, Hampshire, Jefferson, Morgan, Pendleton, Raleigh, Randolph, and Summers.

Virginia Records.--Alleghany Co.; Dunlap Cr. at Callaghan, 10 July 1973, 1 male, FLC; Dunlap Cr. at Snake Run, 10 July 1973, 1 male, FLC.

Bath Co.; Cowpasture R. at Rt. 39, 18 July 1973, 2 males, FLC; Cowpasture R. 1 mile N. of Nimrod Hall, 25 July 1973, 1 female, FLC. Bedford Co.; Peaks of Otter Lk., 22 July 1978, 1 male, FLC. Botetourt Co.; James R. at Craig Cr., 27 June 1973, 1 male, SWD. Charlotte Co.; Twittys Cr. at Rt. 642, 14 June 1975, 1 male, FLC; Twittys Cr. at Drakes Br., 18 June 1975, 3 males, FLC; Twittys Cr. at Rt. 642, 12 July 1974, 1 male, FLC; Twittys Cr. at Rt. 642, 12 July 1974, 1 male, FLC, VPI&SU; Twittys Cr. at Rt. 642, 22 July 1978, 1 male, FLC; Twittys Cr. at Rt. 642, 24 July 1973, 3 males, FLC. Chesterfield Co.; Falling Cr., 28 June 1975, 1 female, J. Vannoy, VCU; Turkey Island, 5 July 1938, 1 male, 1 female, V. M. D. and MED, (MDR notes). Clarke Co.; Shenandoah R. S. of Berrys, 7 June 1970, 1 male with exuviae, G. Noonan, USNM. Craig Co.; Barbours Cr. at Rt. 614, 29 May 1977, 1 male, FLC; Johns Cr. at Rt. 311, 14 June 1974, 3 males, FLC; Johns Cr. at Tub Run, 20 July 1975, 1 male, SWB, VPI&SU; Johns Cr. at Rt. 311, 14 Aug. 1973, 1 male, FLC; Potts Cr. 3 miles N. of Paint Bank, 21 Aug. 1978, 1 male, FLC. Dickenson Co.; Cranesnest R. at Camp Br., 12 July 1980, 1 male, FLC. Fairfax Co.; Bull Run, Difficult Run, and Great Falls, "June 15 to Sept. 11", (Donnelly 1961); Great Falls, 17 June 1914, 1 male, 1 female, RPC, USNM; Great Falls, 8 July 1915, 1 female, BPC, USNM; Great Falls, 10 July 1914, 1 male, 1 female (teneral), RPC, USNM; Great Falls, 23 July 1914, 1 male, BPC, USNM; Great Falls, 8 Aug. 1915, 1 female, RPC, USNM; Bull Run, 14 Aug. 1980, 1 male, BCK; Bull Run nr. Centreville, 15 Aug. 1953, 1 male, TWD, (Det. TWD, Donnelly field notes); Bull Run, 16 Aug. 1970, 1 male, OSF, USNM; Difficult Run, 22 Aug. 1901, 1 male, J. E. Benedict, (Det. RPC), USNM; Difficult Run, 0.4 miles downstream from Rt. 193, 19 Sept.

1978, 1 male, FLC. Fauquier Co.; Broad Run at Thoroughfare Gap, 19 Aug.
 1978, 2 males, FLC. Giles Co.; Mtn. Lk., 25 June 1935, CA, (Det. CA,
 Kormondy 1960), MZUM; Mtn. Lk., 29 July 1915, 1 male, P. P. Calvert,
 (Det. MED), ANSP; Sinking Cr. at Rt. 42, 12 Aug. 1973, 1 female, FLC;
 Mtn. Lk., 26 Aug. 1944, 1 male, J. S. Rogers, (Det. LKC), MZUM. Hanover
 Co.; S. Anna R. at Rt. 657, 6 July 1977, 1 male, BCK. Highland Co.;
 Back Cr., 1 Aug. 1973, 1 male, FLC. Louisa Co.; S. Anna R. at Rt. 522,
 5 July 1977, 1 male, BCK; S. Anna R. at Rt. 522, 1 Sept. 1971, 1 male,
 2 females, BCK. Madison Co.; small run flowing into Robinson R., 10
 July 1980, 1 female, Col. E. Smith, (Det. BCK), BCK Collection. Mont-
 gomery Co.; Poverty Cr. Hollow at Rt. 708, 10 July 1977, 1 male, BCK;
 Pandapas Pd., 15 July 1974, 1 female, FLC; Blacksburg, 20 July 1960, 1
 male, RRM, VCU; Pandapas Pd., 14 Aug. 1973, 1 male, FLC; Pandapas Pd.,
 18 Aug. 1978, 1 male, FLC. Nelson Co.; locality unknown, 25 June 1928,
 1 female, WR, (Det. MED, MDR notes), USNM; locality unknown, 11 July
 1928, 1 female, WR, (Det. MED, MDR notes), USNM; locality unknown, 19
 July 1925, 1 male, WR, (Det. MED, MDR notes), USNM; locality unknown,
 1 Aug. 1921, 1 male, WR, (Det. MED, MDR notes), USNM; locality unknown,
 2 Aug. 1925, 1 female, WR, (Det. MED, MDR notes), USNM; locality un-
 known, 11 Aug. 1923, 1 male, WR, (Det. MED, MDR notes), USNM; Wingina,
 14 Aug. 1928, 3 females, WR, (Det. MED, MDR notes), USNM. Orange Co.;
 Mine Run 0.5 mile W. of Rt. 603, 15 July 1980, 1 male, BCK. Prince
 William Co.; Broad Run at Lk. Jackson, "June 15 to Sept. 11", (Donnelly
 1961); N. Branch at Prince Williams Forest Park, 4 July 1973, 1 female,
 OSF, USNM; Broad Run nr. Independent Hill, 15 Aug. 1953, 1 male, 1 fe-
 male, TWD, (Det. TWD, Donnelly field notes); Broad Run at Rt. 55, 19

Aug. 1978, 2 males, FLC. Roanoke Co.; Roanoke R. at Roanoke R. Overlook on Blue Ridge Parkway, 15 July 1973, 1 male, SWB, VPI&SU; locality unknown, 20 Sept. 1976, 1 male, R. Shell, VPI&SU. Rockbridge Co.; Goshen Pass, 23 June 1978, 1 male, FLC. Southampton Co.; Nottoway R. at Rt. 653, 10 Oct. 1978, 2 males, FLC. Stafford Co.; locality unknown, 1 Aug. 1973, 1 male, JFM, ODU. Sussex Co.; Nottoway R. at downstream crossing of Rt. 40, 15 Apr. 1978 (emerged 3 May 1978), 1 female nymph, FLC. Wythe Co.; Wytheville, 26 June 1935, 1 male (teneral), CA, (Det. LKG, Kormondy 1960), MZUM; Reed Cr. at Rt. 121 nr. Max Meadows, 26 June 1973, 1 male, SWD, (Det. SWD); Wytheville, 27 June 1935, 1 female (teneral), CA, (Det. LKG, Kormondy 1960), MZUM; Wytheville, 30 June 1935, 7 males (1 teneral), 4 females, CA, (Det. LKG, Kormondy 1960).

Flight Season.--Apr. 14 (FL) to Nov. 11 (FL); in Virginia May 29 to Oct. 10. Known season in neighboring states are: Kentucky- June to Sept.; Maryland- June 15 to Sept. 11; North Carolina- June 18 to July 5; Pennsylvania- May 24 to Sept. 7; Tennessee- June 5 to Sept. 7; West Virginia- June 2 to Sept. 10.

Biology.--*Dromogomphus spinosus* inhabits mud-bottomed pools of streams, rivers, and lakes. Males commonly alight upon rocks or vegetation near shore.

Remarks.--Although omnipresent the species is seldom abundant.

Dromogomphus spoliatus (Hagen)

(Figures 9c, 10c, 11c, 12c)

Hagen 1857. In Selys, Mon. Gomph., p. 409 (in *Gomphus*).

Length 56-63 mm; abdomen 41-47 mm; hind wings 31-36 mm.

Diagnosis.--Face yellow, not darkened along frontoclypeal sulcus; female vertex without spine at each end of ocellar ridge; male occipital crest evenly convex, female crest convex medially; mesanepisternal mid-dorsal pale stripe narrower than bordering brown areas; lateral mesanepisternal pale stripes well developed; mesanepimeral pale stripes narrowly confluent with metanepisternal pale stripes above metathoracic spiracle; anterior edge of costa yellow; each inner apical edge of anterior hamuli not spinose; each posterior hamuli yellow with shoulder represented by small black spine; vulvar lamina ca. 1/3 length of sternum 9, cleft for ca. 1/2 its length; cerci yellow, ventrally obtusangulate in male.

Distribution.--Known from the states of AL, AR, FL, IL, IN, KS, KY, LA, MO, OH, OK, TN, TX, and WI. Known distribution among the counties of neighboring states include: Kentucky- Butler, Garrard, Henderson, Mercer, Muhlenberg, and Warren; Tennessee- Obion.

Flight Season.--June 3 (KS) to Sept. 20 (IN). Known season in neighboring states are: Kentucky- July 12 to Aug. 29; Tennessee- Aug.

Biology.--*Dromogomphus spoliatus* inhabits streams, rivers, ponds, and lakes.

Remarks.--This species could possibly occur in southwestern Virginia. Harwood (1975) lists records from Cabell and Ritchie counties, West Virginia, but they are probably *D. spinosus*.

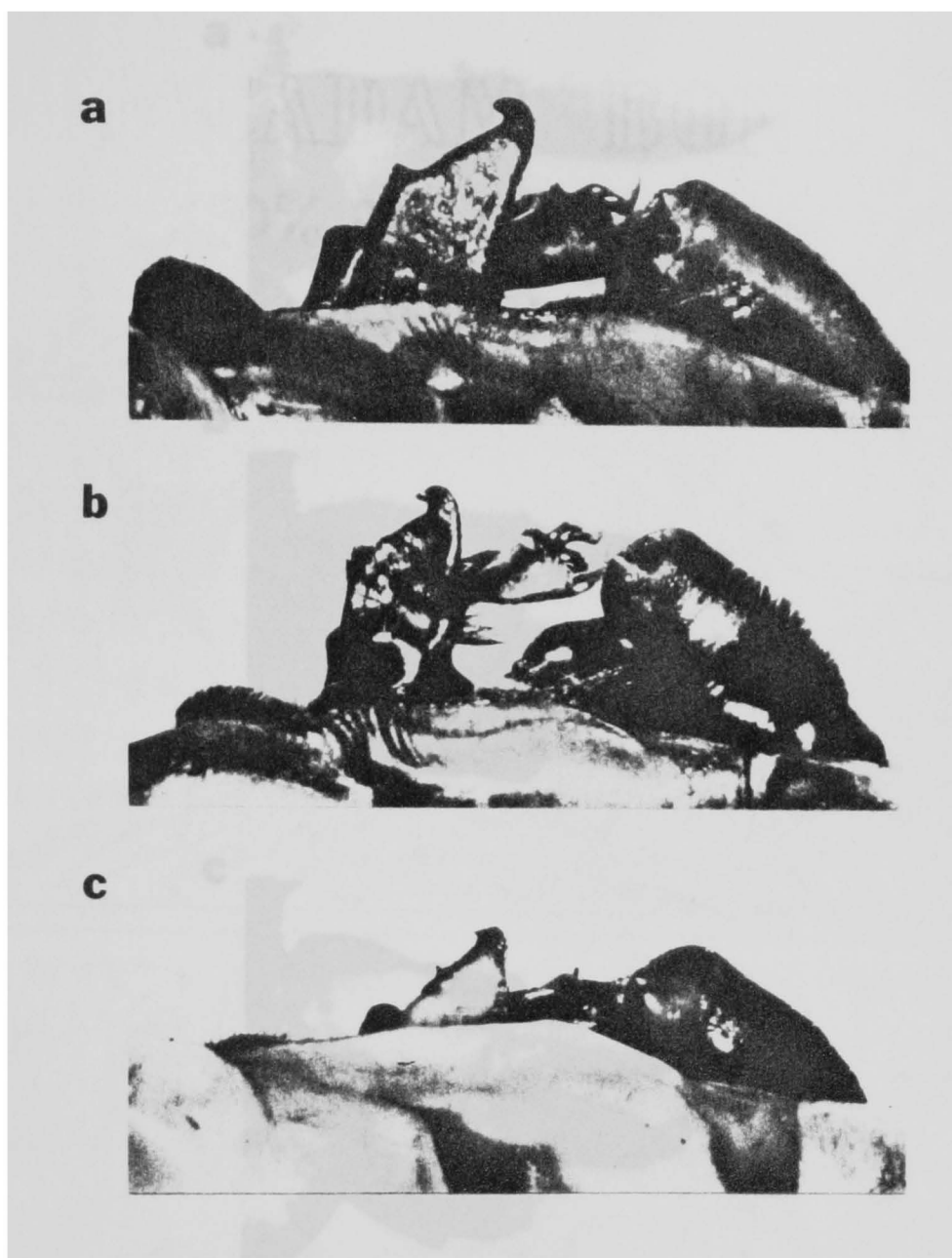


Figure 10. Secondary genitalia in lateral view of *Dromogomphus* x23:
(a) *D. armatus*; (b) *D. spinosus*; (c) *D. spoilatus*.

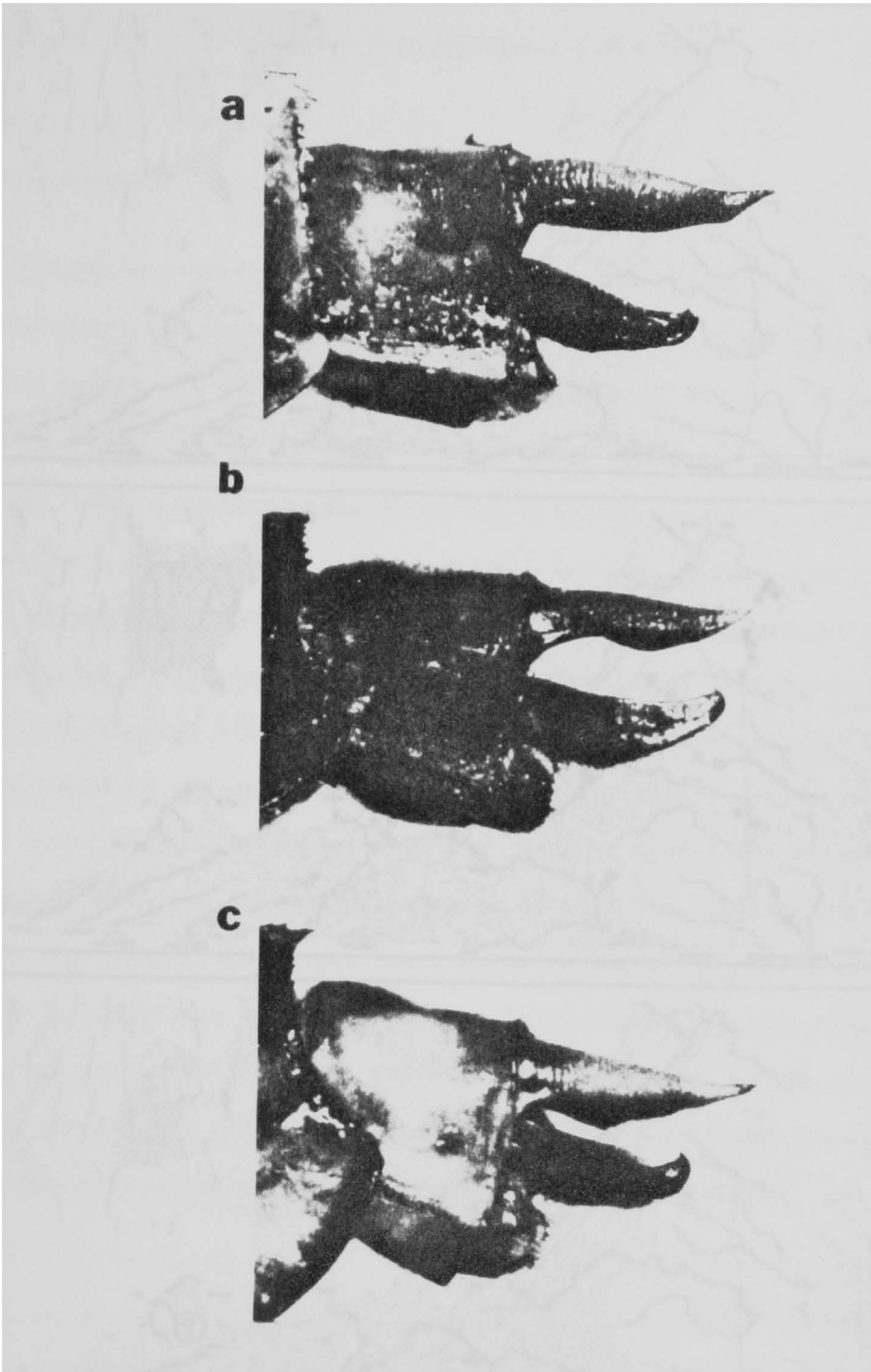


Figure 11. Male terminalia in lateral view of *Dromogomphus*: x23:
(a) *D. armatus*; (b) *D. spinosus*; (c) *D. spoilatus*.

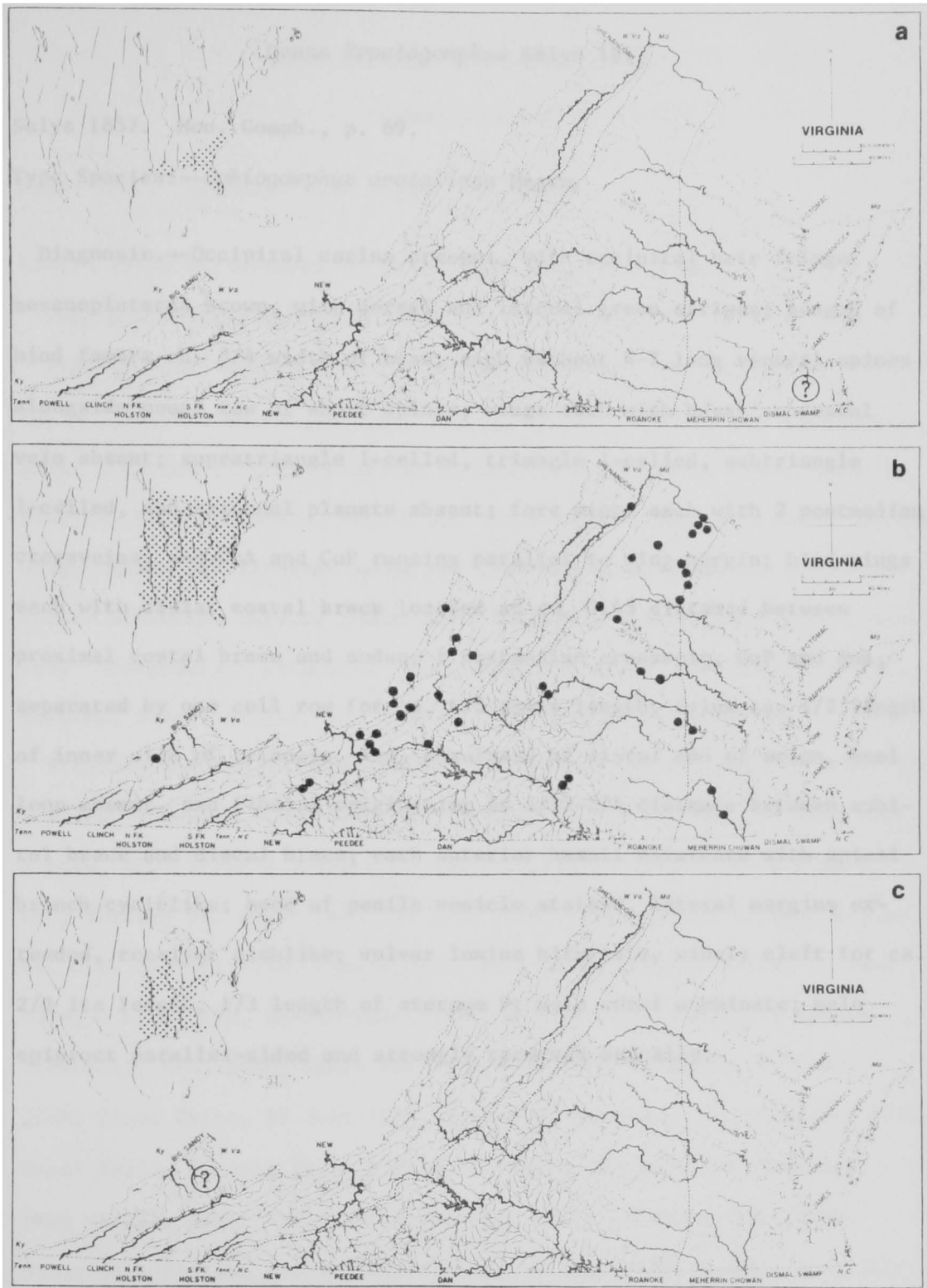


Figure 12. Geographic distribution of *Dromogomphus*: (a) *D. armatus*; (b) *D. spinosus*; (c) *D. spoilatus*.

Genus *Erpetogomphus* Selys 1857

Selys 1857. Mon. Gomph., p. 69.

Type Species.--*Ophiogomphus crocatalinus* Hagen.

Diagnosis.--Occipital carina present, with occipital hair fringe; mesanepisterna brown, with dorsal and lateral green stripes; length of hind femora ca. $3/4$ width of head, each without 4-7 long ventral spines alongside usual row of short spines; wings each with basal subcostal vein absent; supratriangle 1-celled, triangle 1-celled, subtriangle 1-celled, and trigonal planate absent; fore wings each with 2 postmedian crossveins, and CuA and CuP running parallel to wing margin; hind wings each with distal costal brace located at ca. 0.45 distance between proximal costal brace and nodus, 1 postmedian crossvein, CuP and AnA₁ separated by one cell row for ca. $4/5$ their length, solum ca. $1/2$ length of inner side of triangle, AnA₂ angulated at distal end of solum, anal loop absent, and fibulum originating at $3/10$ - $2/5$ distance between cubital brace and discal brace; each anterior hamuli bifurcate with apical branch cyclelike; hood of penile vesicle stalked, lateral margins extended, receiver dishlike; vulvar lamina bifurcate, widely cleft for ca. $2/3$ its length, $1/3$ length of sternum 9; male cerci acuminate; male epiproct parallel-sided and strongly recurved apically.

Erpetogomphus designatus Hagen

(Figures 13, 14)

Hagen 1857. In Selys, Mon. Gomph., p. 401.

Length 49-55 mm; abdomen 34-39 mm; hind wings 30-35 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AL, AR, FL, GA, IN, KS, KY, LA, MD, MO, NV, NM, NC, OH, OK, SC, TN, TX, VA, and WV, and also Mexico. Known from the Virginia counties of Charlotte, Fairfax, Giles, Hanover, Henrico, Louisa, Nelson, Smyth, and Spotsylvania, and the city of Petersburg. Known distribution among the counties of neighboring states include: Kentucky- Butler, Cumberland, Edmonson, Grayson, and Hart. Maryland- Montgomery. Tennessee- Cheatham, Cumberland, Davidson, Hamblen, Hawkins, Henry, Sevier, and Wilson. West Virginia- Jefferson.

Virginia Records.--Charlotte Co.; Twittys Cr. at Rt. 642, 14 June 1975, 3 males, 1 female (teneral), FLC; Twittys Cr. at Rt. 642, 12 July 1974, 1 male, FLC, VPI&SU; Twittys Cr. at Rt. 642, 12 July 1974, 1 female, FLC; Twittys Cr. at Rt. 642, 22 July 1978, 1 male, FLC; Twittys Cr. at Rt. 642, 24 July 1973, 1 male, FLC. Fairfax Co.; Great Falls, 17 June 1914, 1 male, RPC, USNM; Great Falls, 8 July 1915, 1 male, 1 female (teneral), RPC, USNM; Great Falls, 8 July 1915, 1 female, V. Busck, USNM; Great Falls, 12 July 1915, 3 females (teneral), G. Chestnut, USNM; Great Falls, 12 July 1915, 1 male, 1 female (teneral), G. Chestnut, (MDR notes), MZUM; Great Falls, 24 Aug. 1915, 1 female, RPC, USNM. Giles Co.; Sinking Cr. at Newport Park, 4 July 1978, 1 male, BCK, FLC. Hanover Co; N. Anna R. 1 mile W. of Rt. 1, 2 Aug. 1978, 1 female, BCK.

Henrico Co.; Richmond, 18 June 1974, 1 female, E. F. Fox, VCU; Richmond, 19 June 1974, 1 female, B. Crickenberger, VCU; Richmond, 13 July 1973, 1 female, J. Gainer, VCU. Louisa Co.; S. Anna R. at Rt. 657, 21 July 1977, 1 male, BCK; S. Anna R. at Rt. 522, 21 July 1978, 1 male, BCK, C. N. Shiffer Collection; N. Anna R. at Rt. 601, 7 Aug. 1970, 1 male, collector unknown, VCU; N. Anna R. at Rt. 601, 8 Aug. 1976, 1 female, JRV, BCK Collection. Nelson Co.; locality unknown, 30 June 1923, 2 males, WR, USNM; locality unknown, 6 July 1923, 1 female, WR, USNM. Smyth Co.; N. Fork of Holston near Saltville, date unknown, nymph, (Roback and Westfall, 1967). City of Petersburg; Petersburg, 10 July 1976, 1 female, D. James, VCU.

Flight Season.--May 27 (TX) to Oct. 7 (SC); in Virginia June 14 to Aug. 24. Known season in neighboring states are: Kentucky- July to Sept.; Maryland- July 27 to Sept. 10; Tennessee- July 25 to Oct. 6; West Virginia- Sept. 10 to 17.

Biology.--*Erpetogomphus designatus* inhabits streams and rivers. Adult males are often observed hovering at the head of riffle areas.

Remarks.--This species is easily distinguished by the saffron color of the wing bases.

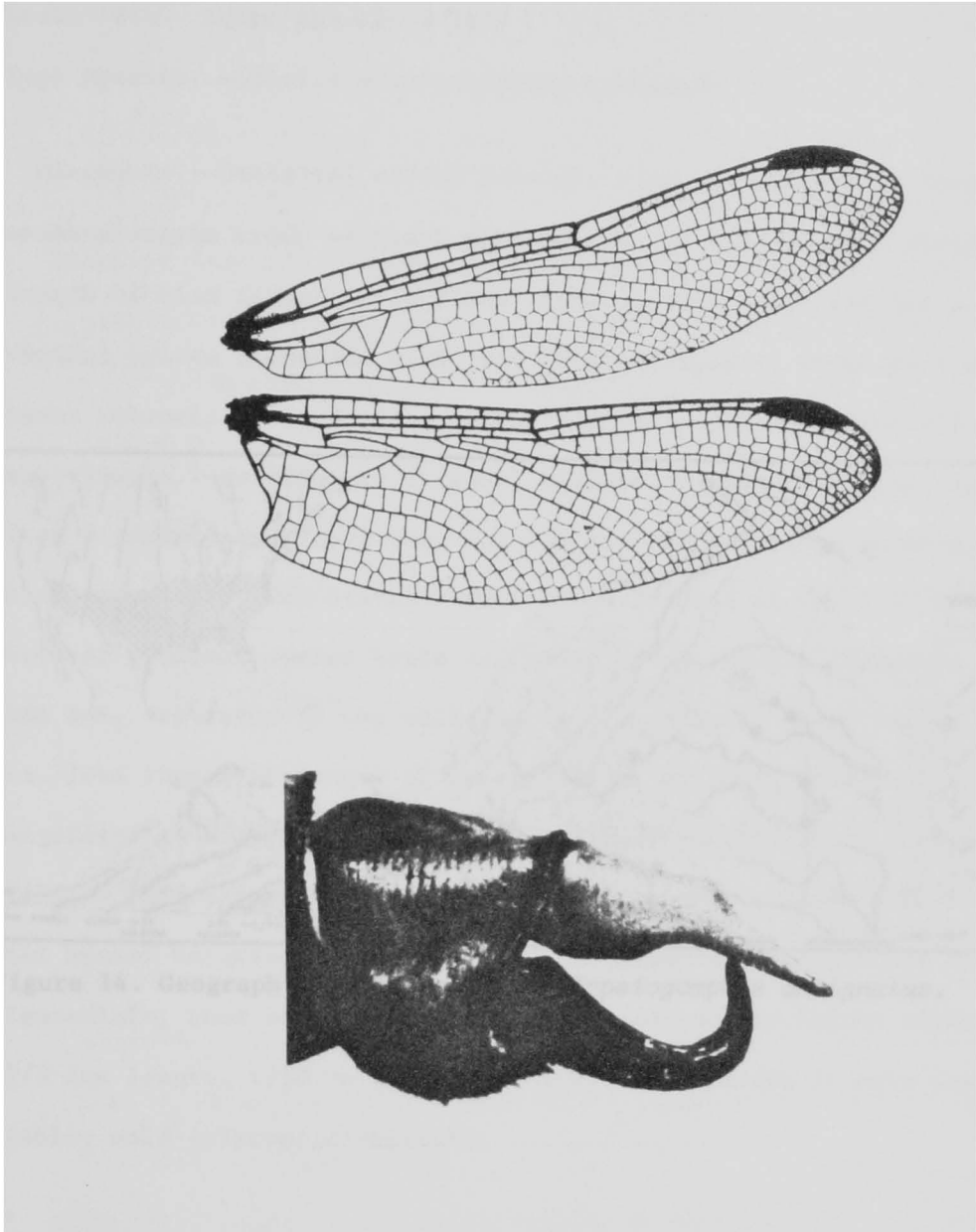


Figure 13. Wings x3 and male terminalia in lateral view x18 of *Erpetogomphus designatus*.

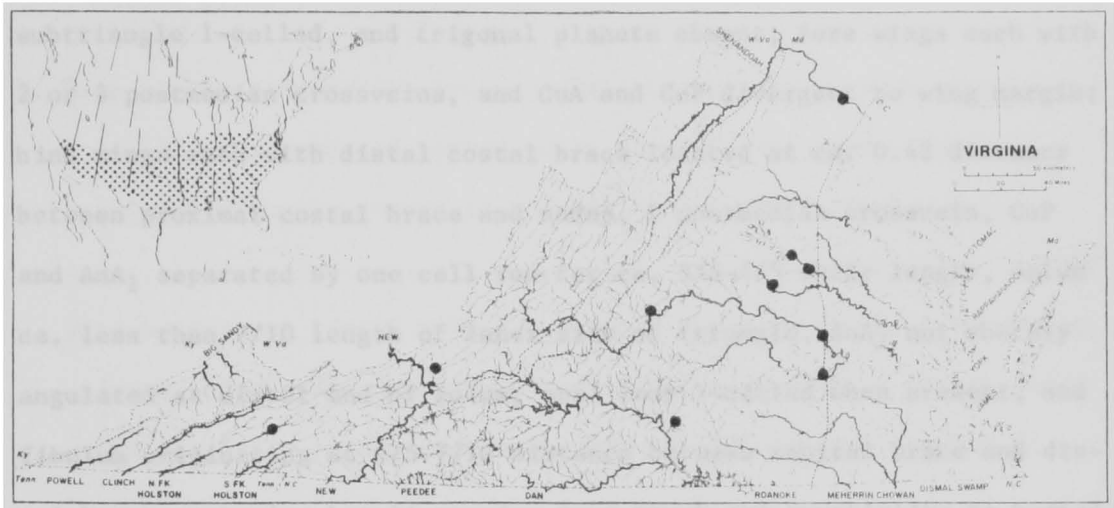


Figure 14. Geographic distribution of *Erpetogomphus designatus*.

Genus *Gomphus* Leach 1815

Leach 1815. Edin. Encycl. 9:137.

Type Species.--*Libellula vulgatissima* Linnaeus.

Diagnosis.--Occipital carina present, with occipital hair fringe; mesanepisterna brown or black with dorsal and lateral pale stripes; length of hind femora 1-1.4 times width of head, each without 4-7 long ventral spines alongside usual row of short spines; wings each with basal subcostal vein absent, supratriangle 1-celled, triangle 1-celled, subtriangle 1-celled, and trigonal planate absent; fore wings each with 2 or 3 postmedian crossveins, and CuA and CuP divergent to wing margin; hind wings each with distal costal brace located at ca. 0.42 distance between proximal costal brace and nodus, 1 postmedian crossvein, CuP and AnA₁ separated by one cell row for ca. 3/5-4/5 their length, solum ca. less than 7/10 length of inner side of triangle, AnA₂ not sharply angulated at distal end of solum, anal loop 1-celled when present, and fibulum originating at 2/5-7/10 distance between cubital brace and discal brace; anterior hamuli varying from thumb-and-knucklelike to hooked-lanceolate; hood of penile vesicle variable; vulvar lamina cleft for ca. 1/3 its length, 1/10 to as long as length of sternum 9; male cerci variable; male epiproct divaricate.

Subgeneric Key to Adult *Gomphus*

1. Width of head $7/10-4/5$ length of hind femora; fore wings each with anterior side of triangle shorter than proximal side; lateral rims of abdominal tergum 8 black along apical half
 *Gomphurus* p. 244
- Width of head $7/8$ to equal length of hind femora; fore wings each with anterior side of triangle longer than proximal side; lateral rims of abdominal tergum 8 yellow along apical half (except in mature males of *G. brevis* and *G. viridifrons*) 2
2. Wing apices tinged with brown; male anterior hamuli each with inner apical edge produced beyond outer edge; female vulvar lamina laterally evenly convex to apex at midlength of sternum 9
 *Stenogomphurus* p. 329
- Wing apices not tinged with brown; male anterior hamuli each without inner apical edge produced beyond outer edge; female vulvar lamina not laterally evenly convex to apex at midlength of sternum 9... 3
3. Middorsal length of abdominal segment 8 less than $3/4$ that of segment 7; male with outer apical edge of each anterior hamuli denticulate; female with midventral length of sternum 10 less than $1/2$ its basal width *Gomphus* p. 268
- Middorsal length of abdominal segment 8 more than $3/4$ that of segment 7; male with outer apical edge of each anterior hamuli spinose or hooklike; female with midventral length of sternum 10 more than $1/2$ its basal width *Phanogomphus* p. 289

Subgenus *Gomphurus* Needham 1901

Needham 1901. N.Y. State Mus. Bull. 47:446.

Type Species.--*Gomphus dilatatus* Rambur.

Diagnosis.--Width of head 0.70-0.83 length of hind femora; wing apices hyaline, occasionally tinged with brown in *Gomphus lineatifrons*; hind wings each with 4 (occasionally 5) cells along posterior margin of AnA proximal to AnA₂; anterior hamuli each thumb-and-fingerslike with inner lobe (thumb) not produced posteriorly beyond outer edge and outer edge apically spinose (fingers); apical segment of penis long bifid, short in *G. septima* and *G. dilatatus*; hood of penile vesicle pyramidlike, posterior border straight or concave, receiver wide troughlike; vulvar lamina narrowed basally to 1/3-1/4 width of sternum 9, often with basal constriction, 1/3-3/4 length of sternum 9; middorsal length of abdominal segment 9 0.72-0.82 that of abdominal segment 8; lateral rims of abdominal tergum 8 black in apical half, convexly expanded in all but *G. septima*; male cerci up-arched each with ventral lobes or small spine in apical half (not up-arched or spined in *G. externus*).

Biology.--Nymphs of this subgenera inhabit mud-bottomed pools of large rivers.

Remarks.--This is a comparatively homogeneous subgenus of robust, vividly colored species.

Species Key to Adult *Gomphus*(*Gomphurus*) of Virginia

1. Face with dark band along frontoclypeal sulcus 2
 - Face without dark band along frontoclypeal sulcus 4

2. Frontoclypeal band ca. as wide as median ocellus, inner margins of dorsal mesanepisternal stripes parallel; anterior hamuli each with inner lobe before apex; apices of vulvar lamina blunt
 - *G. lineatifrons* p. 253
 - Frontoclypeal band wider than median ocellus, inner margins of dorsal mesanepisternal pale stripes not parallel; anterior hamuli each with inner lobe apical; apices of vulvar lamina acute 3

3. Lateral rims of abdominal segment 9 yellow; length of penile hood 3/4 height, apical penile segment longer than hood; vulvar lamina more than 1/2 length of sternum 9 *G. vastus* p. 256
 - Lateral rims of abdominal segment 9 black along apical half; length of penile hood ca. equal to height, apical penile segment shorter than hood; vulvar lamina less than 1/2 length of sternum 9
 - *G. dilatatus* p. 248

4. Metanepisternal pale stripes diffuse, not confluent with pale mesanepimeral pale stripes above metathoracic spiracles 5
 - Metanepisternal pale stripes present, confluent with pale mesanepimeral pale stripes above metathoracic spiracles 6

5. Abdominal segment 9 with wide middorsal yellow stripe; male cerci level dorsally; female vulvar lamina more than 1/2 length of sternum 9 *G. externus* p. 249
- Abdominal segment 9 without wide middorsal yellow stripe; male cerci arched dorsally; female vulvar lamina less than 1/2 length of sternum 9 *G. hybridus* p. 252
6. Dorsum of abdominal segment 8 with triangular yellow spot on basal third, metapleural sulci margined with brown; each posterior hamuli with shoulder visible in lateral view; penile vesicle higher than long, receiver troughlike; vulvar lamina more than 1/2 length of sternum 9 7
- Dorsum of abdominal segment 8 without yellow spot on basal third, metapleural sulci not margined with brown; each posterior hamuli with shoulder not visible in lateral view; penile vesicle longer than high, receiver cuplike; vulvar lamina less than 1/2 length of sternum 9 8
7. Dorsum of abdominal segment 9 with yellow spot; male cerci each with lateral margin angulate; female vertex without erect horns behind ends of ocellar ridge, female occiput without medial conical eminence *G. eraneus* p. 247
- Dorsum of abdominal segment 9 without yellow spot; male cerci each without lateral margin angulate; female vertex with erect horns behind ends of ocellar ridge, female occiput with medial conical eminence *G. fraternus* p. 250

8. Lateral rims of abdominal tergum 8 as wide as rims of tergum 9; apical segment of penis shorter than penile hood; female vulvar lamina ca. 1/2 length of sternum 9 with apical lobes divergent and more than twice as long as wide *G. septima* p. 255

Lateral rims of abdominal tergum 8 twice as wide as rims of tergum 9; apical segment of penis longer than penile hood; female vulvar lamina ca. 1/3 length of sternum 9 with apical lobes not divergent and less than twice as long as wide . . . *G. ventricosus* p. 259

Gomphus crassus Hagen

Syn.: *walshii* Kellicott

(Figures 15a, 18a, 19a)

Hagen 1878. In Selys, Bull. Acad. Belg. 46:453.

Length 54-59 mm; abdomen 41-43 mm; hind wings 31-36 mm.

Diagnosis.--Face yellowish-green without dark band along frontoclypeal sulcus; female vertex with decurved lateral spines and without erect spines near end of ocellar ridge; crest of female occiput concave; inner margins of dorsal mesanepisternal pale stripes parallel to slightly divergent; metanepisternal pale stripes present, confluent with mesanepimeral pale stripes above metathoracic spiracles; anterior hamuli each with inner lobe subapical; posterior hamuli each with shoulder slightly visible in lateral view; apical penile segment slightly longer than penile hood, filaments ca. as long as base; penile hood higher than long with level-concave posterior margin, receiver troughlike; dorsum of abdominal segments 7-9 with midbasal yellow spots; vulvar lamina ca. 2/3

length of sternum 9, constricted basally; lateral lobes ca. 3 times as long as wide, acute-divaricate apically; male cerci uparched and each with lateral angulation.

Distribution.--Known from the states of IN, IO, KY, MN, OH, TN, and VA(?). Known from the Virginia county of Wise(?). Known distribution among the counties of neighboring states include: Kentucky- Green and Marion; Tennessee- Davidson.

Virginia Records.--Wise Co.; N. Fork Reservoir at Phillips Cr. Recreation Area, 12 July 1980, 1 male (observed), FLC.

Flight Season.--May 11 (IN) to July 31 (IN); in Virginia July 12(?). Known season in neighboring states are: Kentucky- May 16 to July 10; Tennessee- May 23.

Biology.--Nymphs of *Gomphus crassus* inhabit mud-bottomed pools of rivers.

Remarks.--Although previously unreported from Virginia a medium-sized *Gomphurus* observed flying with *G. fraternus* in western Virginia may be this species.

Gomphus dilatatus Rambur

(Figures 15b, 18b, 19b)

Rambur 1842. Ins. Neur., p. 155.

Length 67-73 mm; abdomen 46-53 mm; hind wings 34-43 mm.

Diagnosis.--Face green with wide dark band along frontoclypeal sulcus; female vertex with vestigial lateral spines and without erect spines near end of ocellar ridge; crest of female occiput level; inner margins

of dorsal mesanepisternal pale stripes divergent; metanepisternal pale stripes present, either slightly confluent or not confluent with mesanepimeral pale stripes above metathoracic spiracles; anterior hamuli each with inner lobe apical; posterior hamuli each with shoulder slightly visible in lateral view; apical penile segment shorter than penile hood, filaments shorter than base; penile hood ca. as high as long, receiver wide troughlike; dorsum of abdominal segment 7 with midbasal yellow spot, 8 and 9 black dorsally; vulvar lamina ca. $\frac{2}{5}$ length of sternum 9, constricted basally; lateral lobes ca. 2.5 times as long as wide, acute-parallel apically; male cerci up-arched and each with lateral angulation.

Distribution.--Known from the states of AL, FL, GA, NC, and SC. Known distribution among the counties of neighboring states include: North Carolina- Chatham; Tennessee- Fentress(?).

Flight Season.--Mar. 6 (FL) to Aug. 19 (FL). Known season in neighboring states are: North Carolina- May 19; Tennessee- June 28(?).

Biology.--Nymphs inhabits mud-bottomed pools of coastal plain rivers.

Remarks.--*Gomphus dilatatus* is easily distinguished by its large size and dark apical abdominal segments. This coastal plain species doubtfully occurs in Virginia.

Gomphus externus Hagen

Syn.: *consobrinus* Walsh, *fraternus* Walsh

(Figures 15c, 18c, 19c)

Hagen 1857. In Selys, Mon. Gomph., p. 411.

Length 52-59 mm; abdomen 36-42 mm; hind wings 29-33 mm.

Diagnosis.--Face yellowish-green without dark band along frontoclypeal sulcus; female vertex with laterally directed horns at ends of ocellar ridge; crest of female occiput convex; inner margins of dorsal mesanepisternal pale stripes slightly divergent; metanepisternal pale stripes diffuse, not confluent with mesanepimeral pale stripes above metathoracic spiracles; anterior hamuli each with inner lobe apical; posterior hamuli each with shoulder visible in lateral view; apical penile segment longer than penile hood, filaments longer than base; penile hood higher than long, receiver wide troughlike; dorsum of abdominal segments 7-9 with large yellow spots; vulvar lamina ca. $\frac{2}{3}$ length of sternum 9, not constricted basally; lateral lobes wider than long, blunt-parallel apically; male cerci not up-arched and each without lateral angulation.

Distribution.--Known from the states of IL, IN, IO, KS, KY, LA, MI, MN, MO, NE, NM, ND, OH, TX, UT, WI, and WY, and the province of Man. Known distribution among the counties of neighboring states include: Kentucky-- Bullitt, Green, and Trigg.

Flight Season.--May 1 (TX) to Aug. 10 (MO). Known season in neighboring states are: Kentucky-- June to July.

Biology.--Nymphs inhabit mud-bottomed pools of rivers.

Remarks.--This midwestern species doubtfully occurs in Virginia.

Gomphus fraternus (Say)

(Figures 16a, 18d, 20a)

Say 1839. J. Acad. Phila. 8:16 (in *Aeschna*).

Length 48-55 mm; abdomen 34-40 mm; hind wings 28-33 mm.

Diagnosis.--Face yellowish-green without dark band along frontoclypeal sulcus; female vertex with lateral spines vestigial, with erect spines near end of ocellar ridge; crest of female occiput with median conical eminence; inner margins of dorsal mesanepisternal pale stripes parallel; metanepisternal pale stripes present, confluent with mesanepimeral pale stripes above metathoracic spiracles; inner lobe of anterior hamuli subapical; shoulder of posterior hamuli visible in lateral view; apical penile segment longer than penile hood, filaments longer than base; penile hood higher than long, receiver wide troughlike; dorsum of abdominal segments 7-9 with midbasal yellow spots; vulvar lamina ca. 1/2 length of sternum 9, slightly constricted basally; lateral lobes ca. 2 times as long as wide, acute-divaricate apically; male cerci up-arched without lateral angulation.

Distribution.--Known from the states of IL, IN, IA, KY, MD, MA, MI, MN, MO, NH, NY, OH, PA, TX(?), VA, WV, and WI, and the provinces of Man., Ont., and Que. Known from the Virginia counties of Fairfax and Wise. Known distribution among the counties of neighboring states include: Kentucky- Adair, Allen, Barren, Bell, Bullitt, Butler, Cumberland, Edmonson, Fayette, Green, Harrison, Letcher, Marion, Metcalfe, Pike, Rockcastle, Taylor, Trigg, Union, Warren, and Washington. Maryland- Montgomery. Pennsylvania- Allegheny, Fayette, Huntingdon, and Westmoreland. West Virginia- Jackson.

Virginia Records.--Fairfax Co.; Potomac R. at Rt. 495, 29 May 1978, 1 male, FLC. Wise Co.; North Fork Reservoir at Phillips Cr. Recreation Area, 12 July 1980, 2 males, FLC.

Flight Season.--Apr. 19 (FL) to Aug. 10 (OH); in Virginia May 29 to

July 12. Known season in neighboring states are: Kentucky- May 27 to June 22; Maryland- May 26.

Biology.--Nymphs inhabit mud-bottomed lakes and rivers.

Remarks.--*Gomphus fraternus* is probably more common in Virginia than apparent from previous collection records. The southwestern locality is somewhat unique in the region because the small bay encompasses a spring-fed stream and an artificial beach.

Gomphus hybridus Williamson

(Figures 16b, 18e, 20b)

Williamson 1902. Entomol. News 13:47.

Length 50-52 mm; abdomen 35-37 mm; hind wings 27-29 mm.

Diagnosis.--Face yellowish-green without dark band along frontoclypeal sulcus; female vertex with lateral spines vestigial and with erect spines near end of ocellar ridge; crest of female occiput convex; inner margins of dorsal mesanepisternal pale stripes slightly divergent; metanepisternal pale stripes diffuse, not confluent with mesanepimeral pale stripes above metathoracic spiracles; anterior hamuli each with inner lobe apical; posterior hamuli each with shoulder visible in lateral view; apical penile segment longer than penile hood, filaments slightly longer than base; penile hood ca. as high as long, receiver wide troughlike; dorsum of abdominal segments 7-9 with midbasal yellow spots; vulvar lamina ca. 1/2 length of sternum 9, not constricted basally; lateral lobes ca. twice as long as wide, acute divaricate apically; male cerci up-arched and each without lateral angulation.

Distribution.--Known from the states of AL, FL, IN(?), KY, and TN. Known distribution among the counties of neighboring states include: Kentucky- Cumberland; Tennessee- Davidson.

Flight Season.--Mar. 24 (FL) to June 7 (TN). Known season in neighboring states are: Kentucky- May 19; Tennessee- May 12 to June 7.

Biology.--Nymphs inhabit mud-bottomed pools of rivers.

Remarks.--The male of this species is similar to *G. fraternus* and the female to *G. externus*. Although previously unreported from Virginia a medium-sized *Gomphurus* observed flying with *G. fraternus* in southwestern Virginia may be this species.

Gomphus lineatifrons Calvert

(Figures 16c, 18f, 20c)

Calvert 1921. Trans. Amer. Entomol. Soc. 47:222.

Length 62-70 mm; abdomen 46-52 mm; hind wings 37-45 mm.

Diagnosis.--Face yellowish-green with narrow dark band along fronto-clypeal sulcus; female vertex with lateral spines vestigial and without erect spines near end of ocellar ridge; crest of female occiput slightly concave; inner margins of dorsal mesanepisternal pale stripes slightly divergent; metanepisternal pale stripes present, confluent with mesanepimeral pale stripes above metathoracic spiracles; anterior hamuli each with inner lobe before apex; posterior hamuli each with shoulder visible in lateral view; apical penile segment longer than penile hood, filaments ca. as long as base; penile hood higher than long, receiver narrow, cuplike; dorsum of abdominal segment 7 with midbasal yellow spot,

8 and 9 black dorsally; vulvar lamina ca. 1/2 length of sternum 9, constricted basally; lateral lobes shorter than wide, blunt-parallel apically; male cerci up-arched and each without lateral angulation.

Distribution.--Known from the states of AL, IL, IN, KY, MI, MN, NY, NC, OH, PA, TN, VA, and WV. Known from the Virginia counties of Bland, Botetourt, Carroll, Craig, Floyd, Giles, Grayson, Highland, Lee, Rockbridge, and Wythe. Known distribution among the counties of neighboring states include: Kentucky-- Adair, Allen, Barren, Butler, Casey, Edmonson, Green, Marion, Taylor, Warren, Washington, and Whitley. Pennsylvania-- Perry. Tennessee-- Campbell. West Virginia-- Hampshire, Monroe, Randolph, and Pocahontas.

Virginia Records.--Bland Co.; Wolf Cr. at picnic area along Rt. 61, 10 June 1978, 1 male, FLC. Botetourt Co.; Craig Cr. at Rt. 706 ford at Oriskany, 29 May 1977, 3 males, FLC; Craig Cr. at Rt. 706 ford at Oriskany, 17 June 1978, 1 male, 1 female, FLC; Craig Cr. at Patterson Cr., 18 June 1978, 1 male, FLC. Carroll Co.; New R. at Rt. 721, 19 June 1977, 1 female, FLC. Craig Co.; Johns Cr. at Rt. 311, 28 May 1977, 1 male, FLC. Floyd Co.; Little R. at Rt. 615, 21 May 1977, 1 male, BCK. FLC Collection; Little R. at Rt. 615, 27 May 1977, 29 males, 6 females (1 teneral), FLC; Little R. at Rt. 615, 3 June 1977, 11 males, 3 females, FLC; Little R. at Rt. 686, 8 June 1978, 3 males, BCK; Little River at Rt. 686, 10 June 1978, 4 males, 1 female, FLC; Little R. at Rt. 682, 10 June 1980, 4 males, 1 female, FLC. Giles Co.; Greenbrier Br. at Newport, 28 May 1977, 1 male, FLC; Sinking Cr. at Rt. 42, 28 May 1977, 2 males, FLC. Grayson Co.; New R. at Rt. 810, 23 May 1978, 1 nymphal exuviae, FLC; New River at Rt. 810, 19 June 1977, 1 male, 1 female, FLC;

New River at Fox Cr., 19 June 1977, 1 female, FLC; New River at Rt. 810, 19 June 1977, 1 male, BCK. Highland Co.; Bullpasture R. at head of gorge, 30 May 1977, 2 males, FLC; Bullpasture R. at head of gorge, 8 June 1974, 1 male, FLC. Lee Co.; Pennington Gap, 22 June 1920, P. P. Calvert, MCZ. Rockbridge Co.; Lk. Merriweather spillway, 23 June 1978, 1 male, FLC; Goshen Pass, 23 June 1978, 2 males, FLC. Wythe Co.; Wytheville, 20 June 1935, 1 male, CA, (Det. LKG), MZUM; Wytheville, 26 June 1935, 1 male, 1 female, CA, (Det. LKG), MZUM; Wytheville, 27 June 1935, 4 males, 2 females, CA, (Det. LKG); Wytheville, 27 June 1935, 1 male, 1 female, CA, (Det. LKG), MZUM.

Flight Season.--May 10 (AL) to July 20 (WV); in Virginia May 21 to June 27. Known season in neighboring states are: Kentucky- May 17 to July; Tennessee- June 28; West Virginia- June 12 to July 20.

Biology.--Inhabits mud-bottomed pools of rivers and streams. Frequently alights upon streamside rocks and vegetation.

Remarks.--The most common large *Gomphurus* in Virginia. Very bold and easy to capture, occasionally very abundant. A male of this species has been captured while eating a male *Ophiogomphus asperus*.

Gomphus septima Westfall

(Figures 17a, 18g, 21a)

Westfall 1956. J. Fla. Acad. Sci. 19:251.

Length 53-62 mm; abdomen 39-46 mm; hind wings 32-36 mm.

Diagnosis.--Face yellowish-green without dark band along frontoclypeal sulcus; female vertex with depressed lateral spines and without erect

spines near end of ocellar ridge; crest of female occiput notched medially; inner margins of dorsal mesanepisternal pale stripes slightly divergent; metanepisternal pale stripes present, confluent with mesanepimeral pale stripes above metathoracic spiracles; anterior hamuli each with inner lobe subapical; posterior hamuli each with shoulder slightly visible in lateral view; apical penile segment slightly shorter than penile hood, filaments shorter than base; penile hood shorter than long, receiver cuplike; dorsum of abdominal segment 7 with medial yellow stripe, 8 occasionally with small basal yellow spot, and 9 dark dorsally; vulvar lamina ca. 1/2 length of sternum 9, not constricted basally; lateral lobes ca. 3 times as long as wide, acute-divaricate apically; male cerci up-arched and each with slight lateral angulation.

Distribution.--Known from the states of AL, NC, and TN. Known distribution among the counties of neighboring states include: North Carolina- Chatham; Tennessee- Cumberland.

Flight Season.--May 5 (NC) to June 2 (AL). Known season in neighboring states are: North Carolina- May 5 to 26.

Biology.--Nymphs inhabit mud-bottomed pools of medium-sized rivers.

Remarks.--Although not previously collected in Virginia this species probably occurs in medium-sized rivers of the lower piedmont.

Gomphus vastus Walsh

(Figures 17b, 18g, 21b)

Walsh 1862. Proc. Acad. Phila., p. 391.

Length 47-57 mm; abdomen 33-41 mm; hind wings 28-34 mm.

Diagnosis.--Face yellowish-green with dark band along frontoclypeal sulcus; female vertex with small erect lateral spines and without erect spines near end of ocellar ridge; crest of female occiput concave; inner margins of dorsal mesanepisternal pale stripes divergent; metanepisternal pale stripes present, either slightly confluent or not confluent with mesanepimeral pale stripes above metathoracic spiracles; anterior hamuli each with inner lobe apical; posterior hamuli each with shoulder visible in lateral view; apical penile segment longer than penile hood, filaments slightly longer than base; penile hood higher than long, receiver wide-cleftlike; dorsum of abdominal segment 7 with middorsal yellow stripe, 8 and 9 black dorsally; vulvar lamina ca. $\frac{3}{5}$ length of sternum 9, constricted basally; lateral lobes ca. 2.5 times as long as wide, acute-parallel apically; male cerci up-arched and each with lateral angulation.

Distribution.--Known from the states of AL, AR, DC, GA, IL, IN, IA, KS, KY, MD, MA, MI, MN, MS, MO, NH, NY, NC, OH, OK, PA, SC, TN, TX, VA, WV, and WI, and the provinces of Ont. and Que. Known from the Virginia counties of Botetourt, Buckingham, Carroll, Culpeper, Fairfax, Giles, Grayson, Montgomery, Nelson, and Warren. Known distribution among the counties of neighboring states include: Kentucky- Bullitt, Cumberland, Edmonson, Green, Russell, Trigg, and Whitley. Maryland- Montgomery. North Carolina- Buncombe and Harnett. Pennsylvania- Allegheny, Beaver, Cumberland, Dauphin, Delaware, Forest, Jefferson, Juniata, Perry, Susquehanna, and Venango. Tennessee- Davidson and Hardin, West Virginia- Hampshire and Jefferson.

Virginia Records.--Botetourt Co.; Craig Cr. at Patterson Cr., 29 May 1977, 3 males, FLC; Craig Cr. at Patterson Cr., 4 June 1977, 6 males,

FLC; Craig Cr. at Patterson Cr., 18 June 1978, 1 male, FLC. Buckingham Co.; locality unknown, 21 June 1919, 1 female, W. T. Davis, (Det. W. T. Davis, MDR notes). Carroll Co.; New R. at Rt. 606 and Rt. 721, 11 June 1980, 1 male, BCK. Culpeper Co.; Rapidan R. 1.5 miles S. of Rt. 681, 15 July 1980, 4 males, 3 females (2 pair in tandem), BCK. Fairfax Co.; Great Falls, 14 May 1915, 1 male, RPC, USNM; Great Falls, 2 June 1914, 1 female, RPC, USNM. Giles Co.; New R. at Spruce Run, 19 May 1977, 1 male, 1 female (teneral), 8 nymphal exuviae, Hammond. Grayson Co.; New R. at Rt. 810, 23 May 1978 (emerged 29 May 1978), 1 nymph, FLC; New R. at Rt. 810, 23 May 1978, 15 males, 7 females (teneral), 36 nymphal exuviae, FLC. Montgomery Co.; New R. at Rt. 625, 16 May 1977, 1 male, 2 females (in emergence), C. Sheppard, VPI&SU; Blacksburg, 21 May 1955, 1 male, W. M. Thornton, VPI&SU; New R. nr. McCoy, 21 May 1962, 1 male, Johnson, FSCA; Blacksburg, 24 May 1955, 1 male, collector unknown, VPI&SU; New R. at McCoy Falls, 29 May 1979, 2 males, M. R. Meador, VPI&SU; Blacksburg, 20 July 1960, 1 female, RRM, VCU. Nelson Co.; locality unknown, 25 June 1928, 2 females, WR, USNM; locality unknown, 19 July 1925, 1 female, WR, (Det. MED, MDR notes), USNM; locality unknown, 25 July 1925, 1 female, WR, (Det. MED, MDR notes), USNM. Warren Co.; S. Fork Shenandoah R. at Morgan Ford, 8 May 1970, 1 nymph, E. W. Surber, FLC collection.

Flight Season.--Apr. 8 (MS) to Sept. 15 (OH); in Virginia May 14 to July 25. Known season in neighboring states are: D.C. June 3 to 11; Kentucky- May to July 18; Maryland- May 18 to July 31; North Carolina- May 10 to 30; Pennsylvania- May 24 to Aug. 23; Tennessee- May 19 to Aug. 23; West Virginia- June 13 to Sept. 9.

Biology.--Nymphs inhabit mud-bottomed pools of small to large rivers.

Adult males most frequently observed hovering at the head of rapids where they seldom alight on projecting rocks.

Remarks.--This small, blackish species is the most widespread species of *Gomphurus* occurring in Virginia.

Gomphus ventricosus Walsh

(Figures 17c, 18h, 21c)

Walsh 1863. Proc. Entomol. Soc. Phila. 2:249.

Length 45-53 mm; abdomen 31-39 mm; hind wings 24-33 mm.

Diagnosis.--Face light green without dark band along frontoclypeal sulcus; female vertex with small erect lateral spines and without erect spines near end of ocellar ridge; crest of female occiput "V"-shaped; inner margins of dorsal mesanepisternal pale stripes slightly divergent; metanepisternal pale stripes present, confluent with mesanepimeral pale stripes above metathoracic spiracles; anterior hamuli each with inner lobe apical; posterior hamuli each with shoulder not visible in lateral view; apical penile segment longer than penile hood, filaments longer than base; penile hood shorter than long, receiver cuplike; dorsum of abdominal segment 7 with midbasal stripe, 8 and 9 black dorsally; vulvar lamina ca. 1/3 length of sternum 9, not constricted basally, lateral lobes ca. as long as wide, semiacute-divaricate apically; male cerci up-arched and each with lateral angulation

Distribution.--Known from the states of CT, IL, IN, IA, KY, MA, MI, MN, NY, OH, PA, TN, VA, and WI, and the provinces of N.B., N.S., Ont., and Que. Known from the Virginia counties of Fairfax and Smyth.

Known distribution among the counties of neighboring states include: Kentucky- Grayson and Green. Pennsylvania- Dauphin and York. Tennessee- Sullivan.

Virginia Records.--Fairfax Co; Great Falls, 14 May 1915, 1 female (teneral), RPC, USNM; Great Falls, 21 May 1974, 1 female, RPC, (Det. RPC, MDR notes), USNM; Great Falls, 26 May 1914, 1 male, 1 female, RPC, USNM; Great Falls, 2 June 1914, 1 male, 2 females, RPC, USNM. Smyth Co.; N. Fork of Holston R. nr. Saltville, date unknown, 1 nymph, S. S. Roback, (Roback and Westfall, 1967).

Flight Season.--May 14 (VA) to July 24 (MI); in Virginia May 14 to June 2. Known season in neighboring states are: Kentucky- May to June; Pennsylvania- May 24 to July 23; Tennessee- June 9.

Biology.--Inhabits mud-bottomed pools of large rivers.

Remarks.--A rare species of which little is known. Many specimens in collections are teneral suggesting that mature adults frequent the more inaccessible midstream areas of large rivers.

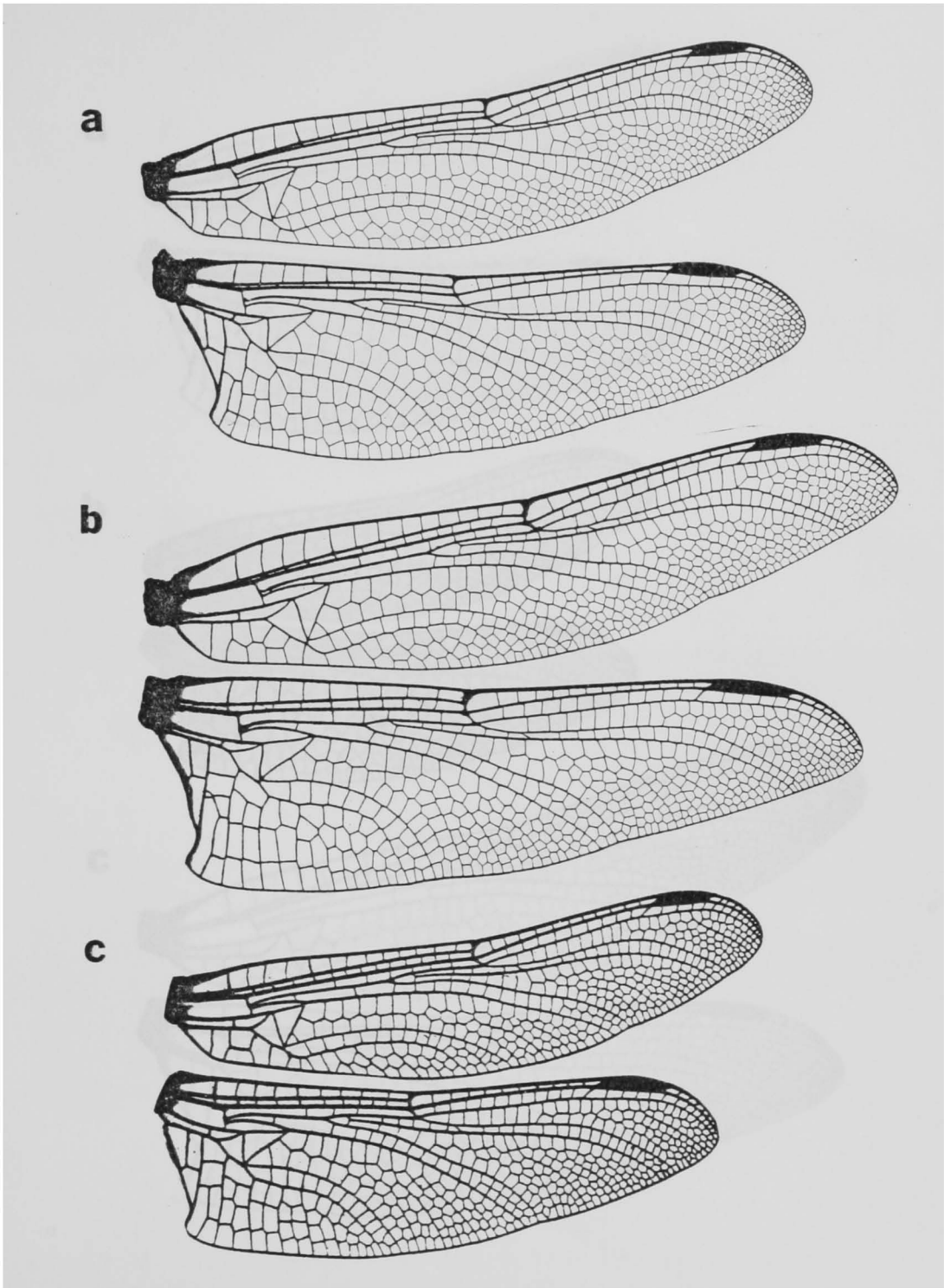


Figure 15. Wings of *Gomphus*(*Gomphurus*) x3: (a) *G. crassus*;
(b) *G. dilatatus*; (c) *G. externus*.

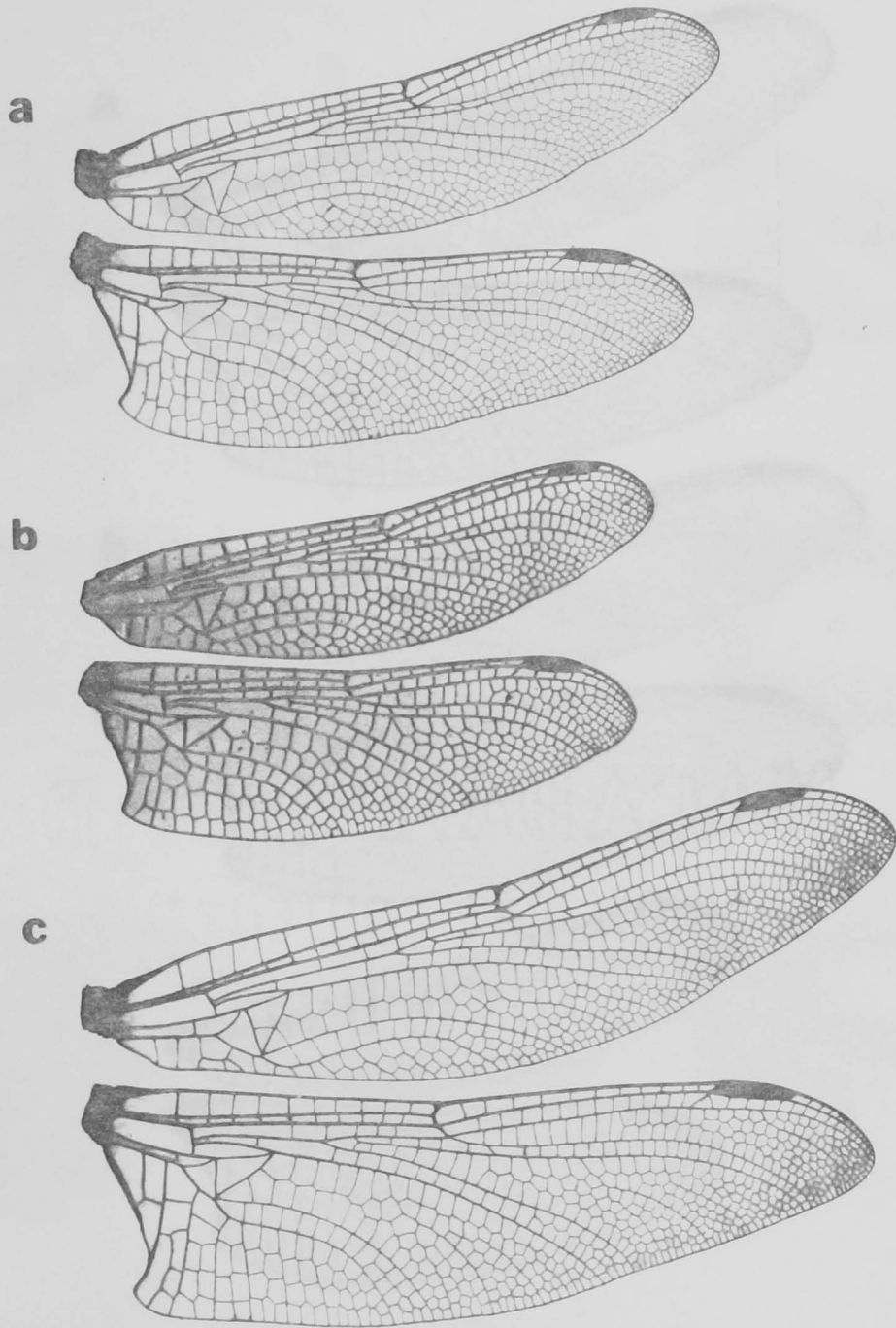


Figure 16. Wings of *Gomphus*(*Gomphurus*) x3: (a) *G. fraternus*;
(b) *G. hybridus*; (c) *G. lineatifrons*.

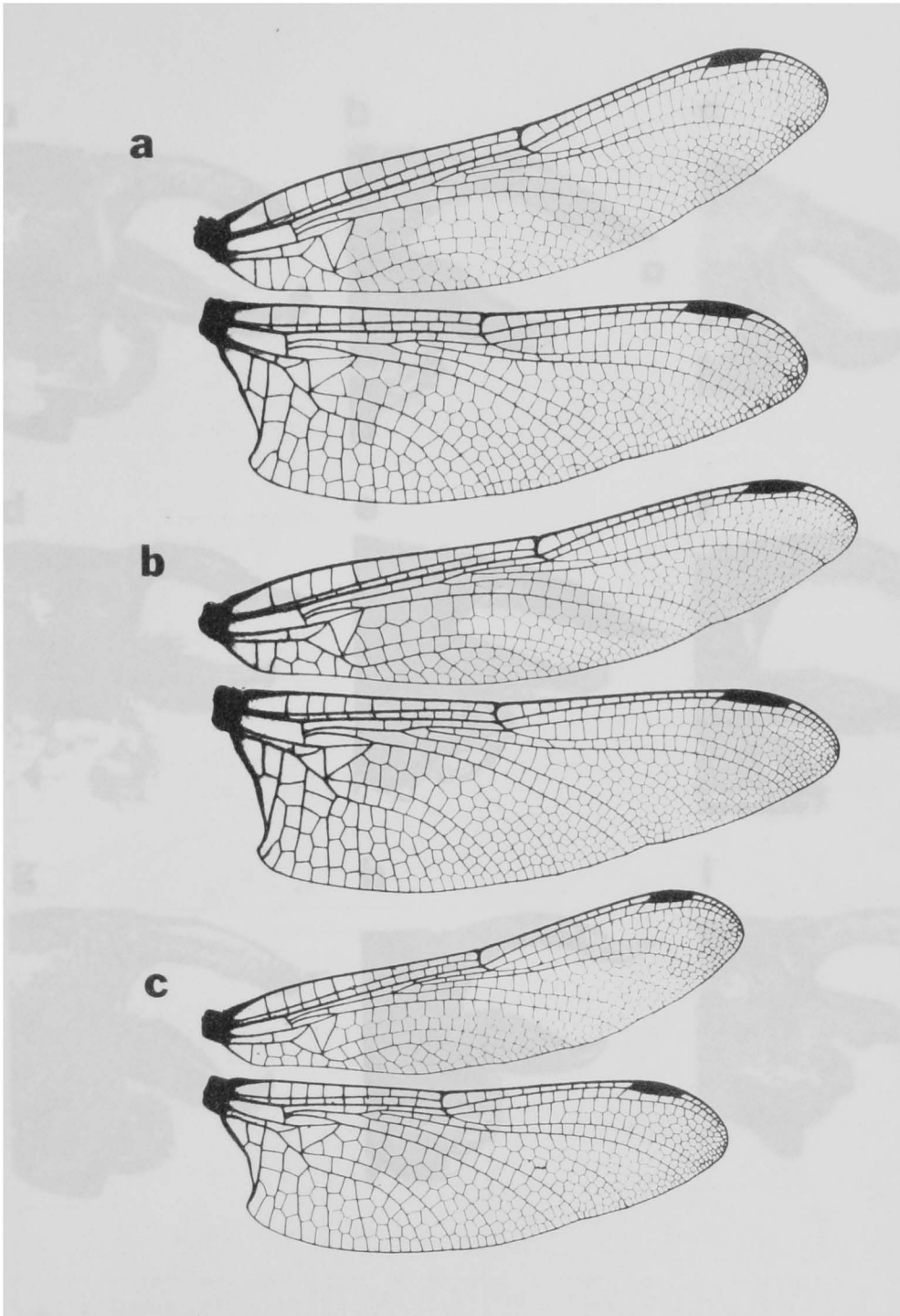


Figure 17. Wings of *Gomphus* (*Gomphurus*) $\times 3$: (a) *G. septima*; (b) *G. vastus*; (c) *G. ventricosus*.

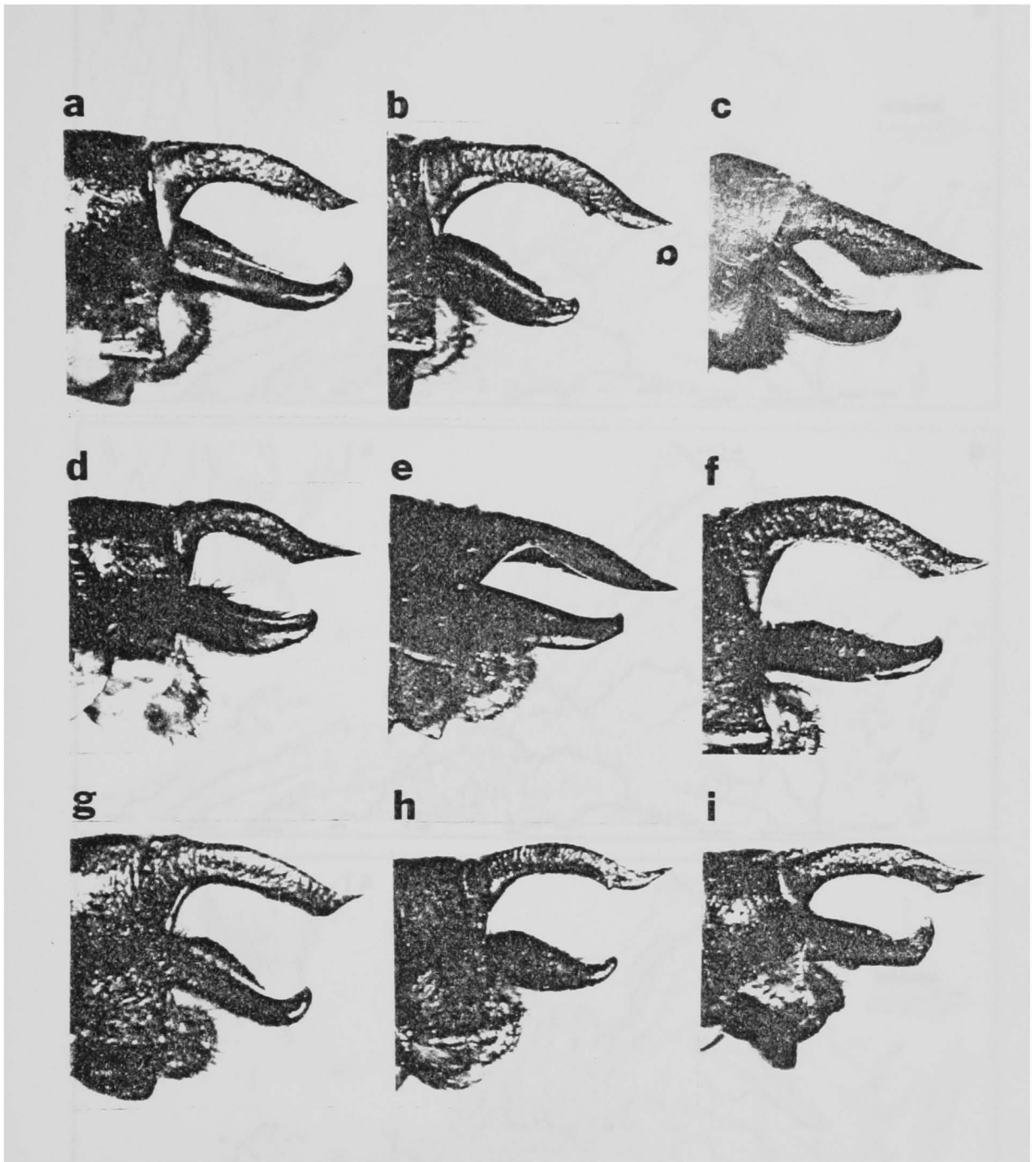


Figure 18. Male terminalia in lateral view of *Gomphus* (*Gomphurus*) x21:
 (a) *G. crassus*; (b) *G. dilatatus*; (c) *G. externus*;
 (d) *G. fraternus*; (e) *G. hybridus*; (f) *G. lineatifrons*;
 (g) *G. septima*; (h) *G. vastus*; (i) *G. ventricosus*.

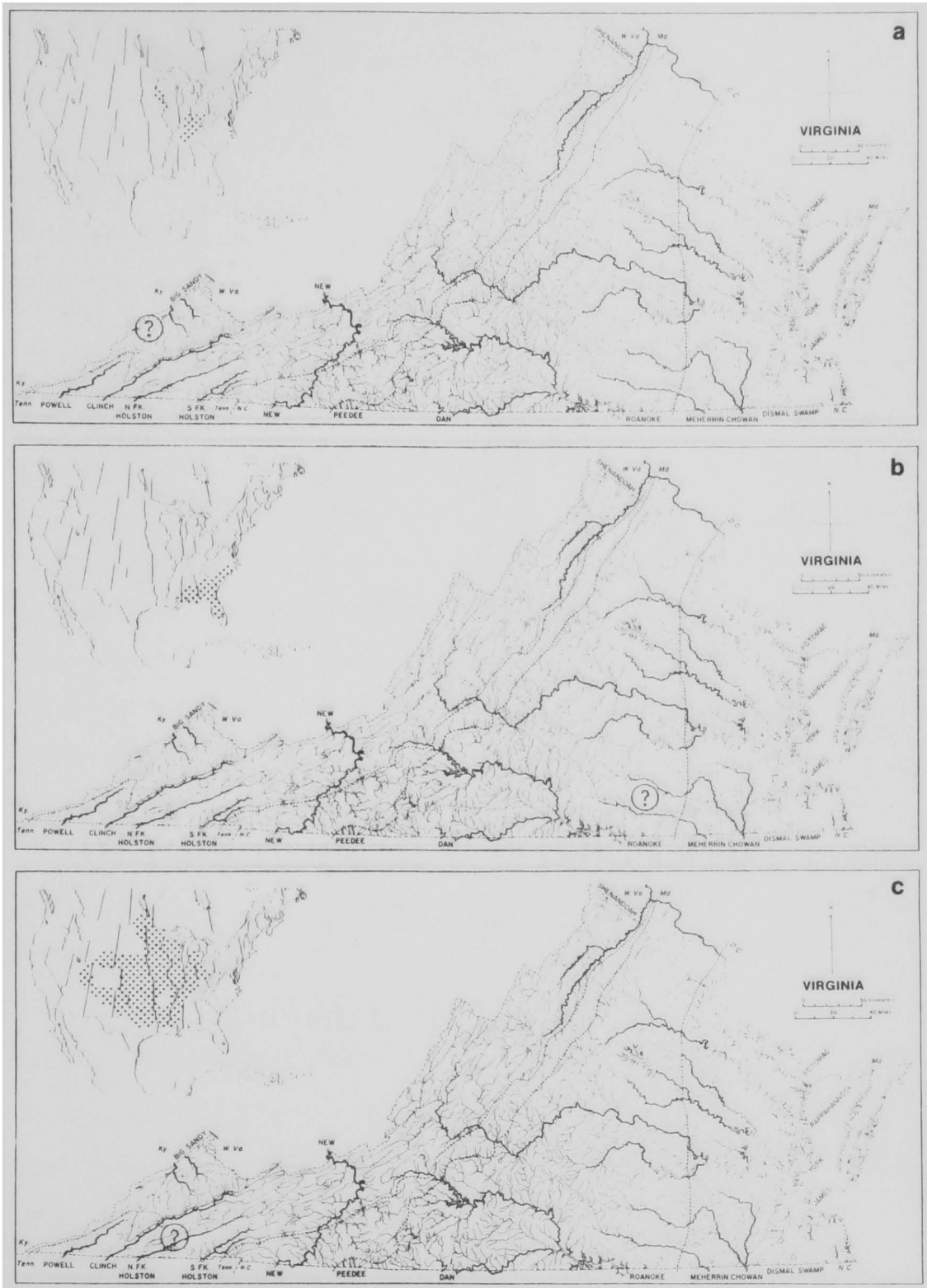


Figure 19. Geographic distribution of *Gomphus* (*Gomphurus*):
 (a) *G. crassus*; (b) *G. dilatatus*; (c) *G. externus*.

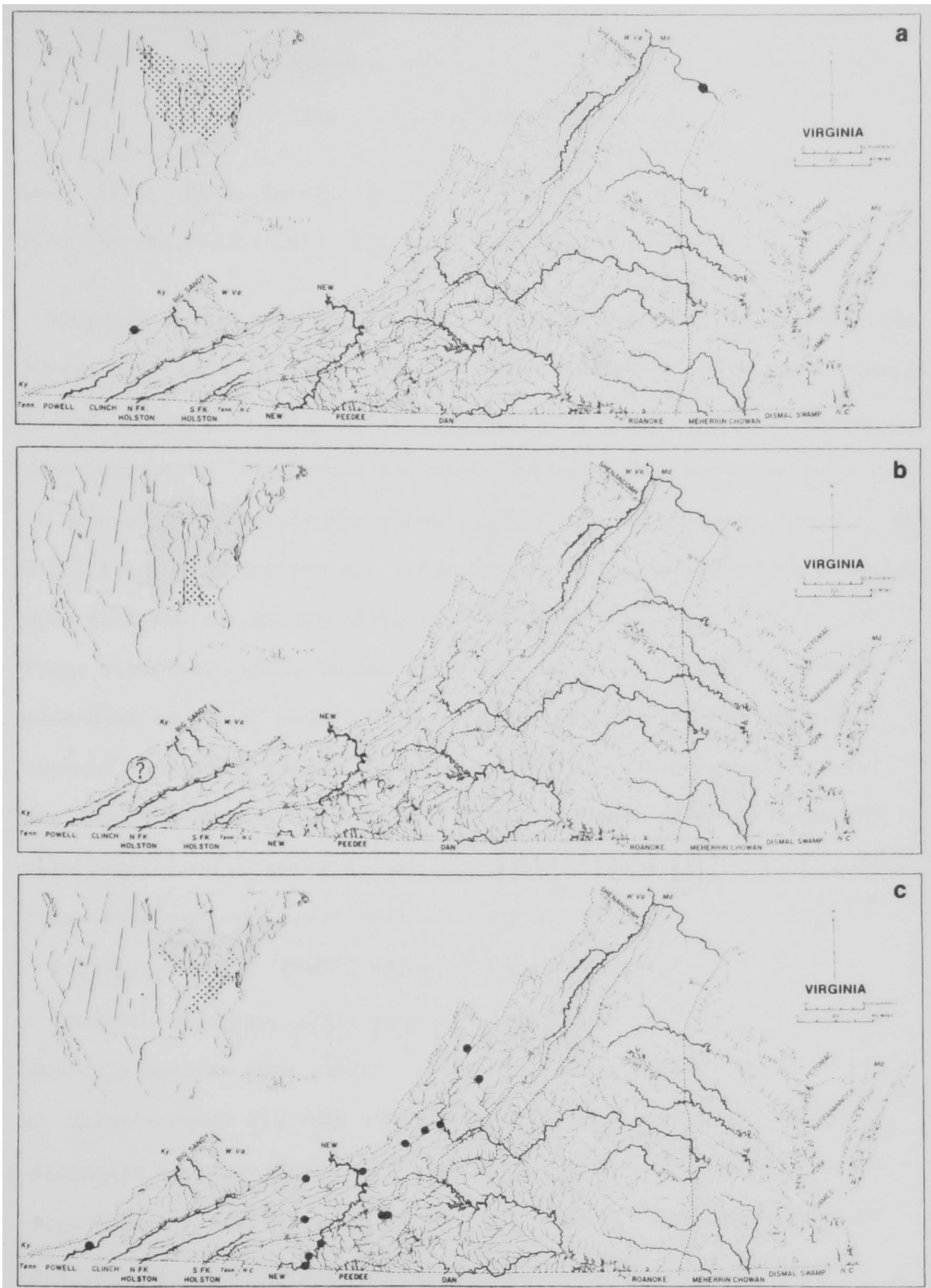


Figure 20. Geographic distribution of *Gomphus* (*Gomphurus*):
 (a) *G. fraternus*; (b) *G. hybridus*; (c) *G. lineatifrons*.

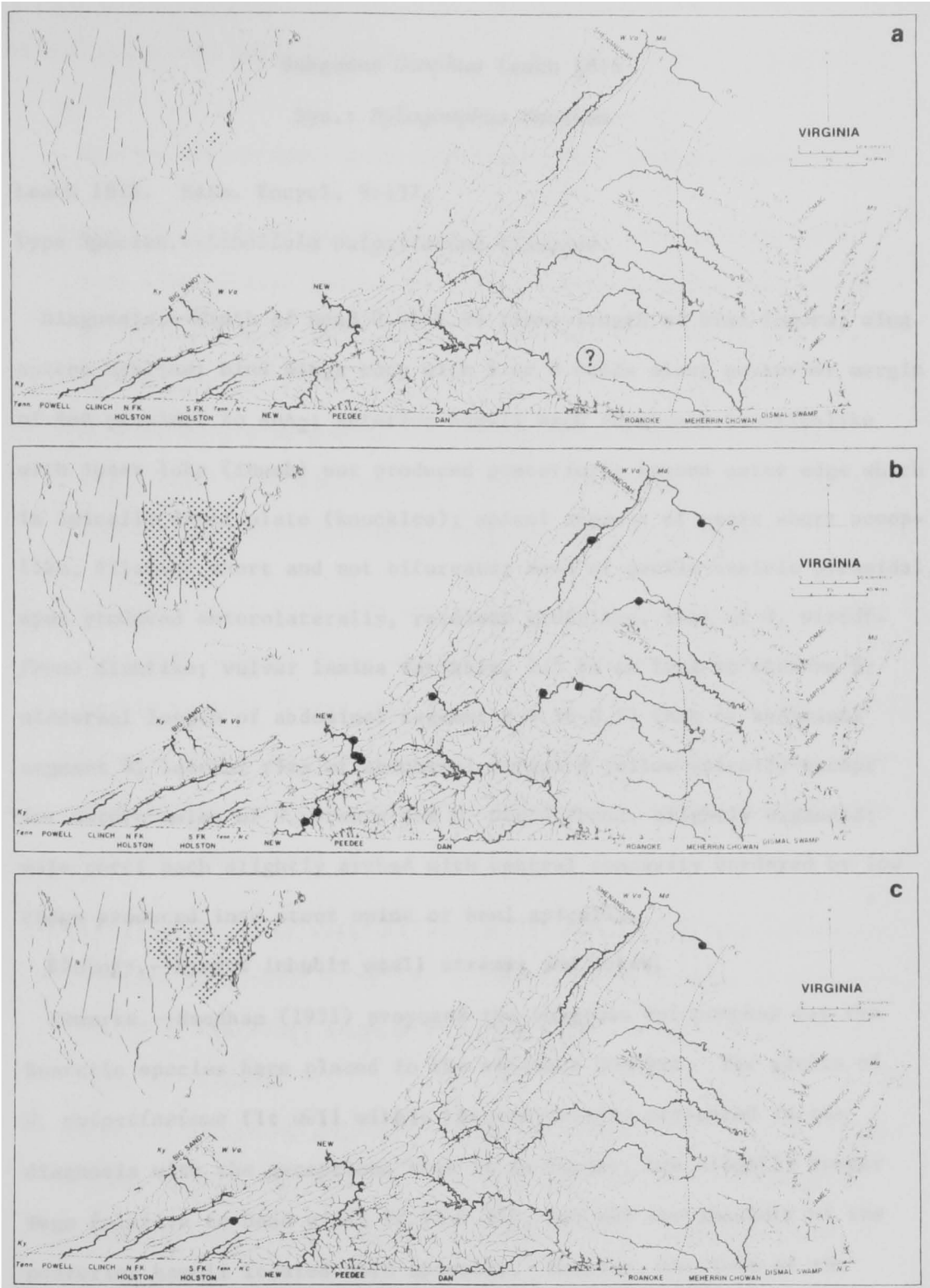


Figure 21. Geographic distribution of *Gomphus* (*Gomphurus*):
 (a) *G. septima*; (b) *G. vastus*; (c) *G. ventricosus*.

Subgenus *Gomphus* Leach 1815Syn.: *Hylogomphus* Needham

Leach 1815. Edin. Encycl. 9:137.

Type Species.--*Libellula vulgatissima* Linnaeus.

Diagnosis.--Width of head 0.96-1.04 times length of hind femora; wing apices hyaline; hind wings each with 5 or 6 cells along posterior margin of AnA proximal to AnA₂; anterior hamuli each thumb-and-knuckleslike with inner lobe (thumb) not produced posteriorly beyond outer edge which is apically denticulate (knuckles); apical segment of penis short scoop-like, filament short and not bifurcate; hood of penile vesicle pyramidal, apex produced anterolaterally, receiver cleftlike, that of *G. viridifrons* dishlike; vulvar lamina variable, 2/5 to as long as sternum 9; middorsal length of abdominal segment 9 0.56-0.73 that of abdominal segment 8; lateral rims of abdominal tergum 8 yellow apically except for mature males of *G. brevis* and *G. viridifrons*, slightly expanded; male cerci each slightly arched with ventral concavity bordered by low ridge produced into stout spine or keel apically.

Biology.--Nymphs inhabit small streams and lakes.

Remarks.--Needham (1951) proposed the subgenus *Hylogomphus* for the Nearctic species here placed in the subgenus *Gomphus*. The adults of *G. vulgatissimus* fit well within the variability presented in the diagnosis with the exceptions that it is larger, has slightly longer legs relative to head width (0.93-0.95), and has the shoulder of the posterior hamuli located more apically. However, the form of the anterior hamuli and vulvar lamina indicate a close affinity between

G. vulgarissimus and *G. brevis*.

Species Key to Adult Male *Gomphus* (*Gomphus*) of North America

1. Posterior margin of penile vesicle convex in lateral view; cerci each with ventral process keellike; metanepisternal pale stripes poorly developed, each generally represented by small yellow area near wing base *G. apomyius* p. 274
 Posterior margin of penile vesicle linear or concave in lateral view; cerci each with ventral process spinelike; metanepisternal pale stripes well developed, extending length of pleura 2
2. Posterior hamuli each with apical hook ending in medial ridge; cerci each with ventral spine located at 0.5-0.6 its length; hood of penile vesicle longer than high *G. abbreviatus* p. 272
 Posterior hamuli each with apical hook ending in point; cerci each with ventral spine located at 0.7-0.8 its length; hood of penile vesicle higher than wide 3
3. Posterior margin of epiproct convex in dorsal view; penile vesicle slender in lateral view, ca. 3 times as high as wide at midheight, receiver dishlike; segment 4 of penis with sharp angulation at base of filament *G. viridifrons* p. 280
 Posterior margin of epiproct concave in dorsal view; penile vesicle stout in lateral view, ca. twice as high as wide at midheight, receiver cleftlike; segment 4 of penis evenly rounded at base of filament 4

4. Anterior hamuli each with anteromedial lobe ending in pointed hook; anterior surface of occiput convex; facial sulci including lateral clypeal punctae, and medial and apical portion of labrum heavily lined with black *G. brevis* p. 275
- Anterior hamuli each with anteromedial lobe rounded; anterior surface of occiput concave; with at most frontoclypeal sulcus lined with black 5
5. Epiproctal rami attenuate, setae of inner margin only slightly longer and more abundant near apices; posterior hamuli each with shoulder generally denticulate; mesanepimeral and metanepisternal pale stripes separate *G. geminatus* p. 278
- Epiproctal rami robust, setae of inner margin much longer and more abundant near apices; posterior hamuli each with shoulder not denticulate; mesanepimeral and metanepisternal pale stripes generally confluent 6
6. Hood of penile vesicle ca. 2/5 as long as segment 1, hood ca. 0.7 mm high; in ventral view penile vesicle slightly constricted proximal to, and evenly tapering distal to hood; apical sclerites of penile segment 3 somewhat acuminate at inner margins
- *G. carolinus* p. 277
- Hood of penile vesicle ca. 1/2 as long as segment 1, hood ca. 0.9 mm high; in ventral view penile vesicle distinctly constricted proximal and distal to hood; apical sclerites of penile segment 3 rounded apically *G. parvidens* p. 279

Species Key to Adult Female *Gomphus*(*Gomphus*) of North America

1. Vertex with elongate horn posterior to each end of ocellar ridge.. 2
 Vertex without horns posterior to ocellar ridge 4
2. Vulvar lamina as long as sternum 9; face light bluish-green
 *G. viridifrons* p. 280
 Vulvar lamina ca. 1/2 as long as sternum 9; face either yellow, or
 green and heavily cross-striped with black 3
3. Lateral margins of vulvar lamina curving away from sternum 9,
 forming ventromedial trough; face green, heavily cross-striped
 with black *G. brevis* p. 275
 Lateral margins of vulvar lamina level, not forming ventromedial
 trough; face yellow *G. abbreviatus* p. 272
4. Ocellar ridge extended to lateral margin of vertex; metanepisternal
 pale stripes well developed and separated from mesanepimeral pale
 stripes by dark brown band *G. geminatus* p. 278
 Ocellar ridge ended posterior to lateral ocelli; metanepisternal
 pale stripes either weakly developed, or well developed and
 generally confluent with mesanepimeral pale stripes above
 mesothoracic spiracles 5

5. Apical vulvar laminal lobes divergent, lateral margins concave, apical cleft large; metanepisternal pale stripes weakly developed, each represented by small pale area near wing base
 *G. apomyias* p. 274

Apical vulvar laminal lobes truncate, lateral margins parallel, apical cleft small; metanepisternal pale stripes well developed and generally confluent with mesanepimeral pale stripes above mesothoracic spiracle 6

6. Distance between apex of vulvar lamina and posterior margin of sternum 9 3-4 times width of apical vulvar laminal lobe, vulvar lamina 1.2-1.3 mm long and level laterally; occipital ridge only slightly, if at all, convex anteriorly in dorsal view
 *G. carolinus* p. 277

Distance between apex of vulvar lamina and posterior margin of sternum 9 ca. 1.5 times width of apical vulvar laminal lobe, vulvar lamina 1.4-1.6 mm long and convex laterally; occipital ridge distinctly convex anteriorly in dorsal view
 *G. parvidens* p. 279

Gomphus abbreviatus Hagen

(Figures 22a, 24a, 26a)

Hagen 1878. In Selys, Bull. Acad. Belg. 46:464.

Length 39-42 mm; abdomen 26-30 mm; hind wings 22-25 mm.

Diagnosis.--Face yellow without dark band along frontoclypeal sulcus;

female vertex with vestigial lateral spines and with elongate horns posterior to ocellar ridge, ocellar ridge ended behind lateral ocelli; inner margins of dorsal mesanepisternal stripes slightly divergent; metanepisternal pale stripes present, confluent with mesanepimeral pale stripes above metathoracic spiracles; anterior hamuli each with inner lobe rounded, posterior hamuli each with apical hook keellike; penile hood slightly longer than wide, with posterior surface concave, and receiver cleftlike; vulvar lamina ca. $2/5$ length of sternum 9, lateral lobes acute and divergent apically; male cerci each with ventral spine at ca. 0.55 length; male epiproct level between rami.

Distribution.--Known from the states of CT, ME, MA, NH, NJ, NY, NC, PA, OH, SC, VA, and WV. Known from the Virginia counties of Alleghany, Botetourt, Loudoun, Roanoke, and Warren. Known distribution among the counties of neighboring states include: North Carolina- Caswell. Pennsylvania- Bucks, Huntingdon, Perry, and Union. West Virginia- Hampshire.

Virginia Records.--Alleghany Co.; Jackson R. at Carne Cr. nr. Lowmoor, 29 May 1977, 2 males, 1 female, FLC. Botetourt Co.; Craig Cr. at Rt. 707 nr. Oriskany, 29 May 1977, 6 males, 3 females, FLC; Craig Cr. at Patterson Cr. 29 May 1977, 1 female, FLC; Craig Cr. at Patterson Cr. 29 May 1978, 1 male, FLC. Loudoun Co.; Potomac R. at Rt. 340, 1 May 1977, 1 female (teneral), H. B. White (Det. H. B. White, personal communication). Roanoke Co.; Roanoke R. at Blue Ridge Parkway, 20 May 1977, 1 female, FLC. Warren Co.; Shenandoah R. at Gooney Run, 6 June, 1976, 1 male, FLC; Shenandoah R. at Gooney Run, 6 June 1976, 1 male, FLC, VPI&SU.

Flight Season.--Apr. 27 (SC) to July 3 (ME); in Virginia May 1 to

June 6. Known season in neighboring states are: Pennsylvania- May 24 to July 7; West Virginia- June 12 to July 2.

Biology.--Nymphs inhabit pools of rivers. Adults typically alight upon streamside vegetation as well as on emergent river boulders near the head of rapids.

Remarks.--The keellike apical hook of each posterior hamuli, midventral location of the cercal spine, and short vulvar lamina are distinctive within the subgenus. This species probably occurs in the piedmont regions of Virginia although it has not been collected there previously.

Gomphus apomyius Donnelly

(Figures 22b, 24b, 26b)

Donnelly 1966. Proc. Entomol. Soc. Wash. 68:102.

Length 37-39 mm; abdomen 26-28 mm; hind wings 23-25 mm.

Diagnosis.--Face yellow without dark band along frontoclypeal sulcus; female vertex with depressed lateral spines and without elongate horns posterior to ocellar ridge, ocellar ridge ended posterior to lateral ocelli; inner margins of dorsal mesanepisternal stripes divergent, metanepisternal pale stripes diffuse, bright yellow dorsad; anterior hamuli each with inner lobe rounded; posterior hamuli each with apical hook spinelike; penile hood slightly higher than long, with posterior surface convex, and receiver cleftlike; vulvar lamina ca. 1/2 length of sternum 9, lateral lobes acute and divergent apically; male cerci each with ventral keellike spine at ca. 0.80 length; male epiproct evenly concave between rami.

Distribution.--Known from the states of AL, MS, NJ, NC, and TX.

Known distribution among the counties of neighboring states include:

North Carolina- Cumberland and Wake.

Flight Season.--Apr. 7 (TX) to June 4 (NJ)(?). Known season in neighboring states are: North Carolina- May 1.

Biology.--Nymphs inhabit spring-fed streams.

Remarks.--The keellike spine of each male cerci is similar to that found in the Palearctic *G. vulgatissimus*. Although not previously collected in Virginia this species probably occurs in the coastal plain and lower piedmont regions of the state.

Gomphus brevis Hagen

(Figures 22c, 24c, 26c)

Hagen 1878. In Selys, Bull. Acad. Belg. 46:462.

Length 41-48 mm; abdomen 27-34 mm; hind wings 24-28 mm.

Diagnosis.--Face green with wide dark band along frontoclypeal sulcus; female vertex with vestigial lateral spines and with elongate horns posterior to ocellar ridge, ocellar ridge ended behind lateral ocelli; inner margins of dorsal mesanepisternal stripes slightly divergent, metanepisternal pale stripes present, confluent with mesanepimeral pale stripes above metathoracic spiracles; anterior hamuli each with inner lobe spinelike; posterior hamuli each with apical lobe spinelike; penile hood higher than long, with posterior surface level-concave, and receiver cleftlike; vulvar lamina ca. 3/5 length of sternum 9, lateral lobes curving away from sternum forming median trough, apices acute and not

divergent; male cerci each with ventral spine at ca. 0.70 length; male epiproct level between rami.

Distribution.--Known from the states of CT, ME, MA, MI, NH, NJ, NY, NC, PA, TN, VT, VA, WV, and WI, and the provinces of N.B., N.S., Ont., and Que. Known from the Virginia county of Augusta. Known distribution among the counties of neighboring states include: North Carolina- Yancey; Pennsylvania- Cameron, Clinton, Dauphin, Fayette, Lycoming, Pike, Somerset, Sullivan, Union, and Westmoreland; Tennessee- Carter; West Virginia- Pendleton, Pocahontas, Randolph, and Tucker.

Virginia Records.--Augusta Co.; Calfpasture R. at Rt. 688, 30 May 1977, 5 males, FLC; Calfpasture R. at Rt. 688, 4 June 1977, 4 males, FLC; Calfpasture R. at Rt. 688, 13 June 1980, 12 males, 1 female (1 pair in tandem), FLC.

Flight Season.--May 8 (PA) to Aug. 20 (Ont.); in Virginia May 30 to June 13. Known season in neighboring states are: North Carolina- May 29 to June 26; Pennsylvania- May 8 to June 31; Tennessee- June 17; West Virginia- May 14 to July 5.

Biology.--Nymphs inhabit pools of small, rapid rivers. Adult males frequently alight upon emergent rocks in rapids as well as rocks at the head of rapids. This species is often associated with *Ophiogomphus carolus*.

Remarks.--*Gomphus brevis* is similar to *G. vulgatissimus* in many respects, indicating that *G. vulgatissimus* may have been derived from this species.

Gomphus carolinus Carle

(Figures 23a, 25a, 27a)

Carle 1979. Entomol. Soc. Amer. 72:418.

Length 36-40 mm; abdomen 26-29 mm; hind wings 22-25 mm.

Diagnosis.--Face light greenish-yellow with narrow dark band along frontoclypeal sulcus; female vertex with lateral spines and without elongate horns posterior to ocellar ridge, ocellar ridge ended behind lateral ocelli; inner margins of dorsal mesanepisternal stripes divergent, metanepisternal pale stripes present, narrowly confluent with mesanepimeral pale stripes above metathoracic spiracles; anterior hamuli each with inner lobe rounded; posterior hamuli each with apical hook spinelike; penile hood slightly higher than long, with posterior surface level-concave, and receiver cleftlike; vulvar lamina ca. 2/3 length of sternum 9, lateral lobes truncate and slightly divergent; male cerci each with ventral spine at ca. 0.75 length; male epiproct evenly concave between rami.

Distribution.--Known from the states of NC and SC. Known distribution among the counties of neighboring states include: North Carolina- Lenoir Montgomery, Moore, Robeson, and Wake.

Flight Season.--Apr. 17 (SC) to June 28 (NC). Known season in neighboring states are: North Carolina- May 25 to June 28.

Biology.--Nymphs inhabit small mud-bottomed, slow-flowing, spring-fed streams. Adult males frequently alight upon stream-side vegetation where they are not particularly wary.

Remarks.--*Gomphus carolinus* is possibly a subspecies of *G. parvidens*

from which it is distinguished by slight differences in genitalia, smaller size, more extensive striping, and blunter wing apices. The geographic border between the two seems to run along the fall line.

Gomphus geminatus Carle

(Figures 23b, 25b, 27b)

Carle 1979. Entomol. Soc. Amer. 72:418.

Length 38-46 mm; abdomen 27-33 mm; hind wings 23-29 mm.

Diagnosis.--Face greenish-yellow with wide dark band along fronto-clypeal sulcus; female vertex with erect lateral spines and without elongate horns posterior to ocellar ridge, ocellar ridge extended to lateral margins of vertex; inner margins of dorsal mesanepisternal stripes divergent, metanepisternal pale stripes present, isolated; anterior hamuli each with inner lobe rounded; posterior hamuli each with apical hook spinelike; penile hood higher than long, with posterior surface level-concave, and receiver cleftlike; vulvar lamina ca. 7/10 length of sternum 9, lateral lobes acute and divergent; male cerci each with ventral spine at ca. 0.70 length; male epiproct evenly concave between rami.

Distribution.--Known from the states of FL, GA, and TN.

Flight Season.--May 8 (FL) to May 26 (FL).

Biology.--Nymphs inhabit small streams of the coastal plain and possibly piedmont.

Remarks.--A somewhat questionable record of this southern species from western Tennessee indicates that it may occur in Virginia.

Gomphus parvidens Currie

(Figures 23c, 25c, 27c)

Currie 1917. Proc. U.S. Nat. Mus. 53:223.

Length 39-44 mm; abdomen 28-32 mm; hind wings 24-28 mm.

Diagnosis.--Face greenish-yellow without dark band along frontoclypeal sulcus; female vertex with depressed lateral spines and without elongate horns posterior to ocellar ridge, ocellar ridge ended behind lateral ocelli; inner margins of dorsal mesanepisternal stripes divergent, metanepisternal pale stripes present, widely confluent with mesanepimeral pale stripes above metathoracic spiracles; anterior hamuli each with inner lobe rounded; posterior hamuli each with apical hook spinelike; penile hood higher than long, with posterior surface level-concave, and receiver cleftlike; vulvar lamina ca. 5/6 length of sternum 9, lateral lobes truncate and not divergent; male cerci each with ventral spine at ca. 0.75 length; male epiproct evenly concave between rami.

Distribution.--Known from the states of MD, NC, and VA. Known from the Virginia county of Charlotte. Known distribution among the counties of neighboring states include: Maryland- Prince Georges; North Carolina- Macon and Transylvania.

Virginia Records.--Charlotte Co.; Spring Cr. at Rt. 654, 23 May 1977, 3 males, FLC; Spring Cr. at Rt. 654, 10 June 1975, 1 male, FLC.

Flight Season.--Apr. (NC) to June 25 (NC); in Virginia May 23 to June 10. Known season in neighboring states are: North Carolina- Apr. to June 25.

Biology.--Nymphs inhabit pools of spring-fed streams. Adult males

frequently alight upon vegetation along rapids.

Remarks.--This is a rare species occurring primarily in piedmont streams where it has been infrequently collected due to its short flight season.

Gomphus viridifrons Hine

(Figures 23d, 25d, 28a)

Hine 1901. Ohio Natural. 1:60.

Length 43-48 mm; abdomen 30-35 mm; hind wings 25-29 mm.

Diagnosis.--Face bluish-green with dark band along frontoclypeal sulcus; female vertex with vestigial lateral spines and with elongate horns posterior to ocellar ridge, ocellar ridge ended behind lateral ocelli; inner margins of dorsal mesanepisternal stripes divergent, metanepisternal pale stripes broadly confluent with mesanepimeral pale stripes above metathoracic spiracles; anterior hamuli each with inner lobe rounded; posterior hamuli each with apical hood spinelike; penile hood higher than long, with posterior surface level-concave, and receiver dishlike; vulvar lamina ca. as long as length of sternum 9, lateral lobes acute-truncate and divergent; male cerci with ventral spine at ca. 0.67 length; male epiproct convex between rami.

Distribution.--Known from the states of AL, IN, KY, MI, NY, NC, OH, PA, TN, VA, and WV, and the province of Ont. Known from the Virginia counties of Botetourt, Floyd, and Grayson. Known distribution among the counties of neighboring states include: Kentucky- Green; North Carolina- Alleghany; Pennsylvania- Fayette; West Virginia- Hampshire,

Marshall, Pendleton, Pocahontas, and Randolph.

Virginia Records.--Botetourt Co.; Craig Cr. at Rt. 706 nr. Oriskany, 29 May 1977, 2 males, FLC. Floyd Co.; Little R. at Rt. 615, 21 May 1977, 1 male, FLC; Little R. at Rt. 615, 28 May 1977, 2 males, FLC; Little R. at Rt. 615, 3 June 1977, 3 males, FLC. Grayson Co.; New R. at Rt. 58 nr. Old Town, 23 May 1978 (emerged 23, 24 May 1978), 2 male nymphs, 2 female nymphs, FLC; New R. at Rt. 810, 23 May 1978, 6 nymphal exuviae, FLC.

Flight Season.--May 1 (NC) to July 23 (NY); in Virginia May 21 to June 3. Known season in neighboring states are: North Carolina- May 1; Pennsylvania- May 3; West Virginia- May 14 to July 2.

Biology.--Nymphs inhabit mud-bottomed pools of rivers. Adults are frequently observed at the head of rapids where the females oviposit and males hover and alight upon rocks. Apparently this species is more active on cloudy days or when the sun is obscured by a passing cloud.

Remarks.--The pale marking of the thorax becomes bluish in mature individuals. This rare species is apparently more abundant in the Virginia mountains than elsewhere.

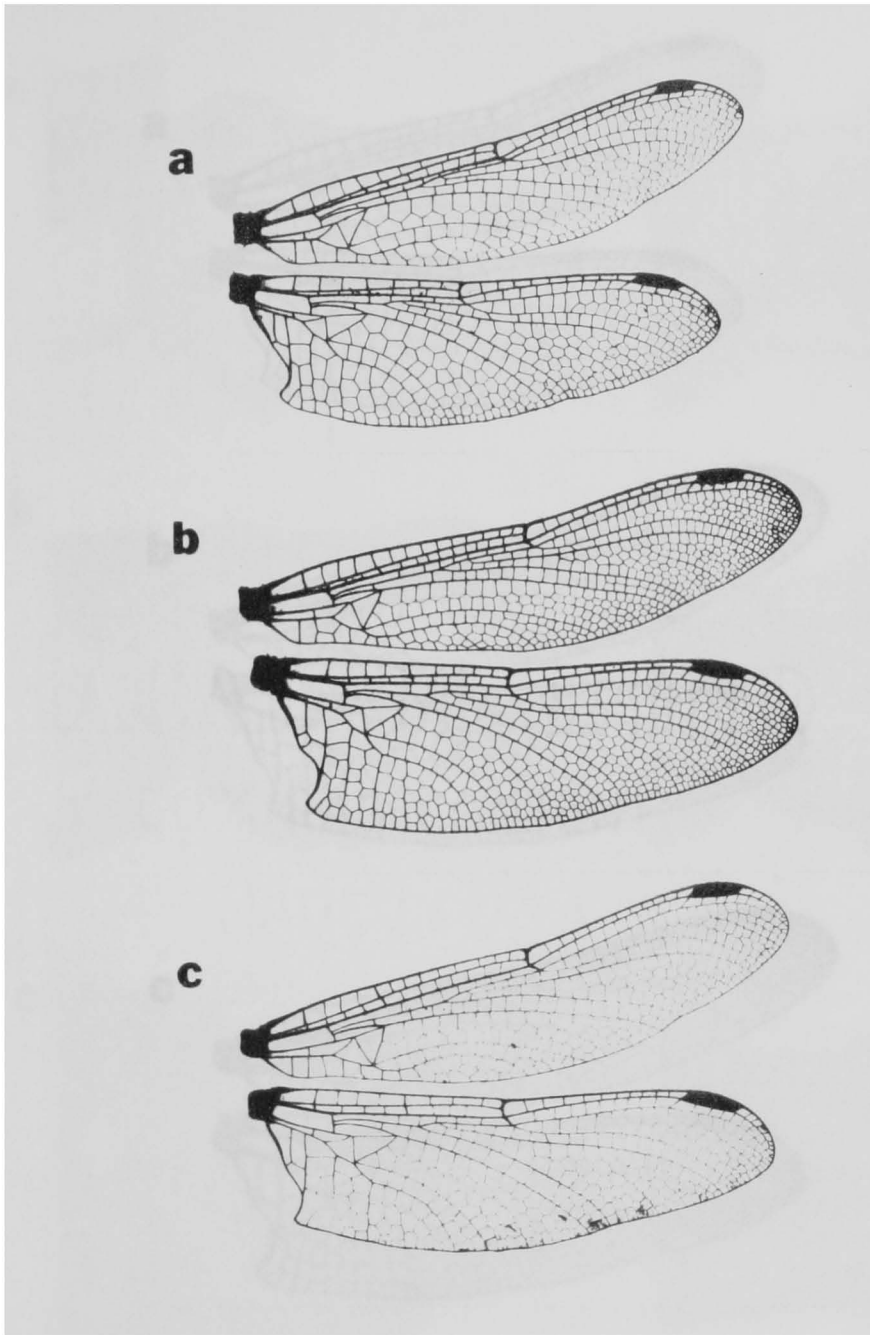


Figure 22. Wings of *Gomphus* (*Gomphus*) x3: (a) *G. abbreviatus*; (b) *G. brevis*; (c) *G. sarolinus*.

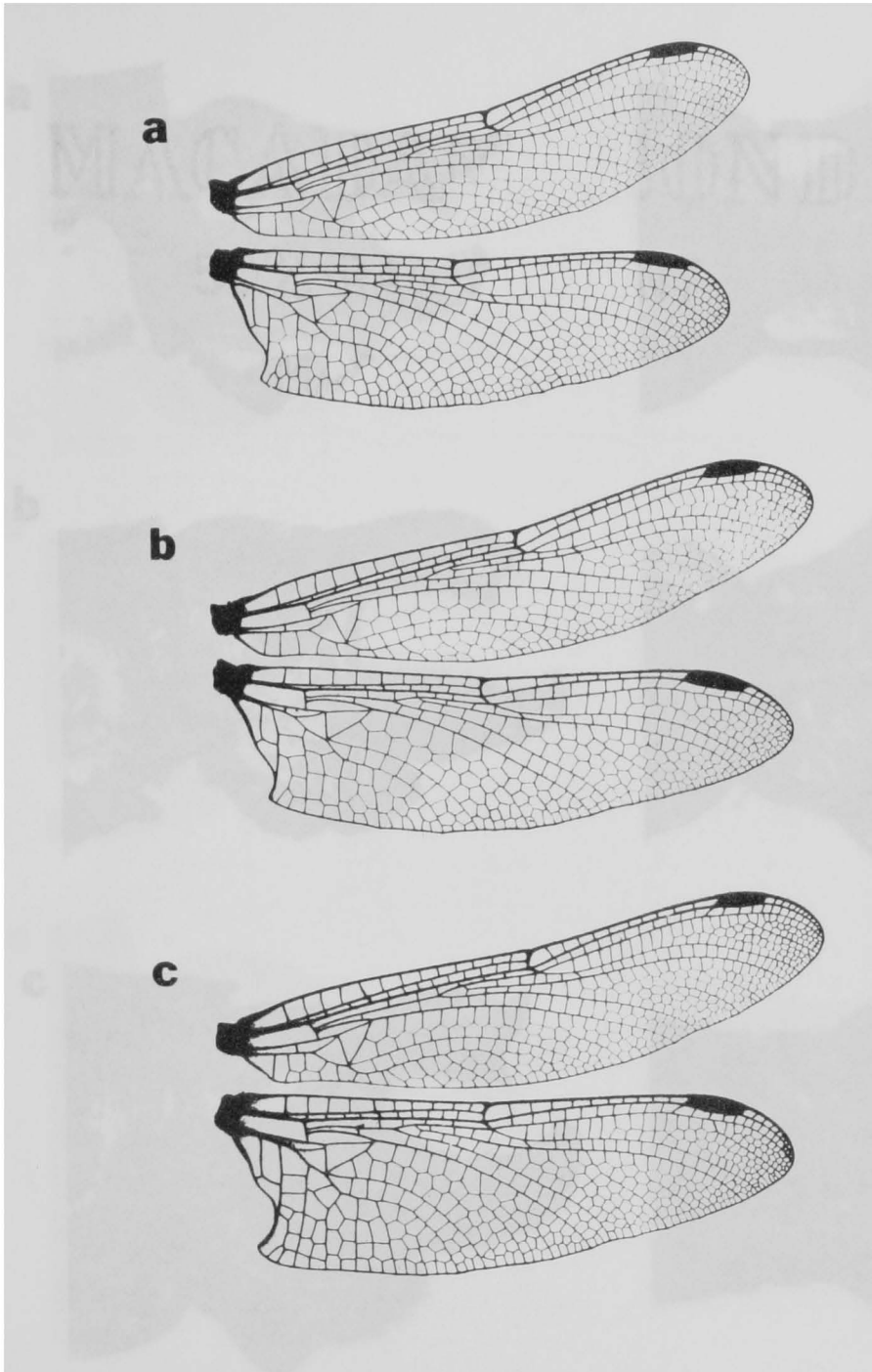


Figure 23. Wings of *Gomphus*(*Gomphus*) x3: (a) *G. geminatus*;
(b) *G. parvidens*; (c) *G. viridifrons*.

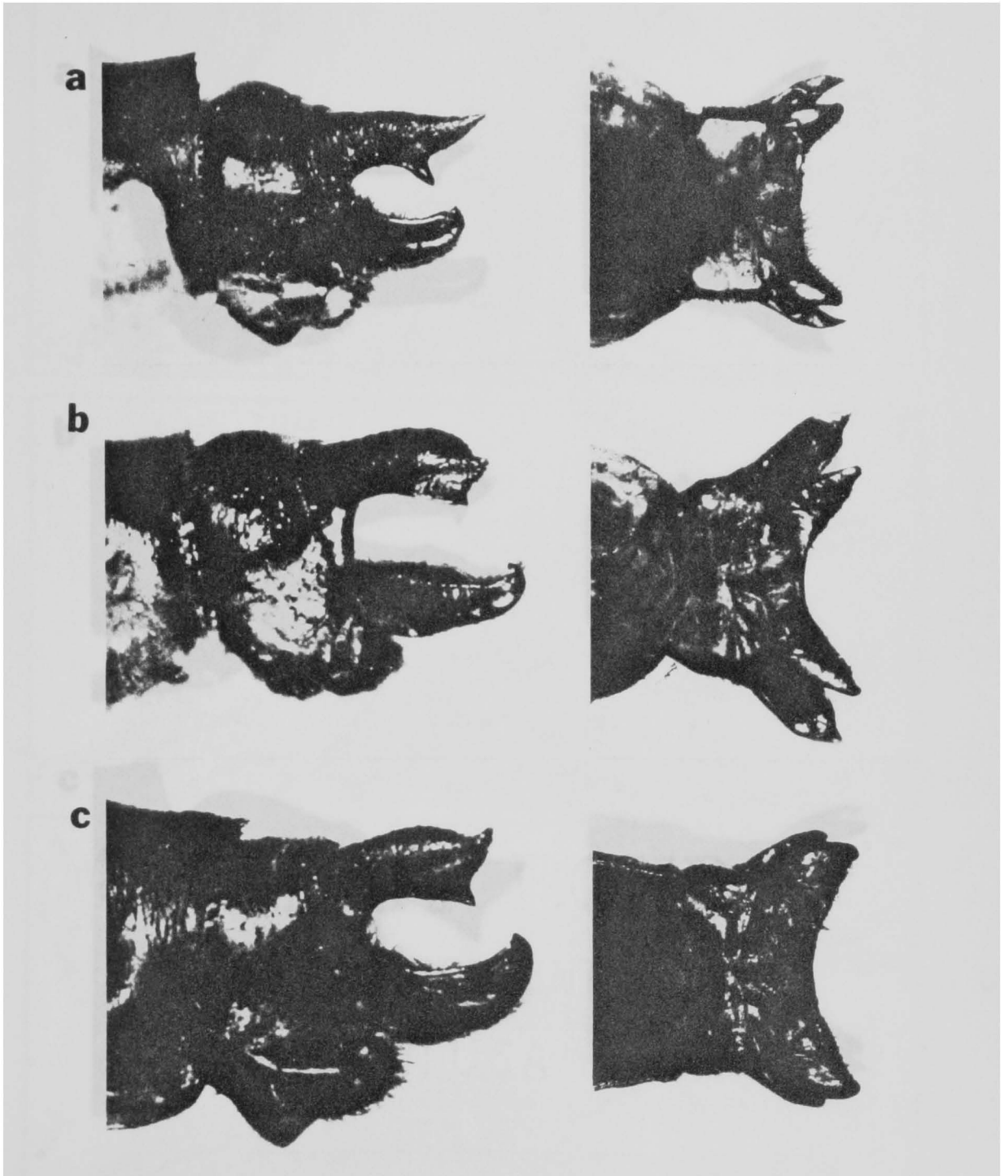


Figure 24. Male terminalia in lateral view x27 and ventral view x15 of *Gomphus* (*Gomphus*): (a) *G. abbreviatus*; (b) *G. apomyioides*, (c) *G. brevis*.

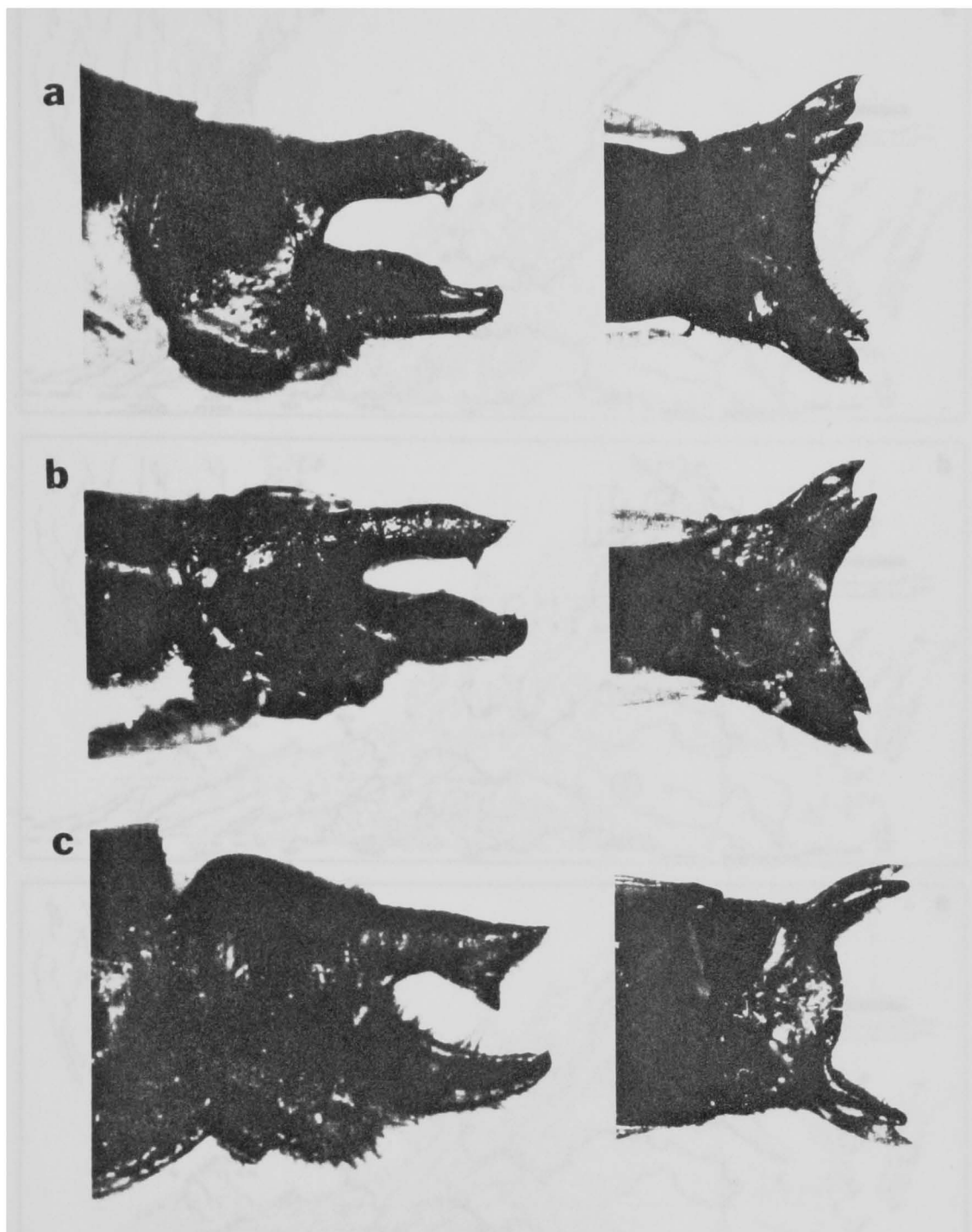


Figure 25. Male terminalia in lateral view x27 and ventral view x15 of *Gomphus* (*Gomphus*): (a) *G. geminatus*; (b) *G. parvidens*; (c) *G. viridifrons*.

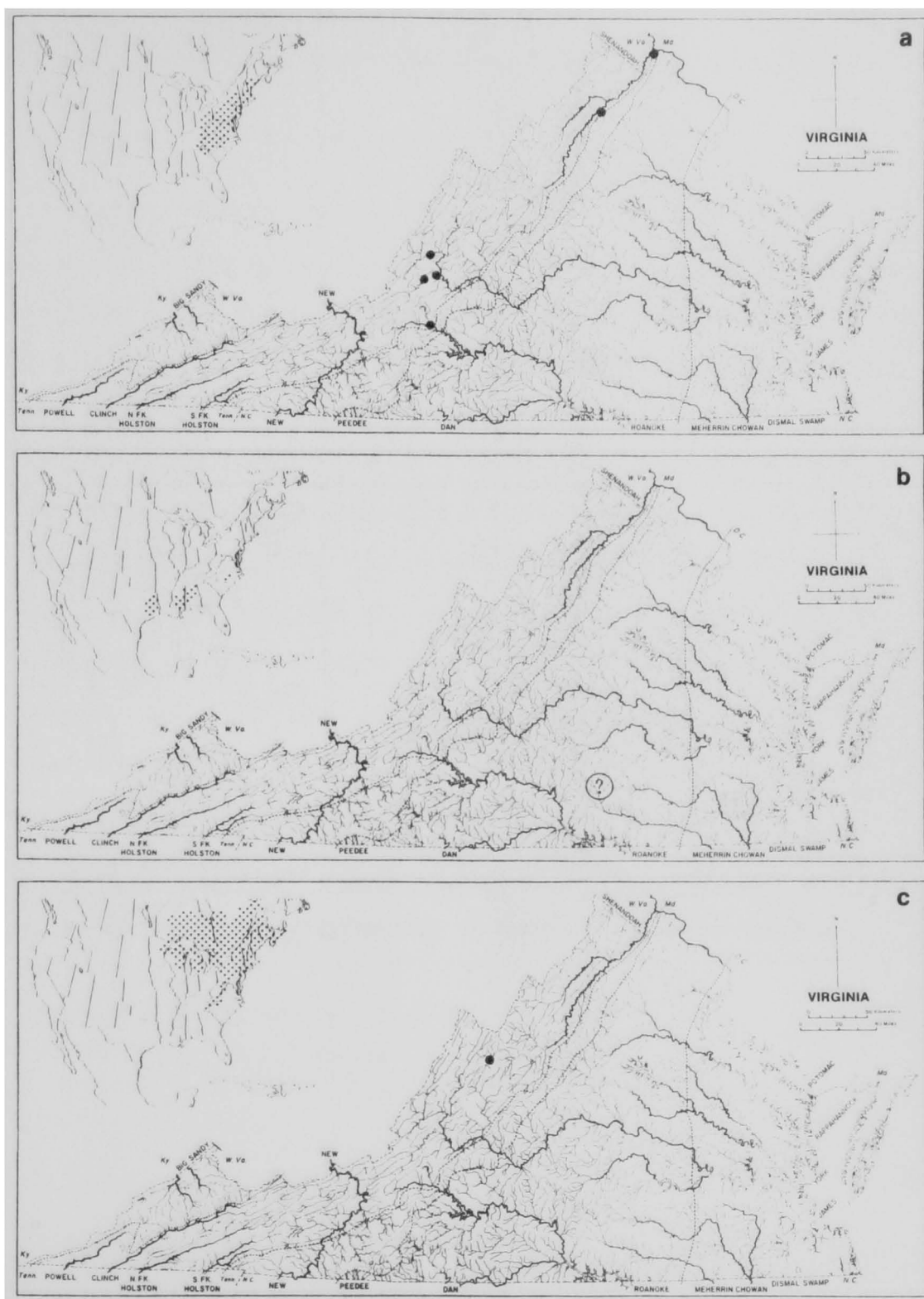


Figure 26. Geographic distribution of *Gomphus* (*Gomphus*):
 (a) *G. abbreviatus*; (b) *G. apomyius*; (c) *G. brevis*.

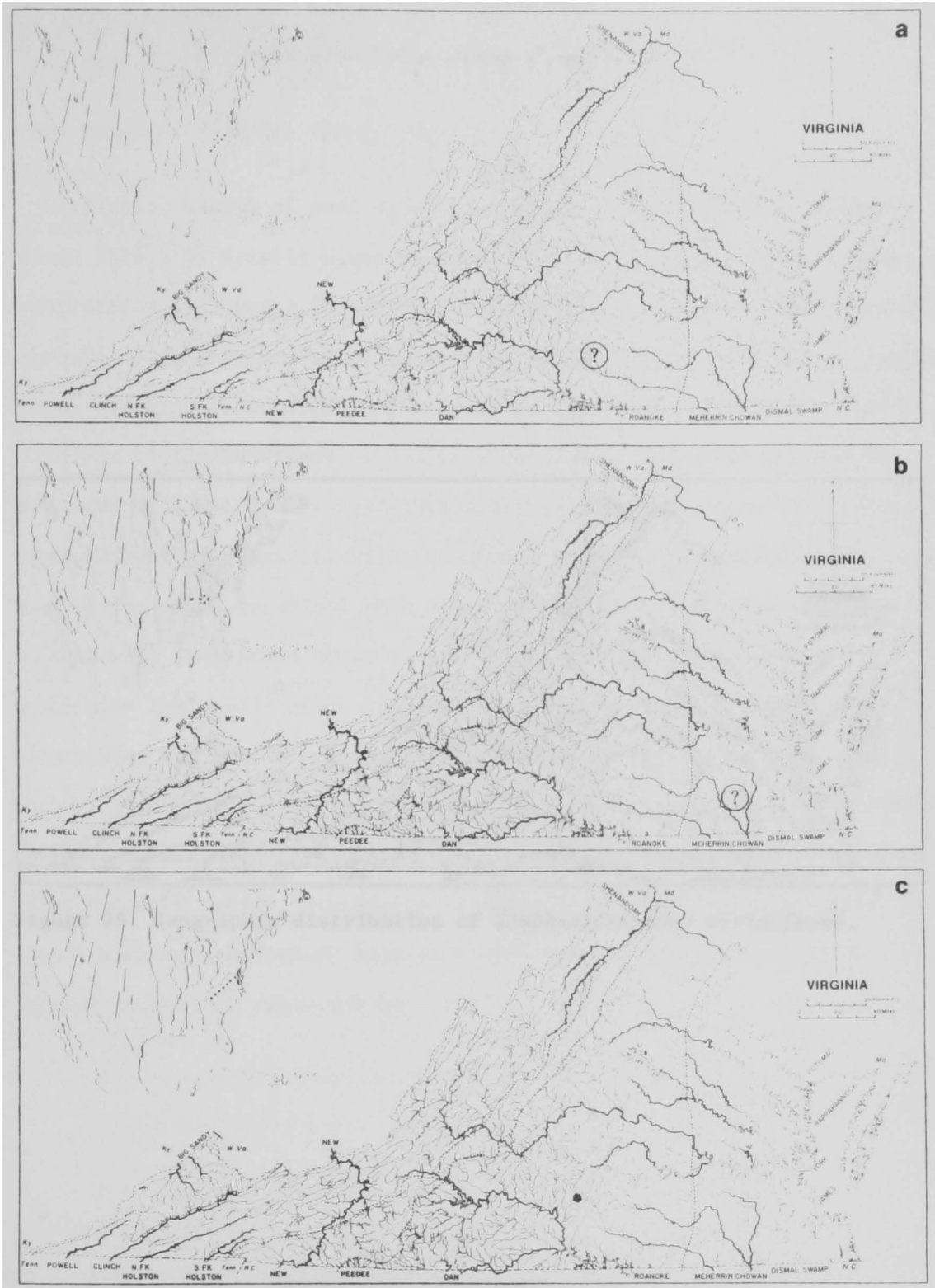


Figure 27. Geographic distribution of *Gomphus* (*Gomphus*):
 (a) *G. carolinus*; (b) *G. geminatus*; (c) *G. parvidens*.

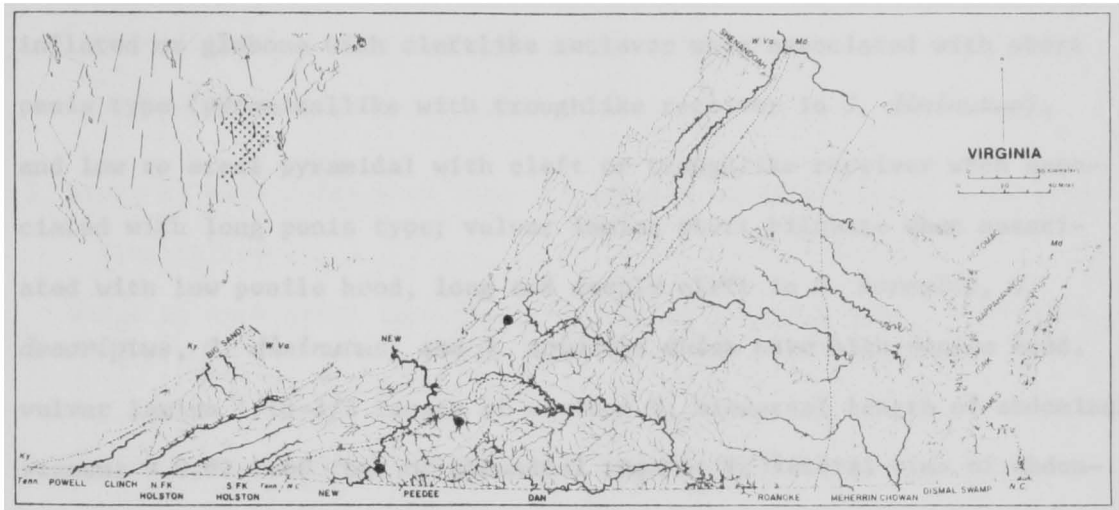


Figure 28. Geographic distribution of *Gomphus (Gomphus) viridifrons*.

Subgenus *Phanogomphus* n. subgenus

Type Species.--*Gomphus minutus* Rambur.

Diagnosis.--Width of head 0.85 to as long as length of hind femora; wings with 5 or 6 cells along posterior margin of AnA proximal to AnA₂; wing apices hyaline; anterior hamuli terminating in apical hook or spine (thumb-and-fingerslike in *G. borealis*); apical segment of penis generally short (long in *G. borealis*, *G. descriptus*, *G. exilis*, and *G. spicatus*), filament either bifurcate or not bifurcate; hood of penile vesicle low inflated or globose with cleftlike receiver when associated with short penis type (pyramidallike with troughlike receiver in *G. diminutus*), and low to erect pyramidal with cleft or troughlike receiver when associated with long penis type; vulvar lamina short bilobate when associated with low penile hood, long and deeply cleft in *G. borealis*, *G. descriptus*, *G. diminutus*, and *G. spicatus* which have high penile hood, vulvar lamina 1/10-3/5 length of sternum 9; middorsal length of abdominal segment 9 0.81-1.60 that of abdominal segment 8; lateral rims of abdominal tergum 8 yellow, distinctly expanded in only *G. australis*; male cerci each not up-arched, acuminate with lateral and ventral tooth, either or both of which may be absent.

Species Key to Adult Male *Gomphus* (*Phanogomphus*)
of Eastern North America

1. External distal surfaces of tibiae black 2
 External distal surfaces of tibiae pale 6

2. Abdominal segment 9 longer than segment 7, basal portion of each
 pale lateral mesanepisternal stripe wider than adjacent brown area
 along mesothoracic sulci *G. australis* p. 294
 Abdominal segment 9 shorter than segment 7, basal portion of each
 pale lateral mesanepisternal stripe narrower than adjacent brown
 area along mesothoracic sulci 3

3. Width of each cerci more than 1/2 length; anterior hamuli thumb-and-
 fingerslike *G. borealis* p. 295
 Width of each cerci less than 1/2 length; anterior hamuli cyclelike
 4

4. Penile hood twice as high as long; dorsal mesanepisternal pale
 stripes as wide as middorsal brown area... *G. descriptus* p. 298
 Penile hood as high as long, dorsal mesanepisternal pale stripes not
 as wide as middorsal brown area 5

5. Cerci each with lateral spine; apical penile segment longer than
 penile hood; external surfaces of tibiae yellow proximally
 *G. spicatus* p. 315
 Cerci each without lateral spine; apical penile segment shorter than
 penile hood; external surfaces of tibiae black proximally
 *G. quadricolor* p. 313

6. Cerci each with lateral spine well developed 7
 Cerci each with lateral spine vestigial 9
7. Cerci each with small spine at proximal end of ventral ridge; anterior hamuli each with inner lobe absent . . *G. cavillaris* p. 296
 Cerci each without small spine at proximal end of ventral ridge; anterior hamuli each with inner lobe present 8
8. Cerci each with lateral spine longer than wide; posterior hamuli each with apical hook keellike *G. hodgei* p. 306
 Cerci each with lateral spine wider than long; posterior hamuli each with apical hook spinelike *G. graslinellus* p. 305
9. Cerci each with ventral spine 10
 Cerci each without ventral spine 11
10. Penile hood pyramidal, higher than long, receiver troughlike; penile filament bifurcate; posterior hamuli each with shoulder located before its medlength *G. diminutus* p. 299
 Penile hood low inflated, longer than high, receiver cleftlike; penile filament bifurcate; posterior hamuli each with shoulder located beyond its midlength *G. minutus* p. 312
11. Cerci each with ventral obtusangular lobe; apical penile segment longer than hood of penile vesicle; posterior hamuli each with shoulder well developed *G. exilis* p. 300
 Cerci each without ventral obtusangular lobe; apical penile segment shorter than hood of penile vesicle; posterior hamuli each with shoulder vestigial *G. lividus* p. 307

Species Key to Adult Female *Gomphus* (*Phanogomphus*)
of Eastern North America

1. External surfaces of tibiae black 2
 External surfaces of tibiae pale 5
2. Abdominal segment 9 longer than segment 7; posterior surface of
 occiput indented laterally *G. australis* p. 294
 Abdominal segment 9 shorter than segment 7; posterior surface of
 occiput not indented laterally 3
3. Ocellar ridge vestigial, vertex with large shallow pits behind each
 lateral ocellus; vulvar lamina more than 1/2 length of sternum 9 .
 *G. borealis* p. 295
 Ocellar ridge not vestigial, vertex without large shallow pits
 behind each lateral ocellus; vulvar lamina less than 1/2 length
 of sternum 9 4
4. Occiput erect-platelike; vulvar lamina ca. 1/3 length of sternum 9 .
 *G. descriptus* p. 298
 Occiput not erect-platelike; vulvar lamina ca. 1/7 length of sternum
 9 *G. quadricolor* p. 313
5. Apical lobes of vulvar lamina as long as wide or longer; vulvar
 lamina 1/5-3/5 length of sternum 9 6
 Apical lobes of vulvar lamina wider than long; vulvar lamina
 1/10-1/7 length of sternum 9 8

6. Frontoclypeal sulcus with brown band; vulvar lamina $1/2-3/5$ length
of sternum 9 *G. diminutus* p. 299
- Frontoclypeal sulcus without brown band; vulvar lamina $1/5-3/10$
length of sternum 9 7
7. Posterior surface of occiput trilobate, occipital ridge raised
medially; vulvar lamina ca. $3/10$ length of sternum 9 with
apices acute *G. spicatus* p. 315
- Posterior surface of occiput not trilobate, occipital ridge evenly
convex; vulvar lamina ca. $1/5$ length of sternum 9 with apices
blunt *G. exilis* p. 300
8. Ocellar ridge extended to lateral margin of vertex 9
- Ocellar ridge not extended to lateral margin of vertex 10
9. Sternum 10 longer than wide; hind wing 20-25 mm long
. *G. cavillaris* p. 296
- Sternum 10 wider than long; hind wing 29-34 mm long
. *G. gaslinellus* p. 305
10. Posterior surface of occiput entire; vulvar lamina with apices
separated for more than $1/2$ its basal width.. *G. lividus* p. 307
- Posterior surface of occiput bilobate; vulvar lamina with apices
separated for less than $1/2$ its basal width 11

11. Occipital ridge convex medially; vertex with robust depressed spine lateral to each end of ocellar ridge *G. hodgei* p. 306
- Occipital ridge concave medially; vertex without robust depressed spine lateral to each end of ocellar ridge... *G. minutus* p. 312

Gomphus australis Needham

(Figures 29a,33a,37a)

Needham 1897. Can. Entomol. 29:184.

Length 52-56 mm; abdomen 38-42 mm; hind wings 27-30 mm.

Diagnosis.--Face greenish-yellow with dark band along frontoclypeal sulcus; female vertex with small depressed lateral spines, ocellar ridge not bilobate, slightly arched, ended near lateral margin of vertex; female occiput with crest convex medially, posterior surface with lateral indentations; inner margins of dorsal mesanepisternal stripes divergent, lateral mesanepisternal pale stripes present, continuous, metanepisternal pale stripes present, isolated; external surface of tibiae black; anterior hamuli each apically thumb-and-fingerslike with middle spine long hooklike; posterior hamuli each with shoulder, apical hook of each spinelike; apical penile segment of short type, filament not bifurcate; penile hood low inflated, receiver cleftlike; vulvar lamina ca. 1/14 length of sternum 9, cleft nearly to base, lateral lobes with blunt apices; male cerci each with lateral and ventral spines, ventral spine not visible in dorsal view.

Distribution.--Known from the states of FL, GA, MS, NC, and SC.

Known distribution among the counties of neighboring states include:

North Carolina- Brunswick.

Flight Season.--Apr. 15 (NC) to Apr. 24 (NC).

Biology.--Inhabits mud-bottomed lakes and ponds. Males frequently observed resting on lily pads.

Remarks.--A very distinctive member of the subgenus which is distinguished from other *Gomphus* by the great length of abdominal segment 9, and by having the lateral rims of abdominal tergum 8 flared at a right angle. This species doubtfully occurs in Virginia

Gomphus borealis Needham

(Figures 29b, 33b, 37b)

Needham 1900. Bull. N.Y. State Mus. 47:453.

Length 44-49 mm; abdomen 31-37 mm; hind wings 25-29 mm.

Diagnosis.--Face olive-green without dark band along frontoclypeal sulcus; female vertex with large shallow pit posterior to each lateral ocellus, without lateral spines, ocellar ridge low, vestigial; female occiput low, vestigial with crest level and posterior surface flat; inner margins of dorsal mesanepisternal stripes not divergent, lateral mesanepisternal pale stripes vestigial, metanepisternal pale stripes present, often confluent with mesanepimeral pale stripes above spiracles; external surface of tibiae black; anterior hamuli each apically thumb-and-fingerslike with fingers represented by several long spines; posterior hamuli each with shoulder, apical hook of each spinelike; apical penile segment of long type, filament not bifurcate; penile hood low pyramidal with anterolateral lobes, receiver narrow troughlike; vulvar

lamina ca. 1/2-3/5 length of sternum 9, cleft for 1/2 its length, lateral lobes with acute apices; male cerci each ca. 1/2 as wide as long with lateral and ventral spines, ventral spine visible in dorsal view.

Distribution.--Known from the states of CT, MA, NH, NY, NC, PA, VT, and VA, and the provinces of Ont. and Que. Known distribution among the counties of neighboring states include: North Carolina- "Magnetic City"; Pennsylvania- Centre, Clearfield, Clinton, Elk, Huntingdon, McKean, Sullivan, Tioga, Union, and Wayne.

Virginia Records.--Highland Co.; Buck Run Beaver Ponds, 7 June 1975, 1 male, FLC.

Flight Season.--May (NH) to July 31 (PA); in Virginia June 7. Known season in neighboring states are: North Carolina- July; Pennsylvania- June 1 to July 31.

Biology.--Inhabits mud-bottomed lakes, ponds, and slow-moving streams. A rare species of which the males will most often be found resting in the open near shore. The Virginia record for *G. borealis* is the only recent record for this species south of Pennsylvania.

Remarks.--Judging from Needham's figures of the female it is evident that he had never seen the true female of *G. borealis*. The North Carolina record for this species requires further verification. This species is perhaps the most ancient member of the subgenus.

Gomphus cavillaris Needham

Syn.: *brimleyi* Muttkowski

(Figures 29c,33c,37c)

Needham 1902. Can. Entomol. 34:276.

Length 37-41 mm; abdomen 24-28 mm; hind wings 20-23 mm.

Diagnosis.--Face greenish-yellow with faint dark band along fronto-clypeal sulcus; female vertex with small lateral spines, ocellar ridge bilobate, extended to lateral margins of vertex; female occiput with crest level, posterior surface with small lateral lobes; inner margins of dorsal mesanepisternal stripes divergent, lateral mesanepisternal pale stripes present, continuous, metanepisternal pale stripes present, isolated; external surface of tibiae pale; anterior hamuli each apically hooked with inner lobe absent; posterior hamuli each with shoulder, apical hook of each spinelike; apical penile segment of short type, filament not bifurcate; penile hood low inflated, receiver cleftlike; vulvar lamina ca. 1/10 length of sternum 9, with apical lobes wider than long and blunt apically; male cerci each with lateral and ventral spines, ventral spine very small and not visible in dorsal view.

Distribution.--Known from the states of FL and NC. Known distribution among the counties of neighboring states include: North Carolina- Bladen.

Flight Season.--Mar. 12 (FL) to May 15 (NC). Known season in neighboring states are: North Carolina- Apr. 22 to May 15.

Biology.--Inhabits sand-bottomed lakes and ponds.

Remarks.--The characteristics which distinguish the northern subspecies (NC to FL) from the southern subspecies (FL) involve color differences such as the development of a brown band along the frontoclypeal sulcus. These color differences vary considerably in some populations casting doubt on the validity of the northern subspecies. This species may

occur in the coastal plain region of Virginia.

Gomphus descriptus Banks

Syn.: *argus* Needham, *mortimer* Needham

(Figures 30a,34a,38a)

Banks 1896. J. N. Y. Entomol. Soc. 4:194.

Length 45-52 mm; abdomen 33-38 mm; hind wings 27-32 mm.

Diagnosis.--Face olive-green without dark band along frontoclypeal sulcus; female vertex without lateral spines, ocellar ridge low, ended behind lateral ocelli; female occiput erect platelike, crest bilobed, posterior surface flat; inner margins of dorsal mesanepisternal stripes not divergent, lateral mesanepisternal pale stripes discontinuous dorsad, metanepisternal pale stripes broadly confluent with mesanepimeral pale stripes above metathoracic spiracles; external surface of tibiae black, outer carina pale proximally; anterior hamuli each cyclelike with long apical hook and with shoulder at midlength; posterior hamuli each bird-shaped with shoulder rounded, apical hook of each spinelike; apical penile segment of long type, filament bifurcate; penile hood narrow pyramidal, ca. 1/2 as long as high, receiver cleftlike; vulvar lamina ca. 1/3 length of sternum 9, cleft for 2/5 its length, apical lobes pointed but not acute, apex of sternum 8 with 2 erect lobes; male cerci each with lateral spine obtusangular, ventral spine visible in dorsal view.

Distribution.--Known from the states of FL(?), IL, IA, KY, MA, MI, NH, NY, NC, PA, VT, VA, and WV, and the provinces of N.B., Ont., and Que. Known from the Virginia county of Highland.

Known distribution among the counties of neighboring states include: Kentucky- Letcher. North Carolina- Avery. Pennsylvania- Centre, Clearfield, Elk, Fayette, Lycoming, Pike, Potter, Somerset, Sullivan, and Union. West Virginia- Boone, Mineral, Nicholas, Pendleton, Pleasants, Pocohontas, Raleigh, Randolph, Ritchie, Tucker, and Wood.

Virginia Records.--Highland Co.; Shaws Fork at Rt. 250 nr. Head Waters, 30 May 1977, 1 male, FLC; Bullpasture R. at head of gorge, 30 May 1977, 5 males, 8 females, FLC; Bullpastrue R. gorge at Rt. 678, 7 June 1975, 7 males, 10 females, FLC.

Flight Season.--Apr. 6 (FL) to Aug. 6 (IA); in Virginia May 30 to June 7. Known season in neighboring states are: Kentucky- May 29; North Carolina- June 15; Pennsylvania- May 16 to June 28; West Virginia- June 2 to June 22.

Biology.--Inhabits mud-bottomed pools of large streams and small rivers. Adults most often observed in stream-side openings.

Remarks.--A wide-ranging but locally distributed species which is occasionally abundant locally.

Gomphus diminutus Needham

(Figures 30b, 34b, 38b)

Needham 1950. Trans. Amer. Entomol. Soc. 56:6.

Length 39-43 mm; abdomen 29-32 mm; hind wings 20-23 mm.

Diagnosis.--Face yellowish-green with narrow dark band along fronto-clypeal sulcus; female vertex with stout lateral spines, ocellar ridge slightly bilobate, ended behind lateral ocelli; female occiput with

crest slightly convex, posterior surface trilobate; inner margins of dorsal mesanepisternal stripes divergent, lateral mesanepisternal pale stripes present, continuous, metanepisternal pale stripes present, isolated; external surface of tibiae pale; anterior hamuli each apically thumb-and-fingerslike with longest spine hooklike; posterior hamuli each with shoulder before middle, apical hook of each spinelike; apical penile segment of short type, filament bifurcate; penile hood erect pyramidal, receiver wide troughlike; vulvar lamina ca. $1/2$ - $3/5$ length of sternum 9, cleft for $3/5$ its length, lateral lobes narrow but blunt apically; male cerci each with lateral spine vestigial, ventral spine present and generally visible in dorsal view.

Distribution.--Known from the states of FL, NC, SC, and TN. Known distribution among the counties of neighboring states include: North Carolina- Moore. South Carolina- Chesterfield.

Flight Season.--Mar. 10 (FL) to May 9 (NC). Known season in neighboring states are: North Carolina- Apr. 14 to May 9; South Carolina- Apr. 16 to May 1.

Biology.--Inhabits sand-bottomed streams.

Remarks.--The long attenuate vulvar lamina is unique for the subgenus. This species may occur in the coastal plain region of Virginia.

Gomphus exilis Selys

(Figures 30c,34c,38c)

Selys 1854. Bull. Acad. Belg. 21:55.

Length 39-48 mm; abdomen 28-36 mm; hind wings 23-27 mm.

Diagnosis.--Face pale yellowish-green without dark band along fronto-clypeal sulcus; female vertex with small denticlelike lateral spines, ocellar ridge slightly bilobate, ended behind lateral ocelli, occasionally extended in low ridge to margin of vertex; female occiput with crest slightly convex, posterior surface slightly convex with small lateral lobes; inner margins of dorsal mesanepisternal stripes divergent, lateral mesanepisternal pale stripes vestigial, metanepisternal pale stripes absent; external surface of tibiae pale; anterior hamuli each apically thumb-and-fingerslike with longest spine hooklike; posterior hamuli each with shoulder, apical hook of each keellike but ended in sharp spine; apical penile segment of long type, filament not bifurcate; penile hood low-pyramidal, receiver cleftlike; vulvar lamina ca. 1/5 length of sternum 9, cleft for 1/2 its length, lateral lobes truncate apically; male cerci each without lateral spines, ventral spines obtus-angular and only slightly visible in dorsal view.

Distribution.--Known from the states of AL, CT, FL, GA, IL, IN, KY, ME, MD, MA, MI, NH, NJ, NY, NC, OH, PA, RI, SC, TN, VT, VA, WV, and WI, and the provinces of Man., N.B., N.S., Ont., and Que. Known from the Virginia counties of Bath, Campbell, Caroline, Charles City, Charlotte, Craig, Cumberland, Dinwiddie, Fairfax, Fauquier, Franklin, Giles, Hanover, Henrico, Highland, Isle of Wight, James City, Louisa, Lunenburg, Mecklenburg, Montgomery, Nottoway, Powhatan, Prince William, Southampton, Spotsylvania, Sussex, and Warren, and the cities of Norfolk and Suffolk. Known distribution among the counties of neighboring states include: Kentucky- Bell, Bullitt, Casey, Fayette, Kenton, Letcher, Marion, Rockcastle, and Washington. Maryland- Montgomery and Prince

Georges. North Carolina- Wake. Pennsylvania- Allegheny, Beaver, Berks, Blair, Bucks, Butler, Cambria, Centre, Chester, Clinton, Columbia, Crawford, Dauphin, Delaware, Fayette, Fulton, Huntingdon, Juniata, Lebanon, Luzerne, Lycoming, Monroe, Montgomery, Perry, Philadelphia, Pike, Somerset, Sullivan, Susquehanna, Union, Wayne, and York. Tennessee- Cumberland. West Virginia- Hampshire, Hancock, Pendleton, and Ritchie.

Virginia Records.--Bath Co.; Beaver Pd. along Rt. 600, 18 June 1978, 2 males, FLC. Campbell Co.; Rt. 646, 2 May 1980, 1 male, BCK. Caroline Co.; N. Anna R. at Rt. 1, 10 June 1978, 1 male, BCK. Charles City Co.; Harrison Lake, 28 May 1967, 1 male, 1 female (in tandem), MDR, VPI&SU; Harrison Lake, 3 June 1967, 1 male, MDR, VPI&SU. Charlotte Co.; Twittys Cr. Reservoir, 25 April 1976, 1 male, FLC, VPI&SU; Spring Cr. at Rt. 654, 18 May 1978, 1 male, FLC; Twittys Cr. at Rt. 642, 23 May 1977, 1 male, FLC. Craig Co.; Tub Run at Rt. 311, 28 May 1977, 1 female, FLC; Potts Cr. at Paint Bank, 7 June 1974, 1 male, 1 female, FLC; Craig Cr. at Rt. 621 and Rt. 651, 17 June 1978, 3 males, 1 female, FLC; Marsh at Rt. 311 and Rt. 611, 28 June 1975, 1 male, SWB, VPI&SU; locality unknown, 19 July 1973, 1 female, E. C. Turner, VPI&SU; Johns Cr. at Rt. 311, 20 July 1975, 1 male, SWB, VPI&SU. Dinwiddie Co.; Sappony Cr. at Rt. 40, 16 Apr. 1978 (emerged 30 April 1978), 1 female nymph, FLC. Cumberland Co.; Bear Cr. Lake, 23 May 1977, 3 males, FLC. Giles Co.; Mt. Lake at Pd. Drain Cr., 5 July 1975, 2 males, FLC; Riopel Pd. at Mt. Lake Bio. Station, 15 July 1973, 1 male, FLC. Fairfax Co.; Great Falls, 9 May 1916, 1 male, RPC, USNM; Great Falls, 26 May 1914, 1 male, 3 females (1 pair in tandem), RPC, USNM; Great Falls, "May 26-June 25" (Donnelly 1961); Great Falls, 2 June 1914, 1 female, RPC, USNM. Fauquier Co.; NW of Hay-

market, 26 June 1971, 1 male, G. Herel, (Det. Davis), USNM. Franklin Co.; Burnt Chimney, 22 April 1976, 1 male, R. Booth, VPI&SU. Hanover Co.; N. Anna R. at Rt. 601, 12 June 1978, BCK, VPI&SU. Henrico Co.; U. of Richmond, date unknown, J. G. Needham, (MDR notes). Highland Co.; Bullpasture R. at head of gorge, 30 May 1977, 2 males, 3 females (1 pair in tandem), FLC. Isle of Wight Co.; Blackwater R., 10 April 1976, 1 male, 2 females (teneral), J. O'Hop, ODU. James City Co.; Lake Matoaka, 13-14 April 1938, 5 males, 6 females, MED and DTR, (Det. MED, MDR notes); Williamsburg, 20 Apr. 1938, 1 female, MED, (Det. MED, MDR notes), W&M; Lake Matoaka, 4 May 1938, 1 male, 1 female, MED and TDM, (Det. Med, MDR notes); Williamsburg, 13 May 1937, 1 male, collector unknown, (Det. MED, MDR notes); Jollys Pond, 16 May 1938, 1 male, MED, (Det. MED, MDR notes); Jollys Pond, 17 May 1966, 1 male, 1 female, MDR, VPI&SU; Lake Matoaka, 17 May 1938, 1 male, MED, (Det. MED, MDR notes); Williamsburg, 18 May 1937, 1 female, collector unknown, (Det. MED, MDR notes), W&M; Williamsburg, 18 May 1937, 2 males, 1 female, CA, (Det. CA, MDR notes); Jollys Pond, 22 May 1938, 2 males, F. M. Koss, (Det. MED, MDR notes); Jollys Pond, 24 May 1966, 1 male, 1 female, MDR, VPI&SU. Louisa Co.; N. Anna R. at Rt. 601, 2 June 1977, 1 male, BCK, FLC Collection; Lake Anna, 3 June 1977, 1 male, 1 female, BCK; S. Anna R. at Rt. 655, 3 June 1977, 1 female, BCK, FLC Collection; S. Anna R. at Rt. 552, 3 June 1977, 1 male, BCK; N. Anna R. at Rt. 601, 12 June 1978, 3 males, BCK; N. Anna R. 1 mile below L. Anna, 13 June 1978, 1 male, 1 female (in tandem), BCK; S. Anna R. at Rt. 522, 22 June 1977, 1 male, BCK. Lunenburg Co.; Nottoway R. at Rt. 49, 14 Apr. 1978 (emerged 25 Apr. 1978), 1 female nymph, FLC; Big Hounds Cr. at Rt. 652, 15 Apr. 1978 (emerged 22 Apr.

1978), 1 male nymph, FLC. Mecklenburg Co.; Farm pond on Rt. 697, 1 June 1980, 2 males, BCK. Montgomery Co.; Pandapas Pd., 17 May 1976, 1 male, BCK, VPI&SU; Craig Cr. beaver pond at Rt. 621, 17 May 1977, 1 male, J. Schmidt, VPI&SU; Poverty Hollow nr. Pandapas Pd., 25 May 1978, 1 male, FLC; Pandapas Pd., 3 June 1977, 4 males, Hammond; Pandapas Pd., 14 June 1974, 7 males, 3 females, FLC; Pandapas Pd. 10 July 1977, 1 male, BCK; Pandapas Pd., 15 July 1973, 1 female, FLC; Pandapas Pd., 23 July 1977, 1 male, FLC. Nottoway Co.; Nottoway R. at Rt. 49, 14 Apr. 1978 (emerged 24, 26 Apr. 1978), 1 male nymph, 2 female nymphs, FLC. Powhatan Co.; locality unknown, 27 June 1975, 1 female, R. Kelley, VCU. Prince William Co.; Youngs Branch at Rts. 29 and 211, "May 26-June 25" (Donnelly 1961). Southampton Co.; Nottoway R. at Rt. 653, 16 Apr. 1978, 1 male, FLC; Delzell Farm 9 miles NW of Windsor off Rt. 635, 5 May 1979, 1 male, S. Brown, VPI&SU. Spotsylvania Co.; Tributary of Matta R. at Rt. 617, 29 May 1978, 2 males (1 teneral), FLC. Sussex Co.; Nottoway R. at Rt. 40 nr. Homeville, 15 Apr. 1978 (emerged 22 Apr. 1978), 2 male nymphs, FLC; Sussex Co. Lake, 6 June 1975, 1 male, J. Hancock, ODU. Warren Co.; Surbers Pd. at Rt. 634, 6 June 1977, 2 males, FLC; Surbers Pd. at Rt. 634, 5 July 1975, 1 male, FLC. City of Norfolk; 6 May 1971, 1 female, M. Huff, ODU. City of Norfolk; Dismal Swamp, 10 May 1937, 3 males, CC, (Det MED, MDR notes). City of Suffolk; Washington Ditch Dismal Swamp, 2 Jan 1975, 1 female nymph, S. Hancock, ODU; Dismal Swamp, 10 May 1970, 1 male, Garrett, ODU; Dismal Swamp, 11 May 1970, 1 male, S. C. Steeve, ODU; Lake Drummond Dismal Swamp, 16 May 1970, 14 males, 3 females, J. F. Matta, ODU; Washington Ditch Dismal Swamp, 16 May 1970, 13 males, 1 female, J. F. Matta, ODU; Dismal Swamp, 25 May 1971, 1 male, H. F. D.,

ODU.

Flight Season.--Apr. 7 (NC) to Sept. (NY); in Virginia Apr. 10 to July 23. Known season in neighboring states are: Maryland- May 26 to June 25; North Carolina- Apr.7 to May; Pennsylvania- May 16 to Aug. 15; Tennessee- June 14; West Virginia- May 26 to July 1.

Biology.--Nymphs inhabit mud-bottomed ponds, lakes, streams, and embayments of large rivers. Adults are commonly observed resting in open areas near shore. This species occasionally exhibits the peculiar flight pattern of up and down concave loops.

Remarks.--This species is the most common gomphine in Virginia with the possible exception of *G. lividus*.

Gomphus graslinellus Walsh

(Figures 31a,35a,39a)

Walsh 1862. Proc. Acad. Phila., p. 394.

Length 44-53 mm; abdomen 32-39 mm; hind wings 28-35 mm.

Diagnosis.--Face olive-green without dark band along frontoclypeal sulcus; female vertex without lateral spines, ocellar ridge bilobed, extended to posterior margin of vertex; female occiput with crest level, posterior surface slightly bilobed; inner margins of dorsal mesanepisternal stripes slightly divergent, lateral mesanepisternal pale stripes absent or vestigial, metanepisternal pale stripes absent dorsad; external surface of tibiae pale; anterior hamuli each apically thumb-and-fingerslike with longest spine hooklike; posterior hamuli each with shoulder, apical hook of each spinelike; apical penile segment of short type,

filament not bifurcate; penile hood low inflated globose, receiver cleft-like; vulvar lamina ca. 1/7 length of sternum 9, cleft for ca. 1/2 its length, lateral lobes blunt apically; male cerci each with robust lateral spine, ventral spine represented by ventroapical ridge, ridge slightly visible in dorsal view.

Distribution.--Known from the states of IL, IN, IA, KS, KY, MI, MN, MO, OH, OK, SD, WA, and WI, and the provinces of B.C., Man., and Ont. Known distribution among the counties of neighboring states include: Kentucky-Bullitt, Fayette, Jefferson, and Marion.

Flight Season.--May 11 (IN) to Aug. 14 (Ont.). Known season in neighboring states are: Kentucky- May 24 to June 5.

Biology.--Inhabits ponds, lakes, and slow-moving streams. Adults commonly observed resting in open areas near shore. Occasionally exhibiting the peculiar flight pattern of up and down concave loops.

Remarks.--A robust species distinctive in the subgenus for the relatively wide apical abdominal segments. Although reported from Kentucky this species doubtfully occurs in Virginia.

Gomphus hodgesi Needham

(Figures 31b, 35b, 39b)

Needham 1950. Trans. Amer. Entomol. Soc. 56:1.

Length 40-45 mm; abdomen 30-33 mm; hind wings 23-26 mm.

Diagnosis.--Face pale yellowish-green without dark band along frontoclypeal sulcus; female vertex with robust depressed lateral spines, ocellar ridge bilobed, ended behind lateral ocelli; female occiput with

crest slightly convex, posterior surface with lateral lobes; inner margins of dorsal mesanepisternal stripes divergent, lateral mesanepisternal pale stripes present, continuous, metanepisternal pale stripes present, isolated; external surface of tibiae pale; anterior hamuli each apically thumb-and-fingerslike with apical spine hooklike; posterior hamuli each with shoulder, apical hook of each keellike; apical penile segment of short type, filament not bifurcate; penile hood low inflated, receiver cleftlike; vulvar lamina ca. 1/10 length of sternum 9, cleft for ca. 3/5 its length, lateral lobes blunt apically; male cerci each with sharp lateral spine, ventral spine represented by ventroapical ridge, ridge not visible in dorsal view.

Distribution.--Known from the states of AL, FL, LA, and MS.

Flight Season.--Mar. 1 (MS) to May 7 (MS).

Biology.--Inhabits slow-moving streams, ponds, and lakes.

Remarks.--A southern species which has been confused with both *G. cavillaris* and *G. diminutus*. Therefore the species may occur as far north as North Carolina or possibly Virginia.

Gomphus lividus Selys

Syn.: *sordidus* Hagen, *umbratus* Needham

(Figures 31c, 35c, 39c)

Selys 1854. Bull. Acad. Belg. 21:53.

Length 46-56 mm; abdomen 34-40 mm; hind wings 27-34 mm.

Diagnosis.--Face yellowish-green without dark band along frontoclypeal sulcus; female vertex with lateral spines, ocellar ridge slightly bi-

lobed, ended behind lateral ocelli; female occiput with crest strongly convex, posterior surface convex; inner margins of dorsal mesanepisternal stripes divergent, lateral mesanepisternal pale stripes vestigial, metanepisternal pale stripes absent; external surface of tibiae pale; anterior hamuli each with shoulder at midlength, apical spine of each hooklike; posterior hamuli each bird-shaped with shoulder vestigial and apical hook spinelike; apical penile segment of short type, filament not bifurcate; penile hood low inflated-subglobose, receiver cleftlike; vulvar lamina ca. 1/10 length of sternum 9, cleft for 4/5 its length, lateral lobes blunt apically; male cerci each with lateral and ventral spines vestigial.

Distribution.--Known from the states of AL, AR, CT, DE, FL, GA, IN, KY, LA, MA, ME, MI, MS, MO, NE, NJ, NY, NC, OH, PA, SC, TN, VT, VA, WV, and WI, and the provinces of Ont. and Que. Known from the Virginia counties of Alleghany, Augusta, Bath, Bedford, Bland, Brunswick, Charlotte, Craig, Cumberland, Dinwiddie, Fairfax, Floyd, Giles, Grayson, Henrico, Henry, Highland, James City, Loudoun, Louisa, Mecklenburg, Middlesex, Montgomery, Pittsylvania, Prince William, Roanoke, Scott, Smyth, Spotsylvania, Tazewell, Washington, and Wythe. Known distribution among the counties of neighboring states include: Kentucky- Adair, Allen, Barren, Bell, Breckinridge, Butler, Edmonson, Floyd, Grant, Grayson, Green, Hart, Henderson, Letcher, Marion, Metcalfe, Rockcastle, Taylor, Trigg, Union, Warren, Washington, and Whitley; North Carolina- Statewide (Brimley 1938); Pennsylvania- Beaver, Bedford, Berks, Bucks, Butler, Centre, Chester, Clearfield, Cumberland, Dauphin, Delaware, Forest, Franklin, Fulton, Huntingdon, Jefferson, Juniata, Lancaster, Monroe, Northampton, Perry, Philadelphia, Pike, Somerset, Union, Wayne, and Westmoreland;

Tennessee- Greene and Sullivan. West Virginia- Mason, Monroe, Pendleton, Pocahontas, Raleigh, and Ritchie.

Virginia Records.--Alleghany Co.; Pond at Griffith, 16 May 1951, 1 male, R. L. Hoffman, (Det. LKG, Gloyd 1951); Pond at Griffith, 18 May 1950, 1 male, R. L. Hoffman, (Det. LKG, Gloyd 1951), MZUM; Pond at Griffith, 18 May 1950, 1 male, R. L. Hoffman, (Det. LKG, Gloyd 1951), MZUM. Augusta Co.; Calfpasture R. at Rt. 688, 4 June 1977, 1 male, FLC. Bath Co.; Cowpasture R. at Rt. 678, 30 May 1977, 1 female, FLC. Bedford Co.; Five Forks Cr. at Rt. 819, 16 May 1979, 1 male, BCK. Bland Co.; Picnic area along Wolf Cr. at Rt. 61, 10 June 1978, 1 male, FLC. Brunswick Co.; Waqua Cr. at Rt. 1, 15 Apr. 1978, 2 males, 1 female, FLC; Waqua Cr. at Rt. 1, 15 Apr. 1978, 2 females, SWB, FLC Collection. Charlotte Co.; Spring Cr. at Rt. 654, 18 May 1978, 7 males, 1 female, BCK, FLC Collection; Spring Cr. at Rt. 654, 18 May 1978, 6 males, 1 female, FLC; Twittys Cr. at Rt. 642, 23 May 1977, 1 male, 1 female, FLC; Twittys Cr. at Rt. 642, 23 May 1977, 1 male, SWB, FLC Collection; Twittys Cr. 1 mile upstream from Drakes Branch, 23 May 1977, 2 males, 3 females, FLC; Twittys Cr. at Rt. 642, 10 June 1975, 1 male, FLC. Craig. Co.; Johns Cr. at Rt. 632, 30 Apr. 1977, 1 male, 6 females, T. Grimes, VPI&SU; Cold Spring Branch at Rt. 611, 28 May 1977, 1 female, FLC (observation); Barbours Cr. at Rt. 614, 29 May 1977, 1 male, FLC; Potts Cr., 7 June 1975, 1 male, FLC, VPI&SU; Potts Cr. at Paint Bank, 7 June 1974, 1 male, FLC. Cumberland Co.; Rt. 624, 20 May 1979, 1 female, BCK. Dinwiddie Co.; Buckskin Cr. at Rt. 40, 15 April 1980, 1 male (teneral), FLC. Fairfax Co.; Great Falls, 30 Apr. 1915, 1 male, BPC, USNM; Great Falls, 30 Apr. 1915, 1 female, RPC, (Det. RPC, MDR notes); Great Falls, 30 Apr. 1915,

1 male, N. Banks, USNM; Great Falls, "Apr. 30-May 9" (Donnelly 1961); Hunter, 8 May 1938, 1 male, A. B. Gurney, (Det. A. B. Gurney), USNM; Great Falls, 9 May 1916, 1 female, RPC, USNM; Great Falls, 9 May 1916, 2 males, 3 females, BPC, (Det. BPC, MDR notes). Floyd Co.; Little R. at Rt. 8, 21 May 1978, 2 nymphal exuviae, FLC; Little R. at Rt. 615, 21 May 1977, 1 male, BCK, FLC Collection; Little R. at Rt. 615, 27 May 1977, 4 females (1 teneral), FLC; Little R. at Rt. 615, 3 June 1977, 9 females, FLC; Little R. at Rt. 686, 8 June 1978, 1 male, BCK. Giles Co.; Farrier farm nr. Newport, 7 May 1938, 4 males, MED, (Det. MED); Sinking Cr. at Newport Park, 18 May 1977, 1 male, BCK; Sinking Cr., 28 May 1975, 1 male, FLC; Sinking Cr. at Rt. 42, 28 May 1977, 2 males, FLC; Mt. Lake at Pond Drain Cr., 5 July 1973, 1 female, FLC; New River Park, 24 July 1974, 1 female, FLC. Grayson Co.; New R. at Rt. 58, 1 May 1977, 1 male, 1 female (teneral), FLC. Henrico Co., Richmond, 12 June 1974, 1 female, R. Kelley, VCU. Henry Co.; Koger Cr. at Rt. 58, 21 May 1978, 1 male, FLC. Highland Co.; Bullpasture R. at head of gorge, 30 May 1977, 5 males, 1 female, FLC; Back Cr. at Rt. 250, 4 June 1977, 1 female, FLC; Bullpasture R. at head of gorge, 8 June 1974, 1 female, FLC. James City Co.; Williamsburg, 20 Mar. 1937, 1 male, collector unknown, (Det. MED, MDR notes); Jollys Pd., 17 May 1966, 1 male, MDR, VPI&SU; Tutters Neck Pd., 18 May 1966, 1 female, MDR, VPI&SU; Jollys Pd., 24 May 1966, 1 female, MDR, VPI&SU. Loudoun Co.; Potomac R. at Rt. 340, 1 May 1977, 1 male (teneral), H. B. White, (Det. H. B. White, personal communication). Louisa Co.; N. Anna R. at Rt. 208, date unknown, nymph, (Roback and Westfall, 1967). Middlesex Co.; Dragon Run Swamp at Rt. 603 nr. Mascot, 13 May 1979, 1 male, R. L. Hoffman, VPI&SU. Mecklenburg Co.;

Tributary of Allens Cr. at Rt. 678, 31 May 1980, 1 female, BCK. Montgomery Co.; Toms Cr. at Rt. 655, 19 Apr. 1977, 1 male, S. Bohan, VPI&SU; Prices Fork Res. Sta., 20 Apr. 1977, 1 male (teneral), BCK; Toms Cr. at Rt. 655, 25 Apr. 1977, 1 female, S. Bohan, VPI&SU; Blacksburg, 20 May 1948, 1 male, G. M. Boush, VPI&SU; Blacksburg, 20 May 1955, 1 male, W. M. Thornton, VPI&SU; Toms Cr. March 0.5 miles downstream from Rt. 655, 24 May 1973, 1 female, FLC; Blacksburg, 25 May 1962, 1 male, H. M. Swisher, VPI&SU; Toms Cr., 27 May 1973, 1 male, FLC, VPI&SU; Pandapas Pd., 3 June 1977, 2 males, Hammond; Blacksburg, 4 June 1961, 1 female, Smith, VPI&SU; New R. nr. McCoy, 12 June 1977, 1 female, BCK; Toms Cr. at Rt. 655, 12 June 1977, 1 male, BCK, FLC Collection; Toms Cr. at Rt. 655, 12 June 1977, 1 female, BCK; Pedlar Hollow at Rt. 603, 13 June 1978, 2 males, FLC; Pandapas Pd., 14 June 1974, 3 males, FLC; Pandapas Pd., 24 June 1975, 1 male, T. Bailey, VPI&SU; Pandapas Pd., 5 July 1973, 1 male, FLC. Pittsylvania Co.; McGuff Cr. at Rt. 874, 21 May 1978, 1 male, C. Shiffer, FLC Collection; McGuff Cr. at Rt. 874, 21 May 1978, 2 males, FLC; Trotters Cr. at Rt. 863, 21 May 1978, 2 males, FLC. Prince William Co.; Broad Run at Thoroughfare Gap. 7 May 1966, 1 male, 1 female (teneral), OSF, USNM. Roanoke Co.; N. Fork Roanoke R. oxbow, 15 May 1977, 1 male, Hammond; Roanoke R. at Blueridge Parkway, 20 May 1977, 1 male, FLC; N. Fork Roanoke R. oxbow, 25 May 1977, 1 female, Hammond. Scott Co.; Clinch R. at Speers Ferry, date unknown, nymph, (Roback and Westfall, 1967); Smyth Co.; N. Fork Holston R. nr. Saltville, date unknown, nymph, (Roback and Westfall, 1967). Spotsylvania Co.; Tributary of Matta R. at Rt. 617, 29 May 1978, 4 males, 1 female, FLC. Tazewell Co.; Station Spring Cr. at Rt. 623, 10 June 1978, 1 male, BCK;

Rt. 666 at Goses Mill, 10 June 1978, 3 males, FLC; Tributary of Cove Cr. at Rt. 662, 10 June 1978, 2 males, FLC; Tributary of Cove Cr. at Rt. 662, 10 June 1978, 1 male, BCK. Washington Co.; Spoon Gap at Rt. 670, 15 June 1980, 1 male, FLC. Wythe Co.; Wytheville, 27 June 1935, 3 males, 3 females, CA, (Det. CA, MDR notes); Wytheville, 1 July 1935, 1 male, CA, (Det. CA), MZUM.

Flight Season.--Mar. 20 (VA) to Aug. 30 (PA); in Virginia Mar. 20 to July 24. Known season in neighboring states are: Kentucky- Apr. 17 to July 5; North Carolina- Mar. to May; Pennsylvania- May 1 to Aug. 30; Tennessee- Apr. 18 to June 5; West Virginia- May 15 to July 7.

Biology.--Nymphs inhabit slow-flowing, mud-bottomed streams. This species is often observed in open areas near slow-moving streams where it often exhibits the peculiar flight pattern of up and down concave loops.

Remarks.--*Gomphus lividus* is easily distinguished in the field by its relatively large size and dull coloration; probably the most common Gomphine in Virginia with the possible exception of *G. exilis*.

Gomphus minutus Rambur

(Figures 32a,36a,40a)

Rambur 1842. Ins. Neur., p. 161.

Length 43-50 mm; abdomen 32-36 mm; hind wings 26-29 mm.

Diagnosis.--Face pale yellowish-green without dark band along fronto-clypeal sulcus; female vertex without lateral spines, ocellar ridge level; female occiput with crest concave, posterior surface bilobate; inner margins of dorsal mesanepisternal stripes divergent, lateral

mesanepisternal pale stripes present, continuous, metanepisternal pale stripes present, isolated; external surface of tibiae pale; anterior hamuli each apically thumb-and-fingerslike with longest spine hooklike; posterior hamuli each with shoulder, apical hook of each keellike; apical penile segment of short type, filament not bifurcate; penile hood low inflated, receiver cleftlike; vulvar lamina ca. 1/10 length of sternum 9, cleft for 9/10 its length, lateral lobes blunt apically; male cerci each without lateral spines, ventral spine present, not visible dorsally.

Distribution.--Known from the states of FL, GA, LA, MA(?), and MS.

Flight Season.--Feb. 21 to May 12 (FL).

Biology.--Inhabits small, sandy streams.

Remarks.--Although this species has been reported from Massachusetts the record was probably based on a misdetermination. *G. minutus* very doubtfully occurs in Virginia, its inclusion here being primarily for the purpose of completeness.

Gomphus quadricolor Walsh

Syn.: *alleni* Howe

(Figures 32b,36b,40b)

Walsh 1862. Proc. Acad. Phila., p. 394.

Diagnosis.--Face light green either with or without dark band along frontoclypeal sulcus; female vertex with small lateral spines, ocellar ridge bilobed, ended behind lateral ocelli; female occiput with crest slightly convex, posterior surface slightly convex; inner margins of dorsal mesanepisternal stripes slightly divergent, lateral mesanepi-

sternal pale stripes present, discontinuous dorsad, metanepisternal pale stripes present, isolated; external surface of tibiae black; anterior hamuli each cyclelike; posterior hamuli each bird-shaped with shoulder vestigial and apical hook spinelike; apical penile segment of short type, filament not bifurcate; penile hood low inflated globose, receiver cleft-like; vulvar lamina ca. 1/8 length of sternum 9, cleft for 1/2 its length, lateral lobes blunt apically; male cerci each without lateral or ventral spines, ventral spine represented by obtusangular ridge.

Distribution.--Known from the states of AL, AR, IL, IN, KY, MA, MI, MN, NH, NY, OH, PA, TN, VA, WV, and WI, and the province of Ont. Known from the Virginia counties of Alleghany, Botetourt, and Montgomery(?). Known distribution among the counties of neighboring states include: Kentucky- Green. Pennsylvania- Bucks, Dauphin, Forest, Juniata, Lycoming, Perry, and Philadelphia. Tennessee- Cheatham. West Virginia- Hardy, Mineral, Pendleton, Pocahontas, Randolph, and Tucker.

Virginia Records.--Alleghany Co.; Pond at Griffith, 18 May 1950, 1 male, R. L. Hoffman, (Det. LKG). Botetourt Co.; Craig Cr. at Rt. 706 nr. Oriskany, 29 May 1977, 1 male, FLC. Montgomery Co.(?); Blacksburg(?).

Flight Season.--May 14 (WV) to July 6 (IN); in Virginia May 18 to 29. Known season in neighboring states are: Kentucky- May 20 to 30; Pennsylvania- May 24 to June 15; Tennessee- June 5; West Virginia- May 14 to June 20.

Biology.--Inhabits pools of rapid streams and rivers. Adults are most often observed in open areas back from the rivers. Males perch on stones at midstream where they are often very wary.

Remarks.--This species is probably much more common in Virginia than

previous records indicate.

Gomphus spicatus Hagen

(Figures 32c,36c,40c)

Hagen 1854. In Selys, Bull. Acad. Belg. 21:54.

Length 41-52 mm; abdomen 32-38 mm; hind wings 25-31 mm.

Diagnosis.--Face pale yellowish-green without dark band along fronto-clypeal sulcus; female vertex without lateral spines, ocellar ridge bilobed, extending to lateral margin of vertex; female occiput with crest undulate and convex medially, posterior surface trilobate; inner margins of dorsal mesanepisternal stripes slightly divergent, lateral mesanepisternal pale stripes absent or vestigial, metanepisternal pale stripes absent; external surface of tibiae black proximally, predominantly pale in female, predominantly black in male; anterior hamuli each cyclelike; posterior hamuli bird-shaped with low shoulder and apical hook spinelike; apical penile segment of long type, filament bifurcate; penile hood low pyramidal, receiver narrow troughlike; vulvar lamina ca. $\frac{3}{10}$ length of sternum 9, cleft for $\frac{2}{3}$ its length, lateral lobes acute apically; male cerci each with lateral and ventral spines, ventral spines not visible in dorsal view.

Distribution.--Known from the states of CT, DE, IL, IN, ME, MA, MI, MN, NH, NJ, NY, OH, PA, VT, and WI, and the provinces of N.S., Ont., and Que. Known distribution among the counties of neighboring states include: Pennsylvania- Cambria, Centre, Crawford, Elk, Erie, Luzerne, Pike, Sullivan, and Wyoming.

Flight Season.--May 4 (MA) to July 31 (Ont.). Known season in neighboring states are: Pennsylvania- May 8 to July 15.

Biology.--Nymphs inhabit marsh-bordered ponds and lakes. Adults are often observed resting on flat, sunlit surfaces near shore.

Remarks.--Although not previously collected in either West Virginia or Virginia this species may occur in beaver ponds of the central Appalachian region.

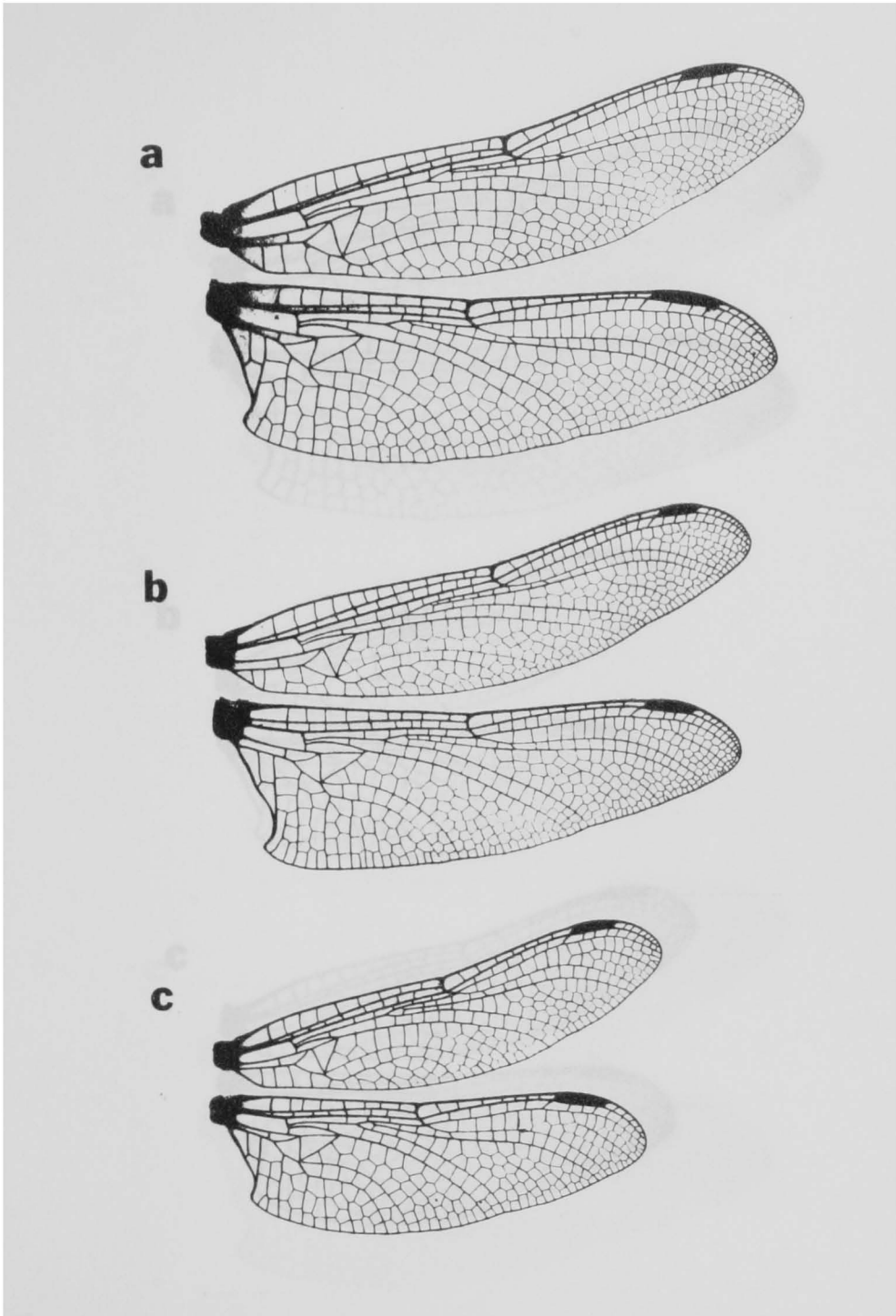


Figure 29. Wings of *Gomphus* (*Phanogomphus*) x3: (a) *G. australis*; (b) *G. borealis*; (c) *G. cavillaris*.

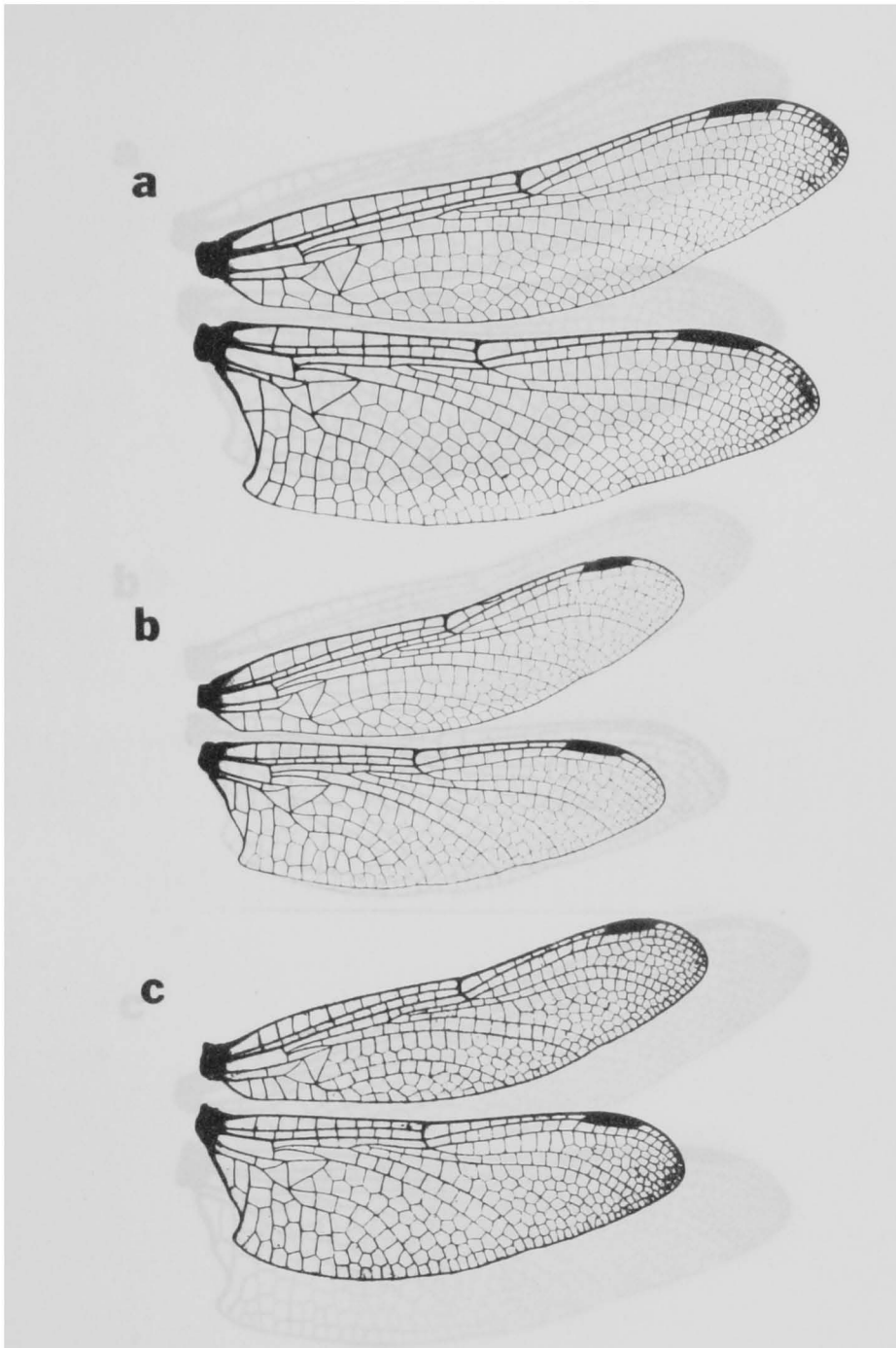


Figure 30. Wings of *Gomphus* (*Phanogomphus*) x3: (a) *G. descriptus*; *G. diminutus*; (c) *G. exilis*.

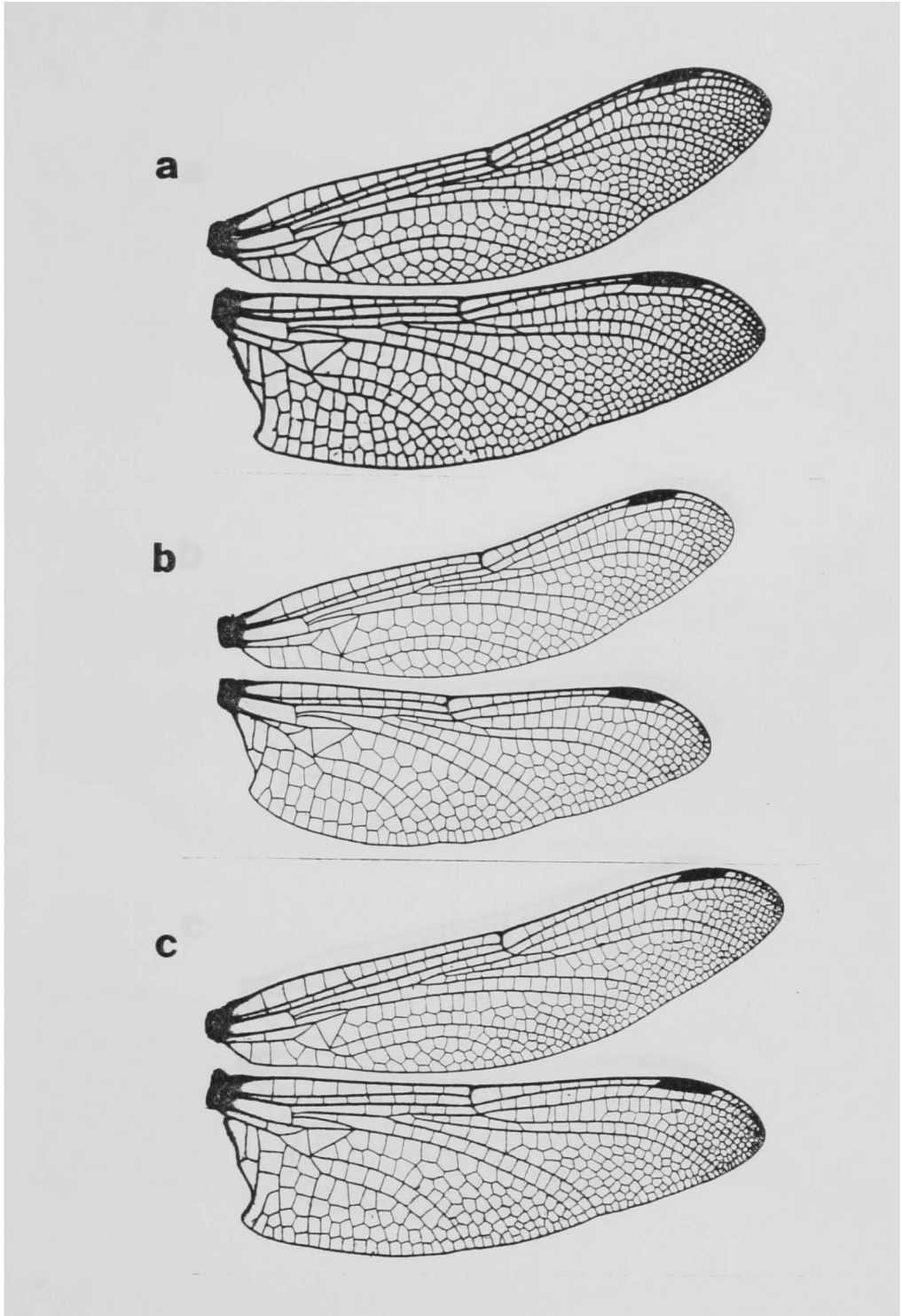


Figure 31. Wings of *Gomphus* (*Phanogomphus*) x3: (a) *G. graslinellus*; (b) *G. hodgesi*; (c) *G. lividus*.

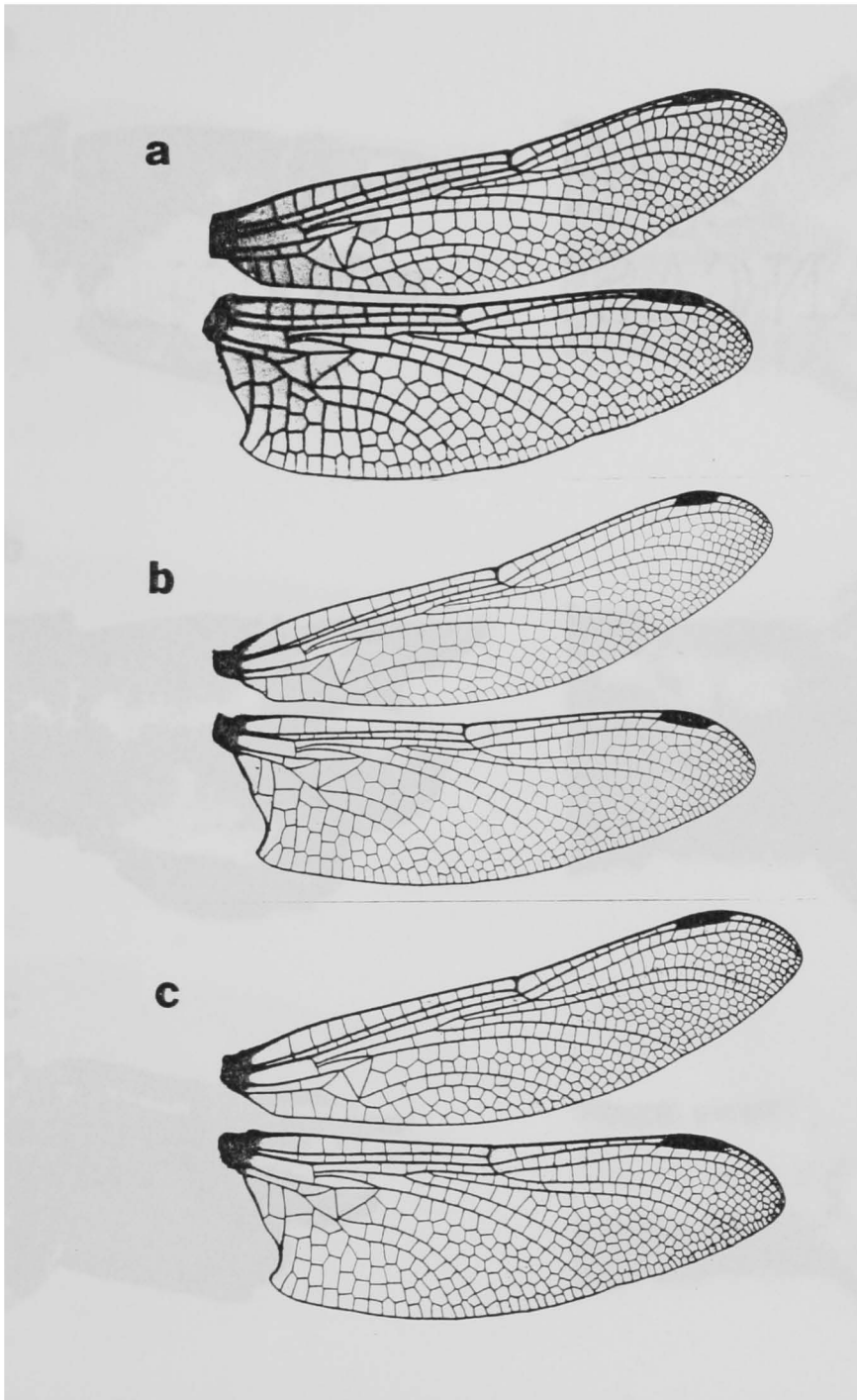


Figure 32. Wings of *Gomphus* (*Phanogomphus*) x3: (a) *G. minutus*; (b) *G. quadricolor*; (c) *G. spicatus*.

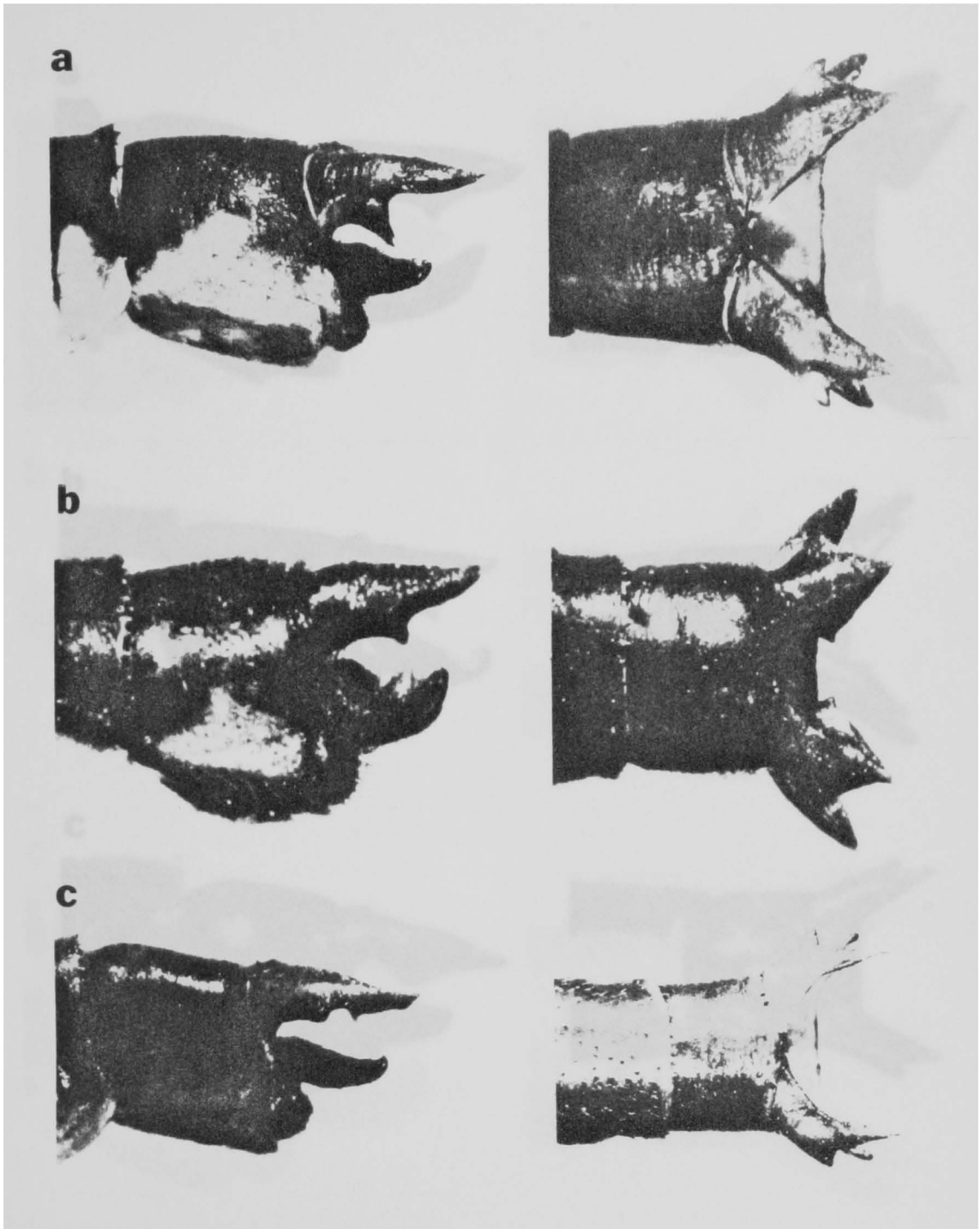


Figure 33. Male terminalia in lateral x20 and dorsal x15 view of *Gomphus* (*Phanogomphus*): (a) *G. australis*; (b) *G. borealis*; (c) *G. cavillaris*.

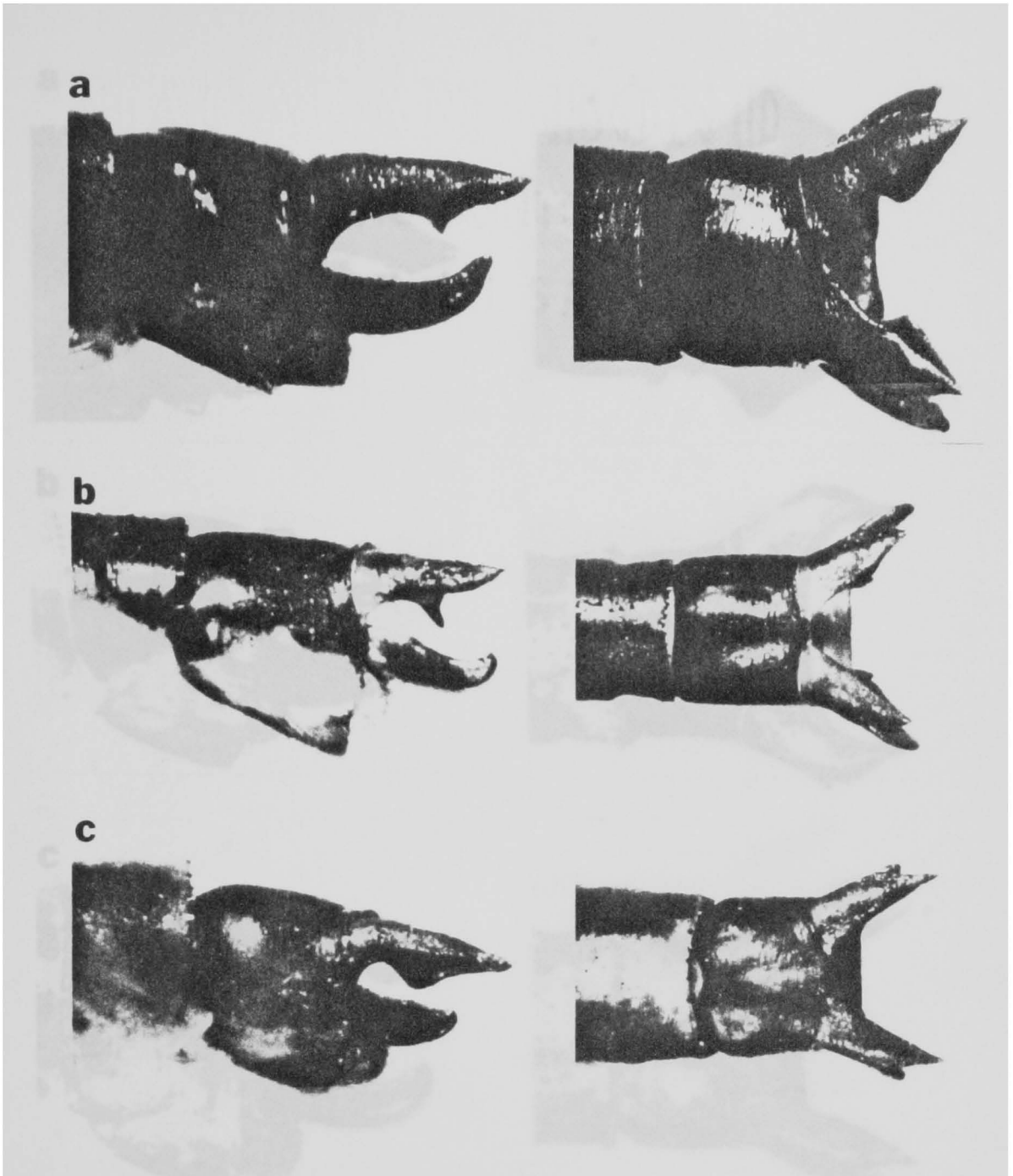


Figure 34. Male terminalia in lateral x20 and dorsal x15 view of *Gomphus* (*Phanogomphus*): (a) *G. descriptus*; (b) *G. diminutus*; (c) *G. exilis*.

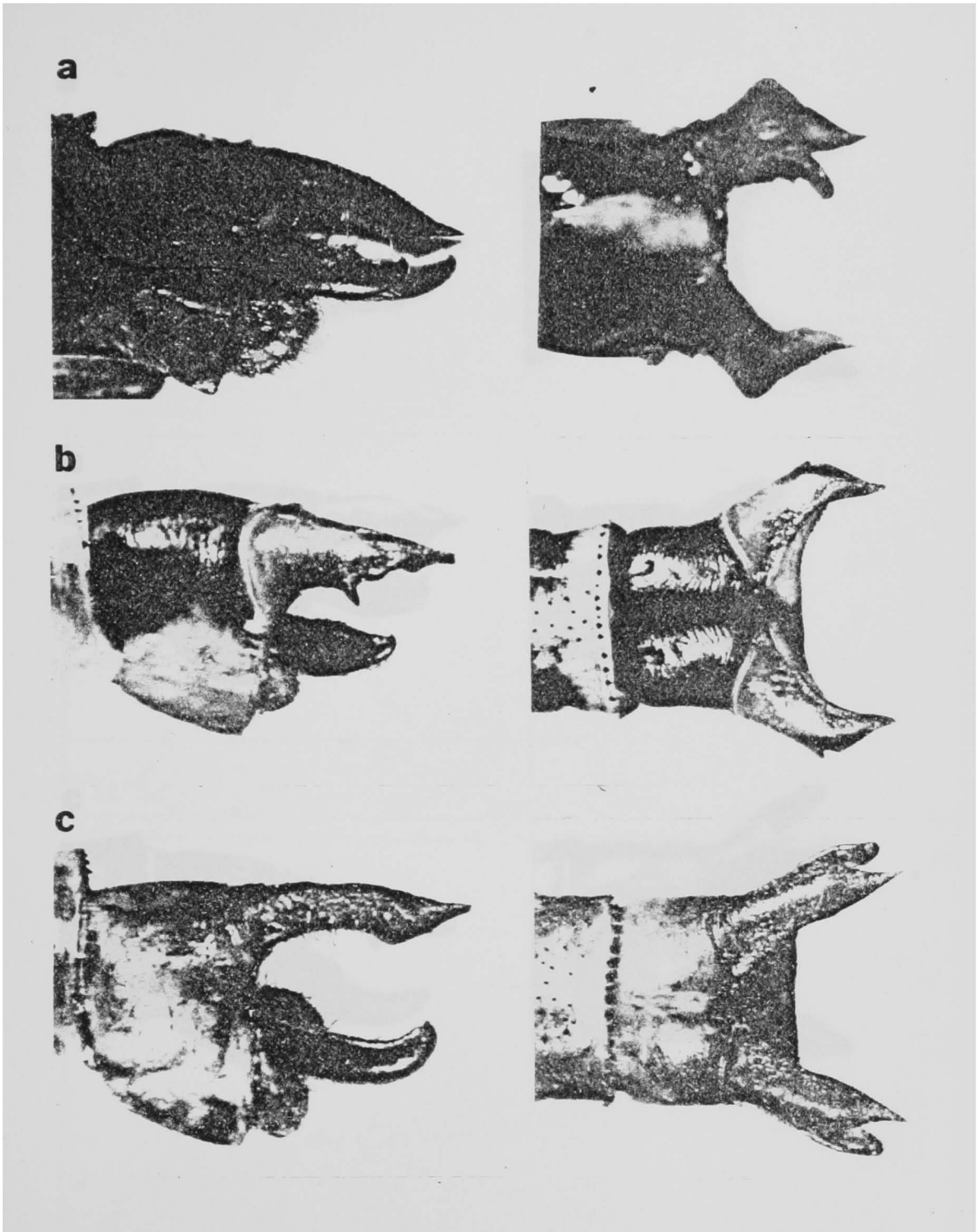


Figure 35. Male terminalia in lateral x20 and dorsal x15 view of *Gomphus* (*Phanogomphus*): (a) *G. graslinellus*; (b) *G. hodgei*; (c) *G. lividus*.

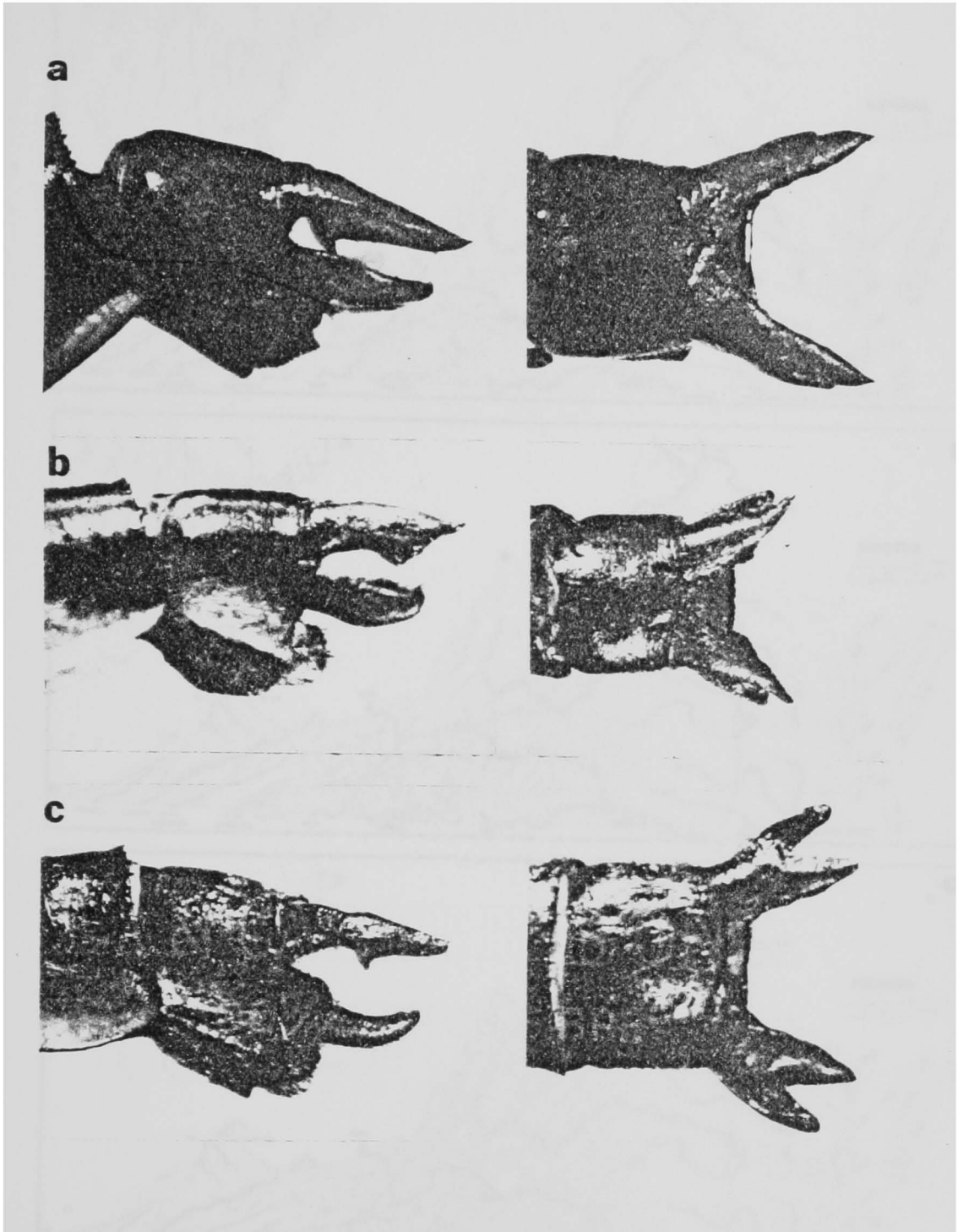


Figure 36. Male terminalia in lateral x20 and dorsal x15 view of *Gomphus* (*Phanogomphus*): (a) *G. minutus*; (b) *G. quadricolor*; (c) *G. spicatus*

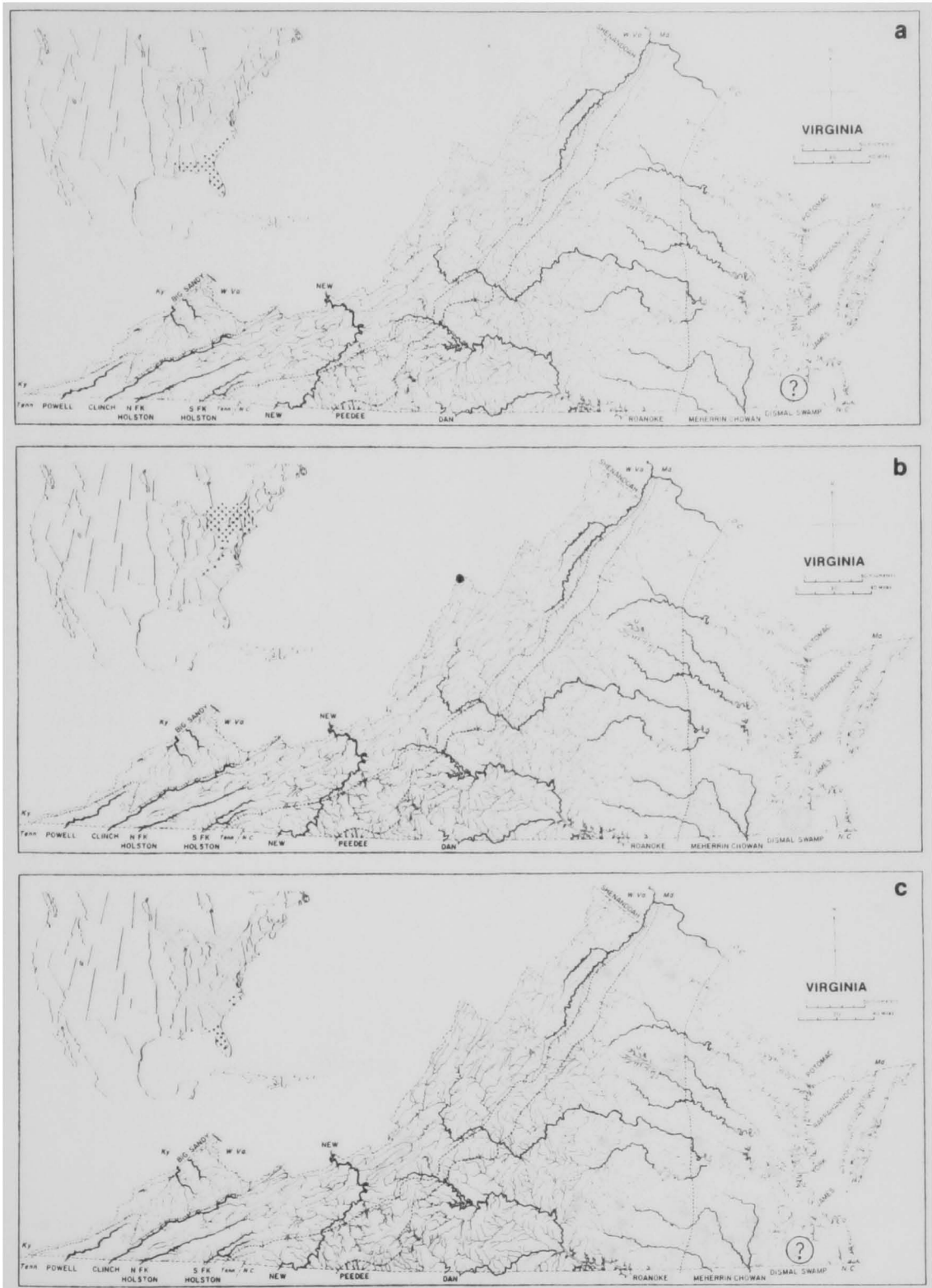


Figure 37. Geographic distribution of *Gomphus* (*Phanogomphus*):
 (a) *G. australis*; (b) *G. borealis*; (c) *G. cavillurris*.

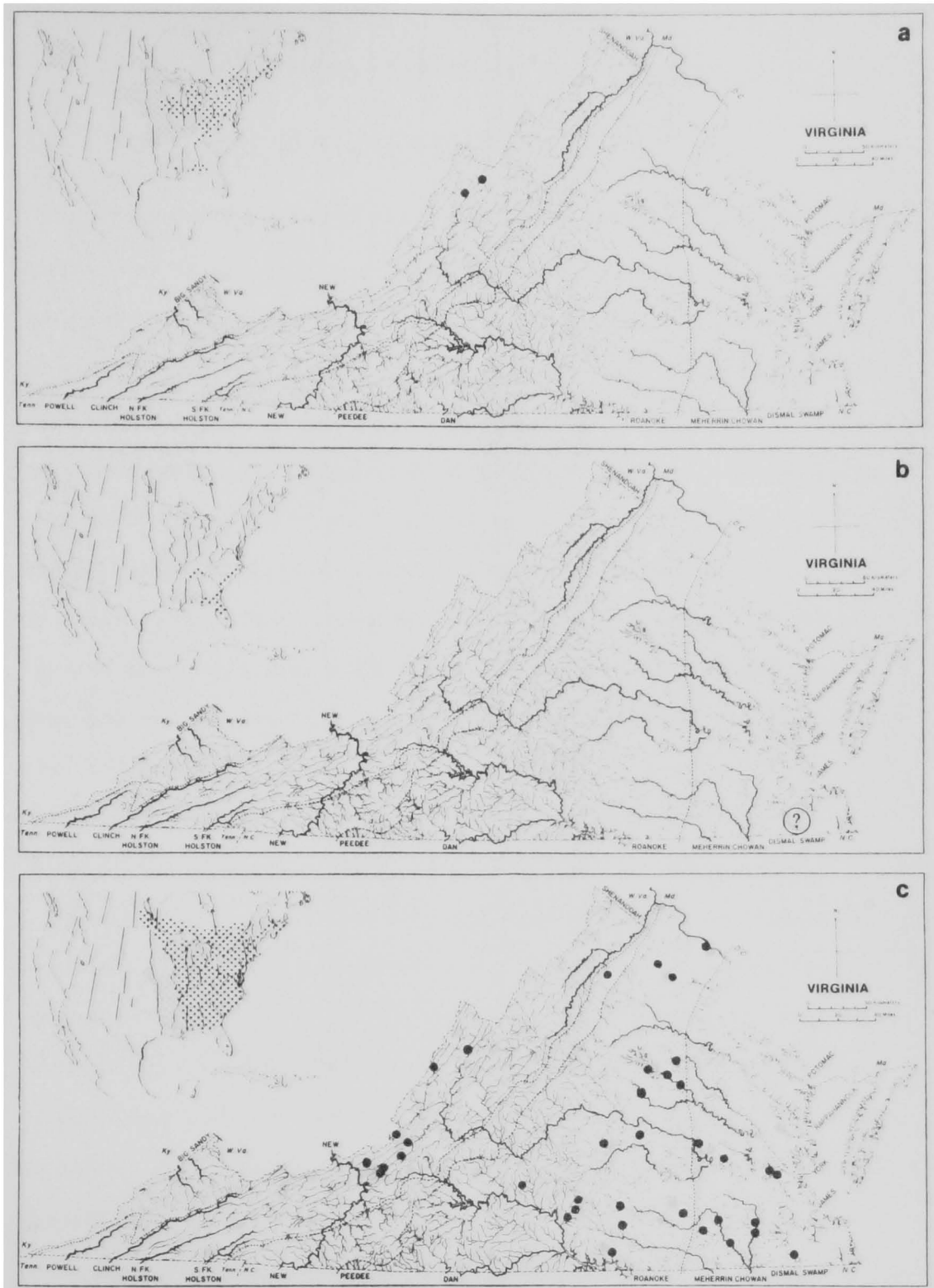


Figure 38. Geographic distribution of *Gomphus* (*Phanogomphus*):
 (a) *G. descriptus*; (b) *G. diminutus*; (c) *G. erilis*.

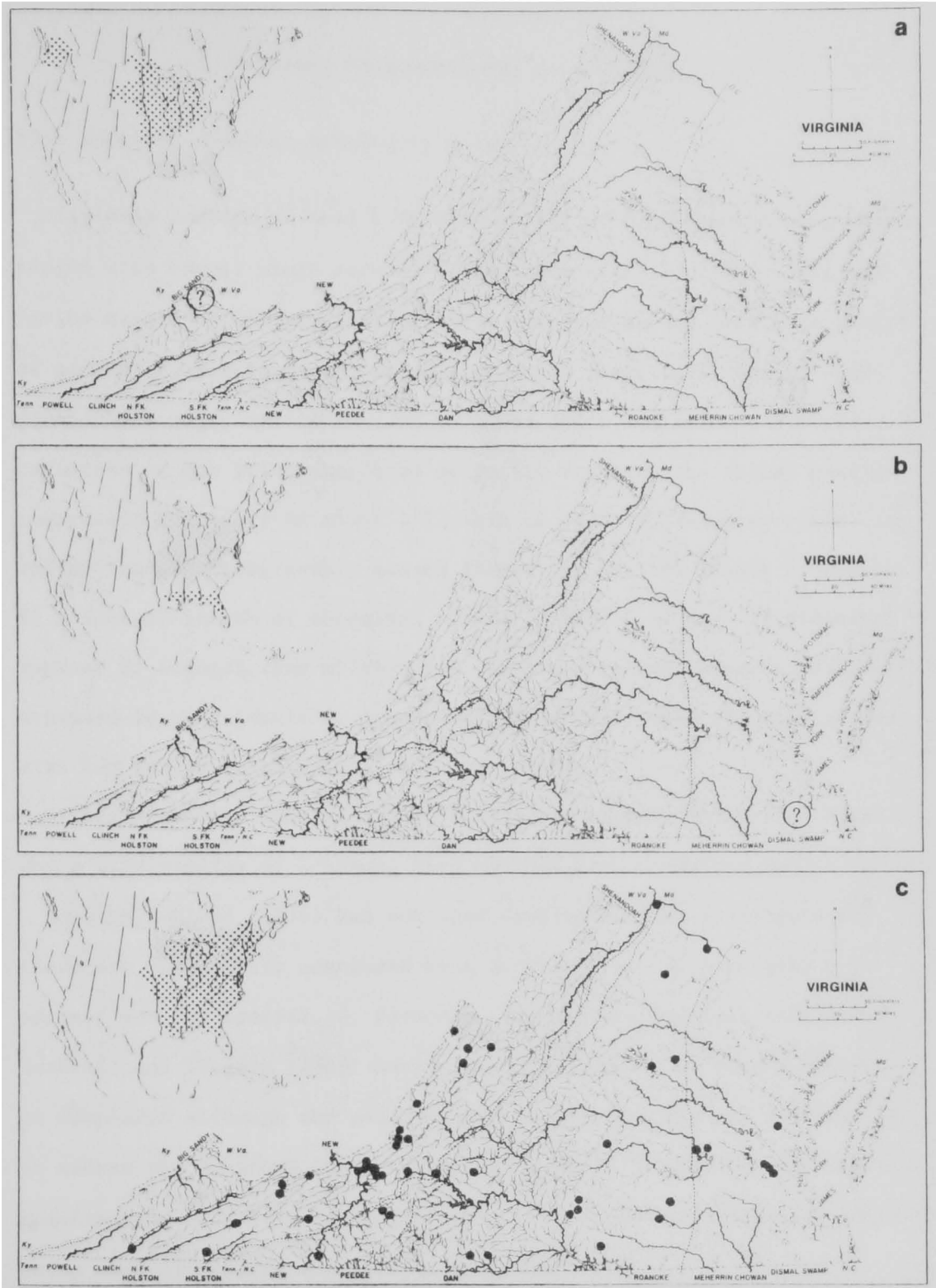


Figure 39. Geographic distribution of *Gomphus* (Phanogomphus): (a) *G. graslinellus*; (b) *G. hodgesi*; (c) *G. lividus*.

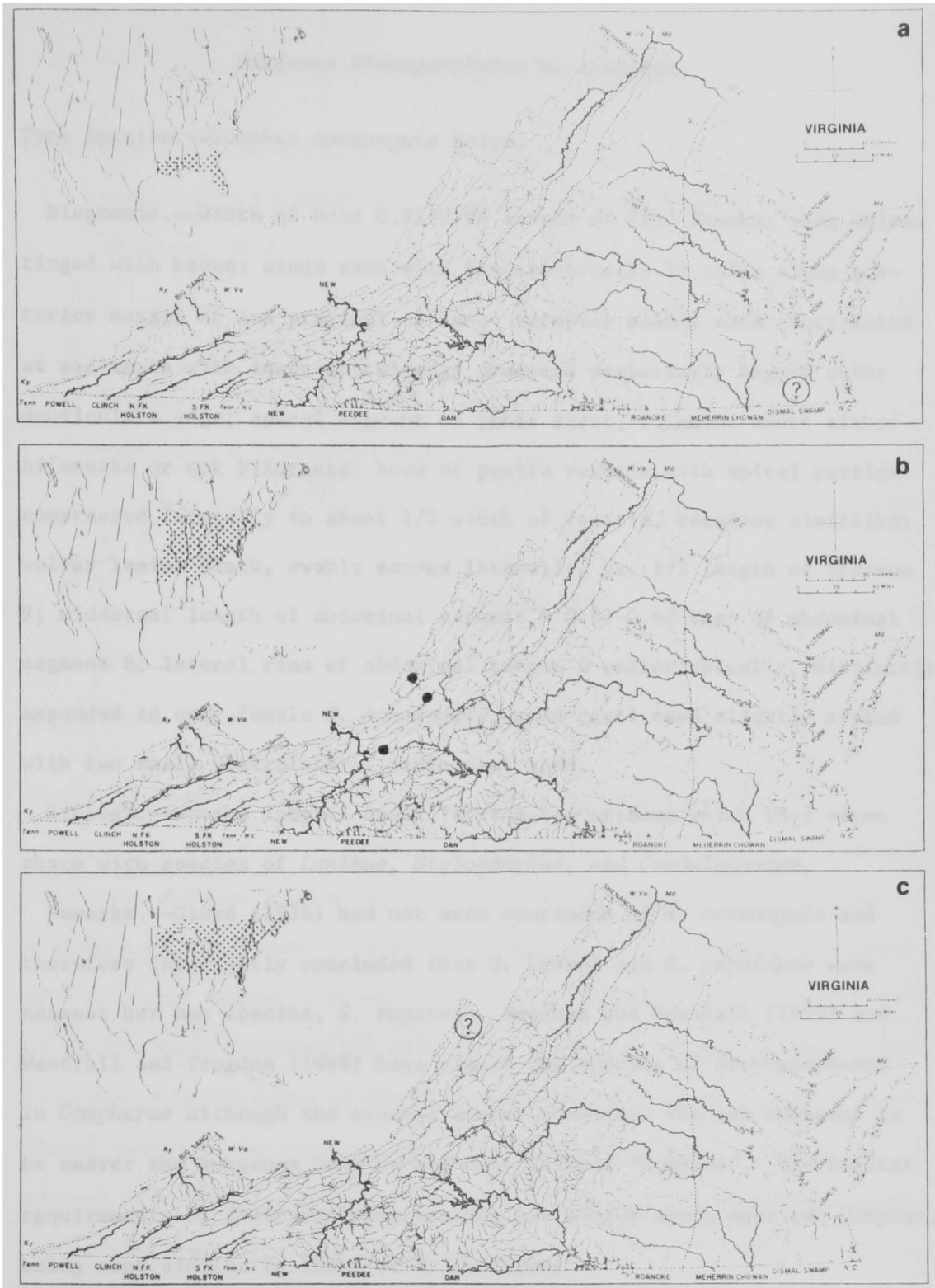


Figure 40. Geographic distribution of *Gomphus* (*Phanogomphus*):
 (a) *G. minutus*; (b) *G. quadricolor*; (c) *G. spicatus*.

Subgenus *Stenogomphurus* n. subgenus

Type Species.--*Gomphus consanguis* Selys.

Diagnosis.--Width of head 0.91-0.96 length of hind femora; wing apices tinged with brown; wings each with 4 (occasionally 5) cells along posterior margin of AnA proximal to AnA₂; anterior hamuli each constricted at midlength with inner apical edge produced posteriorly beyond outer denticulate edge; apical segment of penis short, filament short either bifurcate or not bifurcate; hood of penile vesicle with apical portion compressed laterally to about 1/2 width of vesicle, receiver cleftlike; vulvar lamina black, evenly convex laterally, ca. 1/2 length of sternum 9; middorsal length of abdominal segment 9 0.62-0.67 that of abdominal segment 8; lateral rims of abdominal tergum 8 yellow apically, distinctly expanded in only female *G. consanguis*; male cerci each slightly arched with two small ventrolateral teeth near apex.

Biology.--Nymphs inhabit small, spring-fed streams which they often share with species of *Lanthus*, *Stylogomphus*, and *Cordulegaster*.

Remarks.--Gloyd (1936) had not seen specimens of *G. consanguis* and therefore incorrectly concluded that *G. brevis* and *G. parvidens* were nearest her new species, *G. rogersi*. Needham and Westfall (1955) and Westfall and Trogdon (1966) have placed the species of *Stenogomphurus* in *Gomphurus* although the present author considers the new subgenus to be nearer the subgenus *Gomphus* and many Chinese "*Gomphus*". The habitat requirements of *Stenogomphurus* species are unique among American *Gomphus*, being most similar to those of *G. parvidens*

Species Key to Adult *Gomphus* (*Stenogomphurus*)

1. Occiput predominantly pale; posterior margin of penile hood angulate, penile filament not bifurcate; lateral lobes of vulvar lamina ca. as long as wide, blunt apically
 *G. consanguis* p. 330
- Occiput predominantly black; posterior margin of penile hood not angulate, penile filament bifurcate; lateral lobes of vulvar lamina ca. 1.5 times as long as wide, acute apically
 *G. rogersi* p. 331

Gomphus consanguis Selys

(Figures 41a, 42a, 43a)

Selys 1879. C. R. Soc. Entomol. Belg. 22:66.

Length 44-49 mm; abdomen 33-37 mm; hind wings 29-34 mm.

Diagnosis.--Labrum with central black spot; vertex with posteromedial pale spot; occiput predominantly black; dorsal mesanepisternal pale stripes broadly connected to pale collar stripes; posterior hamuli each with shoulder distinct; apical penile segment shorter than anterior face of penile hood, filament not bifurcate; posterior surface of penile hood angulate; lateral lobes of vulvar lamina ca. as long as wide with apices blunt; lateral rims of tergum 8 in female expanded ca. 1/4 length of segment 8 (width of rim measured from edge of internal membranous area).

Distribution.--Known from the states of AL(?), NC, TN, and VA. Known from the Virginia county of Washington. Known distribution among the

counties of neighboring states include: Tennessee- Campbell and Sullivan.

Virginia Records.--Washington Co.; tributary of Spring Cr. along Rt. 663, 20 May 1978, 1 nymph, FLC; tributary of Spring Cr. along Rt. 663, 15 June 1980, 3 nymphs, FLC; tributary of Spring Cr. along Rt. 663, 15 June 1980, 8 males, 1 female, FLC.

Flight Season.--May 12 (AL)(?) to June 25 (NC); in Virginia May 20 to June 15. Known season in neighboring states are: Tennessee- May 20 to June 29.

Biology.--Nymphs inhabits small, mud-bottomed, spring-fed streams. Adults have not been observed more than 5 m from shore where the males typically alight upon sunlit vegetation. The behavior and flight of this species is most similar to that of *G. rogersi* and *G. parvidens*. This species prefers sunlit openings even more so than does *G. rogersi*, and also tends to hover more and patrol less than *G. rogersi*.

Remarks.--Although the lateral margin of tergum 8 is expanded, it is yellow apically, not black apically as in *Gomphurus*.

Gomphus rogersi Gloyd

(Figures 41b,42b,43b)

Gloyd 1936. Occ. Pap. Mus. Zool. Univ. Mich. 326:1.

Length 47-50 mm; abdomen 35-38 mm; hind wings 31-37 mm.

Diagnosis.--Labrum divided by black band; vertex without posteromedial pale spot; occiput predominantly black; dorsal mesanepisternal pale stripes separated or narrowly connected to pale collar stripe; posterior hamuli each with shoulder rounded, apparently absent; apical penile segment

longer than anterior face of penile hood, filament bifurcate; posterior surface of penile hood not angulate; lateral lobes of vulvar lamina ca. 1.5 times as long as wide with apices acute; lateral rims of tergum 8 in female expanded ca. 1/8 length of segment 8 (width of rim measured from edge of internal membranous area).

Distribution.--Known from the states of AL(?), KY, NC, PA, TN, VA, and WV. Known from the Virginia counties of Spotsylvania and Washington. Known distribution among the counties of neighboring states include: North Carolina- Buncombe, Jackson, and Macon. Tennessee- Fentress, Greene, and Pickett. Pennsylvania- Butler, Centre, Clearfield, Elk, Forest, Franklin, Huntingdon, and Somerset. West Virginia- Raleigh.

Virginia Records.--Spotsylvania Co.; Tributary of Matta R. at Rt. 617, 29 May 1978, 1 male (in emergence), 1 female (in emergence), 1 female (teneral), 1 male nymph (emerged 29 May 1978), 1 female nymph (emerged 2 June 1978), 32 nymphal exuviae, FLC; Tributary of Matta R. at Rt. 617, 7 July 1978, 3 males, FLC. Washington Co.; Spoon Gap at Rt. 670, 15 June 1980, 2 males, 3 nymphs, FLC; Tributary of Spring Cr. at Rt. 663, 15 June 1980, 2 males, FLC.

Flight Season.--May 12 (TN) to July 7 (VA); in Virginia May 29 to July 7. Known season in neighboring states are: North Carolina- May to June 30; Tennessee- May 12 to June 18; Pennsylvania- May 24 to June 31.

Biology.--Inhabits small muddy-bottomed, spring-fed streams. Adults have not been observed more than 30 m from streamside where the males typically alight upon sunlit vegetation. The adults prefer areas along streams which are open to sunlight but unlike *G. consanquis*, *G. rogersi* males have been observed patrolling shaded portions of small streams.

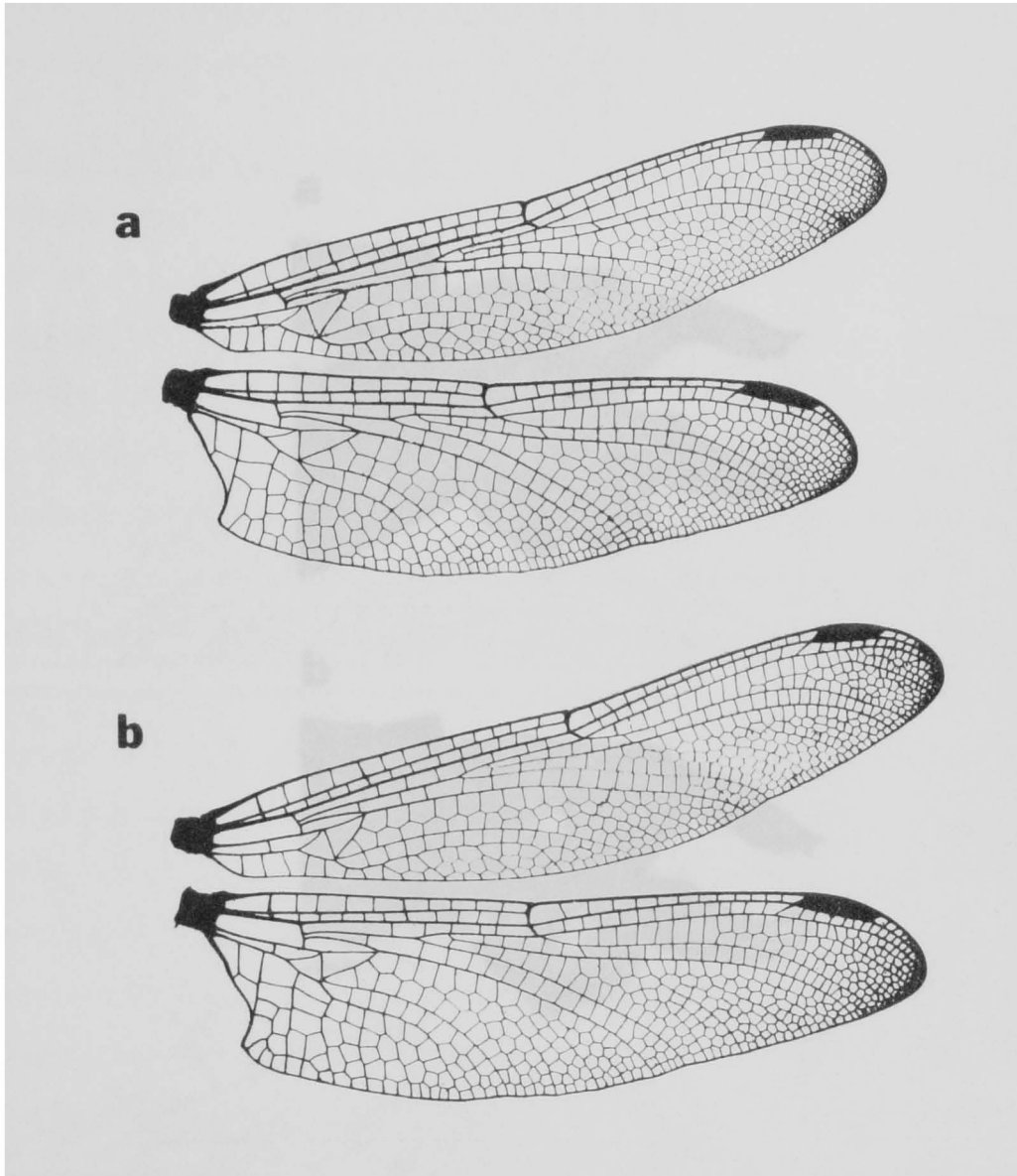


Figure 41. Wings of *Gomphus* (*Stenogomphurus*) x3: (a) *G. consanguis*; (b) *G. rogersi*.

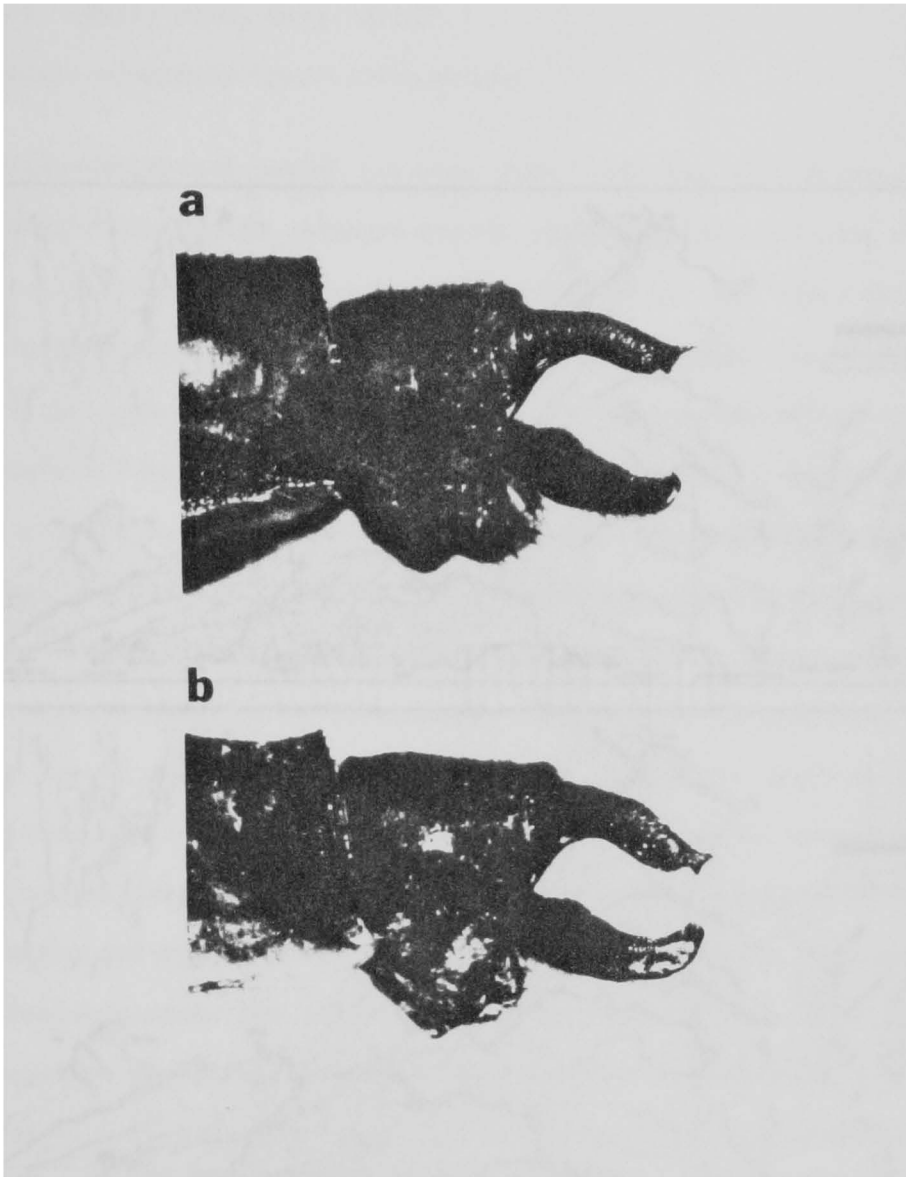


Figure 42. Male terminalia in lateral view of *Gomphus* (*Stenogomphurus*) x18: (a) *G. consanguis*; (b) *G. rogersi*.

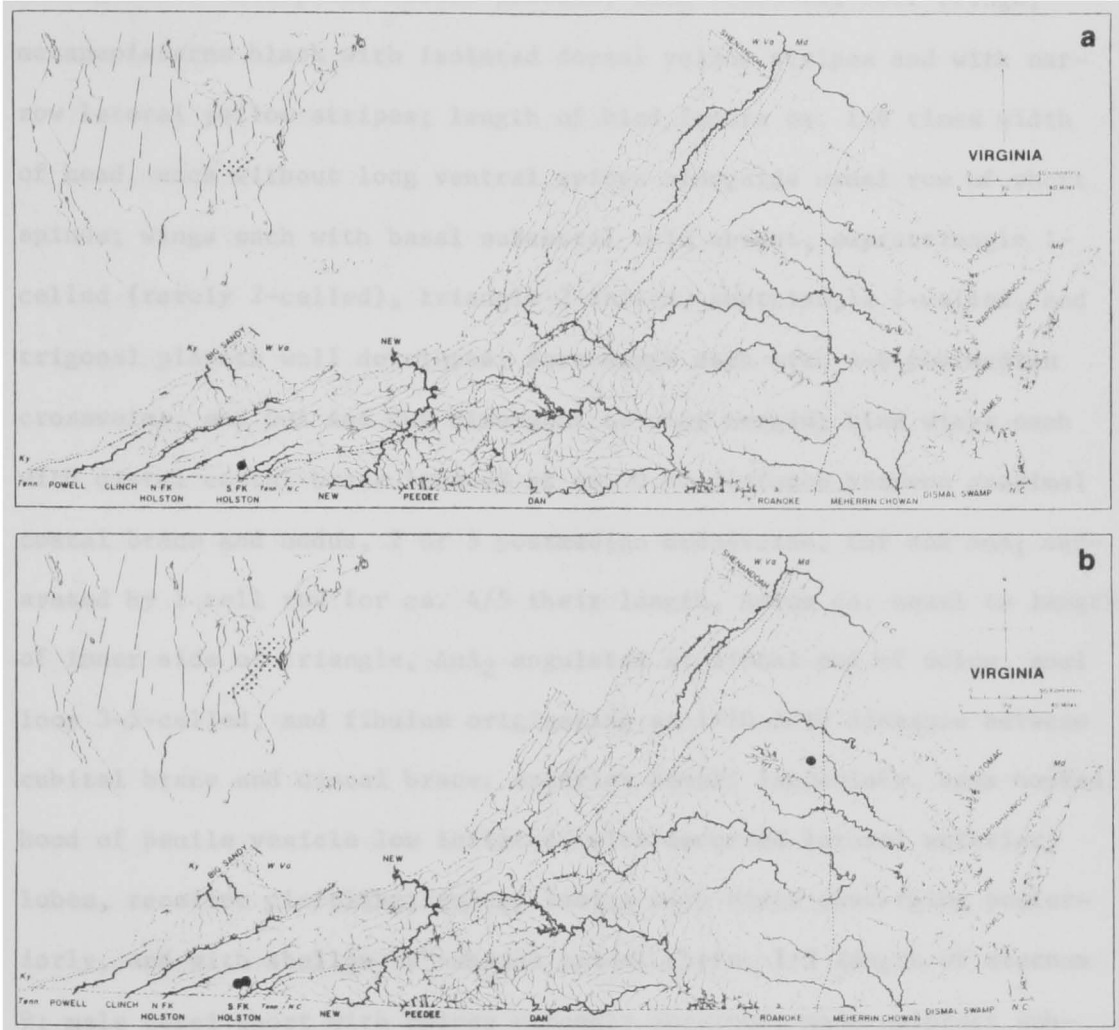


Figure 43. Geographic distribution of *Gomphus* (*Stenogomphurus*):
 (a) *G. consanguis*; (b) *G. rogersi*.

Genus *Hagenius* Selys 1854

Selys 1854. Bull. Acad. Belg. 21:82.

Type Species.--*Hagenius brevistylus* Selys.

Diagnosis.--Occipital carina present, with occipital hair fringe; mesanepisterna black with isolated dorsal yellow stripes and with narrow lateral yellow stripes; length of hind femora ca. 1.6 times width of head, each without long ventral spines alongside usual row of short spines; wings each with basal subcostal vein absent, supratriangle 1-celled (rarely 2-celled), triangle 2-celled, subtriangle 1-celled, and trigonal planate well developed; fore wings each with 4-6 postmedian crossveins, and CuA and CuP divergent to wing margin; hind wings each with distal costal brace located at ca. 0.45 distance between proximal costal brace and nodus, 2 or 3 postmedian crossveins, CuP and AnA₁ separated by 1 cell row for ca. 4/5 their length, solum ca. equal to length of inner side of triangle, AnA₂ angulated at distal end of solum, anal loop 3-5-celled, and fibulum originating at 1/10-3/10 distance between cubital brace and discal brace; anterior hamuli lanceolate, apex hooked; hood of penile vesicle low inflated, with decurved lateral anterior lobes, receiver cleftlike; vulvar lamina with sides converging posteriorly, and with shallow "V"-shaped apical cleft, 1/3 length of sternum 9; male cerci short with apices strongly decurved; male epiproct subquadrate, about as long as cerci.

Hagenius brevistylus Selys

(Figures 44, 45)

Selys 1854. Bull. Acad. Belg. 21:82.

Length 68-90 mm; abdomen 50-63 mm; hind wings 44-58 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AL, AR, CT, DC, FL, GA, IL, IN, KS, KY, LA, ME, MD, MA, MI, MN, MS, MO, NH, NJ, NY, NC, OH, OK, PA, SC, TN, TX, VT, VA, WV, and WI, and the provinces of Man., N.B., N.S., Ont., and Que. Known from the Virginia counties of Alleghany, Bath, Botetourt, Charles City, Charlotte, Craig, Culpeper, Fairfax, Floyd, Louisa, Montgomery, Nelson, Prince William, Rockbridge, Scott, and Warren. Known distribution among the counties of neighboring states include: Kentucky- Adair, Allen, Barren, Bell, Butler, Carter, Edmonson, Green, Harrison, Metcalfe, Oldham, Rockcastle, Trigg, and Warren; Maryland- Montgomery, Prince Georges, Wicomico, and Worcester; North Carolina- McDowell, Moore, and Wake; Pennsylvania- Beaver, Bucks, Butler, Centre, Chester, Clinton, Columbia, Cumberland, Dauphin, Delaware, Erie, Fayette, Franklin, Fulton, Huntingdon, Juniata, Lycoming, Mifflin, Northampton, Perry, Philadelphia, Pike, Somerset, Union, and Wayne; Tennessee- Anderson, Blount, Cheatham, Coffee, Hawkins, Lewis, Marion, and Monroe; West Virginia- Hampshire, Monroe, Morgan, Pendleton, and Ritchie.

Virginia Records.--Alleghany Co.; Jackson R. at Falling Spring, 5 July 1973, 1 male, FLC. Bath Co.; Douthat Lk. at Rt 629, 27 June 1973, 1 male, SWD; Cowpasture R. at Rt. 632 S. of Nimrod Hall, 29 June 1973, 1 male, SWD; Jackson R. 1 mile N. of Greenwood, 10 July 1973, 1 male, 2

females, FLC. Botetourt Co.; Cowpasture R. at Rt. 60, 4 June 1977, 1 male (teneral), FLC; Pine Campground 15 miles N.E. of Newcastle at Rt. 617, 27 June 1973, 1 male, SWD. Charles City Co.; Harrison Lk. at Roxbury, 14 Mar. 1938, nymphs, R. Hess, (Det. A. D. Hess), A. D. Hess Collection. Charlotte Co.; Twittys Cr. at Rt. 642, 22 July 1978, 1 male, FLC. Craig Co.; Johns Cr. at Rt. 311, 14 June 1974, 1 male, FLC; Johns Cr. at Rt. 311, 22 July 1977, 1 male, FLC; Johns Cr. at Rt. 311, 12 Aug. 1973, 1 male, FLC. Culpeper Co.; Buzzard Mtn. 3 miles N. of Rapidan, 17 June 1956, 1 male, A. B. Gurney, USNM; Hazel R. at Rt. 707, 7 July 1979, 1 male, 1 female, BCK. Fairfax Co.; Great Falls, 17 June 1914, 1 male, BPC, USNM; Great Falls, 17 July 1914, 1 male, BPC, USNM; Bull Run Cr., 14 Aug. 1980, 1 male, BCK; Bull Run Cr., 16 Aug. 1970, 2 males, OSF, USNM. Floyd Co.; Little R. at Rt. 615, 27 May 1977, 1 nymphal exuviae, FLC; Little R. at Rt. 615, 3 June 1977, 2 males (teneral), FLC. Louisa Co.; 4 miles N.W. of Mineral, 10 July 1953, 1 male, R. L. Hoffman, (Det. LKG); N. Anna R. at Rt. 601, 21 July 1977, 1 male, BCK; S. Anna R. at Rt. 522, 19 Aug. 1977, 1 male, 1 female, JRV, BCK Collection; S. Anna R. at Rt. 522, 19 Aug. 1977, 1 female, BCK; S. Anna R. at Rt. 522, 2 Sept. 1977, 1 male, BCK. Montgomery Co.; Toms Cr. at Blacksburg, 11 Aug. 1978, 1 male, FLC. Nelson Co.; locality unknown, 19 June 1925, WR, USNM; locality unknown, 20 June 1928, 1 male, WR, (Det. WR, MDR notes), USNM; locality unknown, 5 July 1924, 1 female, WR, (Det. WR, MDR notes), USNM; locality unknown, 9 July 1924, 1 female, WR, USNM; locality unknown, 20 July 1928, 1 male, 1 female, WR, USNM; locality unknown, 30 July 1928, 1 male, WR, USNM; locality unknown, 30 July 1928, 1 female, WR, (Det. WR, MDR notes), USNM. Prince William Co.; Broad

Run at Lk. Jackson, "June 17 to Sept. 11", (Donnelly 1961); Broad Run nr. Independent Hill below Lk. Jackson, 15 Aug. 1953, 1 male, TWD, (Det. TWD, TWD field notes); Broad Run at Rt. 55, 10 Aug. 1978, 1 male, FLC. Rockbridge Co.; Brattons Run at Rt. 618, 16 June 1979, 1 female, BCK. Scott Co.; Clinchport, 13 Aug. 1899, 1 nymph, C. C. Adams, (Det. E. B. Williamson, Williamson 1903). Warren Co.; Gooney Run 0.4 miles N. of Browntown at Rt. 649, 6 July 1975, 1 male, FLC and SWB, FLC Collection. Wythe Co.; Wytheville, 26 June 1935, 1 male, CA, (Det. CA), MZUM; Wytheville, 27 June 1935, 1 female, CA, (Det. CA).

Flight Season.--May 13 (FL) to Nov. 8 (FL); in Virginia May 27 to Sept. 2. Known season in neighboring states are: D.C.- June 17 to Sept. 11; Kentucky- June to Aug.; Maryland- June 17 to Sept. 11; North Carolina- June 28; Pennsylvania- Apr. 24 to Sept. 15; Tennessee- July 8 to Aug. 30; West Virginia- June 4 to Aug. 3.

Biology.--Inhabits streams and rivers. Males of this huge Gomphine patrol at about 1 meter above the water in a somewhat undulating but strong flight. The males prefer to perch on stems or narrow branches which they often seemingly "sit" on owing to their habit of supporting themselves not with the tarsi but with the inner spinose surface of the femora. The feeding habits of this dragonfly are similar to those of *Tachopteryx thoreyi* in that it prefers other dragonflies and large Lepidoptera. The female oviposits by hovering 10-20 cm above the water and then dropping to slap the water and then rise in a circular motion to hover and then repeat the sequence.

Remarks.--These are the largest gomphines, their nearest relatives are found in the Oriental region.

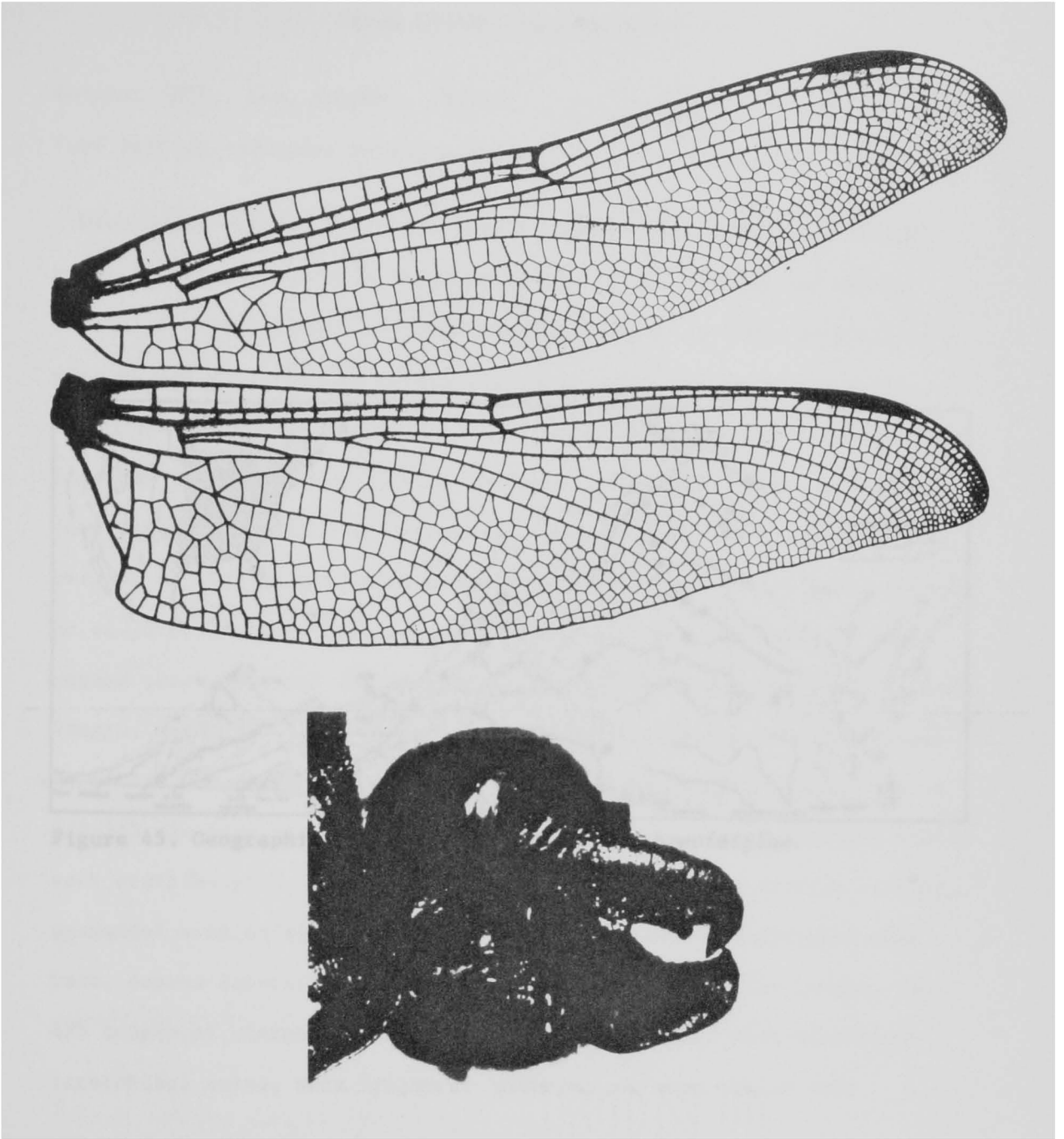


Figure 44. Wings x3 and male terminalia in lateral view x23 of *Hagenius brevistylus*.

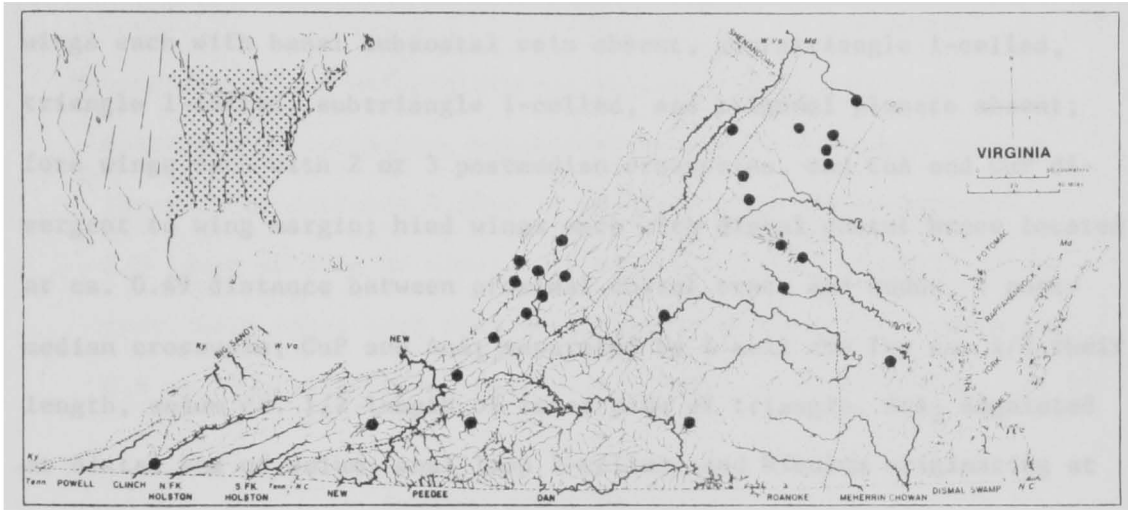


Figure 45. Geographic distribution of *Hagenius brevistylus*.

Genus *Lanthus* Needham 1897

Needham 1897. Can. Entomol. 29:166.

Type Species.--*Gomphus parvulus* Selys.

Diagnosis.--Occipital carina absent, without occipital hair fringe; mesanepisterna black with isolated dorsal yellow stripes and narrow lateral stripes; length of hind femora ca. equal to width of head, each without 4-7 long ventral spines alongside usual row of short spines; wings each with basal subcostal vein absent, supratriangle 1-celled, triangle 1-celled, subtriangle 1-celled, and trigonal planate absent; fore wings each with 2 or 3 postmedian crossveins, and CuA and CuP divergent to wing margin; hind wings each with distal costal brace located at ca. 0.49 distance between proximal costal brace and nodus, 1 postmedian crossvein, CuP and AnA₁ separated by 1 cell row for ca. 1/2 their length, solum ca. 1/2 length of inner side of triangle, AnA₂ angulated at distal end of solum, anal loop 1-celled, and fibulum originating at 1/2-3/5 distance between cubital brace and discal brace; anterior hamuli each stublike with narrow apical cleft; hood of penile vesicle stalked pyramidal with widely cleft receiver; vulvar lamina constricted near base, convex laterally with wide apical cleft for 1/3 its length, 3/5-4/5 length of sternum 9; male cerci black, acuminate each with stout laterobasal spine; male epiproct square-cut between robust rami.

Species Key to Adult *Lanthus* of North America

1. Mesanepimeral and metanepisternal yellow stripes not confluent above metathoracic spiracles, metanepisternal yellow stripes often divided; interocular distance 0.80-1.00 mm; fore wing pterostigmata 3.1-4.0 times as long as wide; male epiproctal rami strongly divergent, male cerci each with ventrobasal tubercle, vulvar lamina ca. 1.0 mm long with "V"-shaped apical cleft
 *L. parvulus* p. 343
- Mesanepimeral and metanepisternal yellow stripes confluent above metathoracic spiracles, metanepisternal yellow stripes entire; interocular distance 0.56-0.77 mm; fore wing pterostigmata 2.4-3.0 times as long as wide; male epiproctal rami slightly divergent, male cerci each with ventrobasal spine; vulvar lamina ca. 0.8 mm long with "U"-shaped apical cleft . . *L. vernalis* p. 345

Lanthus parvulus (Selys)

(Figures 46a, 47a, 48a)

Selys 1854. Bull. Acad. Belg. 21:56 (in *Gomphus*).

Length 34-40 mm; abdomen 24-30 mm; hind wings 21-24 mm.

Diagnosis.--Face greenish-yellow with dark band across frontoclypeal sulcus; vertex without spines or horns; occiput inflated without crest; dorsal separation of compound eyes 0.80-0.91 mm in male, 0.83-1.00 mm in female; dorsal mesanepisternal yellow stripes widely separated from yellow collar stripe; metanepisternal pale stripes often represented by

2 subtriangular spots and not confluent with mesanepimeral pale stripes above metathoracic spiracles; fore wing pterostigmata 3.1-4.0 times as long as wide, posterior margin of penile hood as long as apical margin; vulvar lamina ca. $\frac{4}{5}$ length of sternum 9 with "V"-shaped apical cleft; male cerci each with ventrobasal tubercle, lateral margins of epiproct strongly divergent.

Distribution.--Known from the states of ME, NH, NY, PA, VT, VA, and WV, and the provinces of N.B., N.S., and Que. Known from the Virginia counties of Highland and Montgomery. Known distribution among the counties of neighboring states include: Pennsylvania- Centre and Huntingdon; West Virginia- Hampshire and Raleigh.

Virginia Records.--Highland Co.; Locust Spring Run, 10 June 1979, 1 male with exuviae (in emergence), BCK. Montgomery Co.; Mill Cr. at Rt. 785, 12 Apr. 1979 (emerged 22 Apr. 1979), 1 male nymph, E. J. B., VPI&SU. Poverty Cr. at Pandapas Pd., 16 Apr. 1977, 1 male, S. Johnson, VPI&SU.

Flight Season.--Apr. 16 (VA) to June 28 (WV); in Virginia Apr. 16 to June 10 (teneral). Known season in neighboring states are: Pennsylvania- June 11 to 13; West Virginia- May 14 to June 28.

Biology.--Nymphs inhabit small spring-fed streams. Adults are seldom observed and rarely collected. Nymphs are found among small accumulations of mud and debris at the bottom of pools. Adult males apparently alight upon emergent boulders where they are difficult to detect.

Remarks.--*Lanthus parvulus* is primarily a boreal species which has been taken from the vicinity of mountain springs in Virginia.

Lanthus vernalis Carle

(Figures 46b,47b,48b)

Carle 1980. Ann. Entomol. Soc. Am. 73:172.

Length 29-40 mm; abdomen 21-29 mm; hind wings 20-24 mm.

Diagnosis.--Face greenish-yellow with dark band across frontoclypeal sulcus; vertex without spines or horns; occiput inflated without crest; dorsal separation of compound eyes 0.56-0.74 mm in male, 0.58-0.77 in female; dorsal mesanepisternal yellow stripes narrowly if at all separated from yellow collar stripe; metanepisternal pale stripes well developed and confluent with mesanepimeral pale stripes above metathoracic spiracles; fore wing pterostigmata 2.4-3.0 times as long as wide, posterior margin of penile hood shorter than apical margin; vulvar lamina ca. 2/3 length of sternum 9 with "U"-shaped apical cleft; male cerci each with ventrobasal spine, lateral margins of epiproct slightly divergent.

Distribution.--Known from the states of CT, GA, KY, ME, MA, NJ, NY, NC, PA, SC, TN, VT, VA, and WV. Known from the Virginia counties of Alleghany, Bath, Craig, Grayson, Greene, Highland, Madison, Page, Patrick, Rockbridge, Shenandoah, and Tazewell. Known distribution among the counties of neighboring states include: Kentucky- Harrison. North Carolina- Macon, Swain, and Transylvania. Pennsylvania- Allegheny, Beaver, Berks, Butler, Cambria, Centre, Clarion, Clearfield, Clinton, Delaware, Elk, Erie, Forest, Huntingdon, Lebanon, Lycoming, Monroe, Northampton, Perry, Potter, Sullivan, Tioga, Union, Warren, Wayne, Westmoreland, and York. Tennessee- Greene.

Virginia Records.--Alleghany Co.; Mill Branch at Rt. 607, 12 Oct. 1972,

1 nymph, FLC. Bath Co.; Lick Run at Rt. 634, 29 Oct. 1972, 1 nymph, FLC; Big Spring at Rt. 629, 18 June 1978, 1 male, FLC. Craig Co.; Cove Branch, 12 Oct. 1972, 3 nymphs, FLC; Seep nr. Potts Bog, 14 July 1974, 1 female, FLC. Grayson Co.; Lewis Fork at Rt. 603, 24 May 1980, 1 male with exuviae (in emergence), BCK. Greene Co.; Conway R., 29 June 1976, 1 nymph, J. Harriston, FLC Collection; Conway R., 2 July 1976, 1 nymph, J. Harriston, FLC Collection. Highland Co.; Davis Run, Aug. 1976, 1 nymph, J. Harriston, FLC Collection. Madison Co.; Hog Camp Branch, 16 June 1976, 3 nymphs, J. Harriston, FLC Collection; Rapidan R., 8 July 1976, 1 nymph, J. Harriston, FLC Collection. Page Co.; Jeremys Run, 28, 29 July 1976, 5 nymphs, J. Harriston, FLC Collection. Patrick Co.; Tributary of Little Mill Creek nr. Critz, 3 June 1976, 1 male, FLC; Tributary of Rock Castle Creek, 21 May 1978, 5 males, 7 females, FLC, BCK, and C. Shiffer. Rockbridge Co.; Guys Run, 13 May 1977, 1 male, FLC. Shenandoah Co.; Laurel Run, 10 Aug. 1976, 1 nymph, J. Harriston, FLC Collection. Tazewell Co.; Tributary of Cove Creek at Rt. 662, 29 June 1979, 1 male, FLC; Tributary of Cove Creek at Rt. 662, 29 June 1979, 1 female, BCK.

Biology.--Inhabits the pools of small streams and rivers. Adult males apparently prefer alighting upon sunlit vegetation near shore or on leaves well above shaded streams. Oviposition apparently occurs as the female meanders along a rivulet tapping her abdomen every meter or so.

Remarks.--Although recently described this species appears to be the most common of the genus. The majority of previous southern records for *L. parvulus* belong to this species.

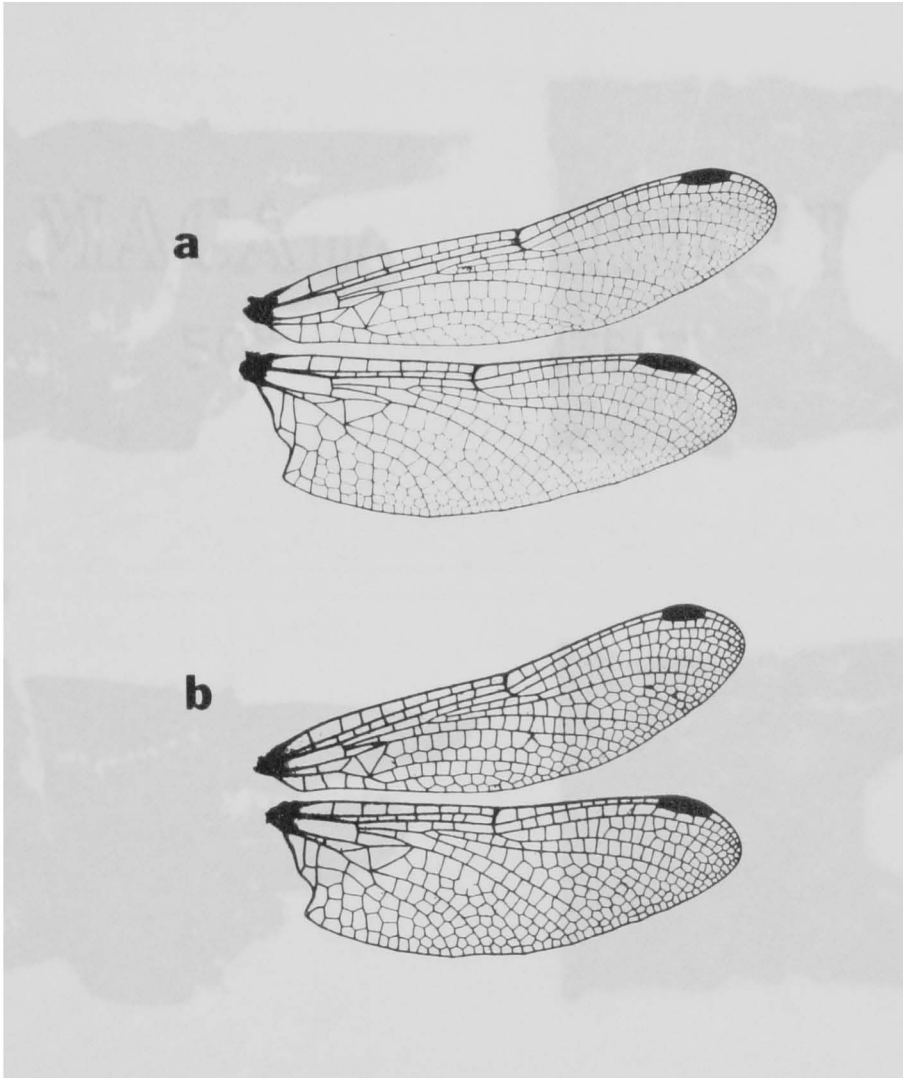


Figure 46. Wings of *Lanthus* x3: (a) *L. parvulus*; (b) *L. vermulis*.

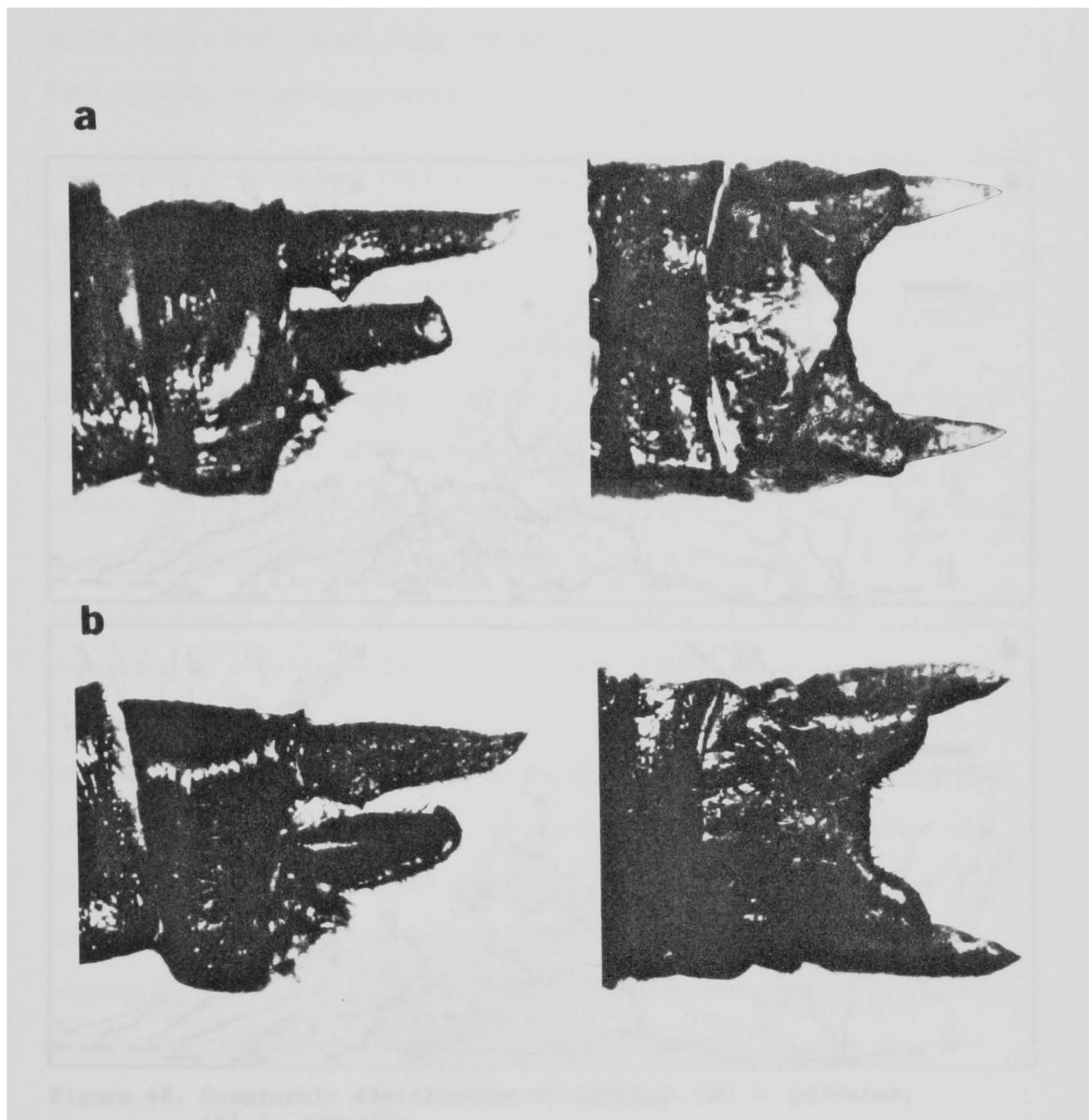


Figure 47. Male terminalia in lateral and ventral view of *Lanthus* x30:
(a) *L. parvulus*; (b) *L. vernalis*.

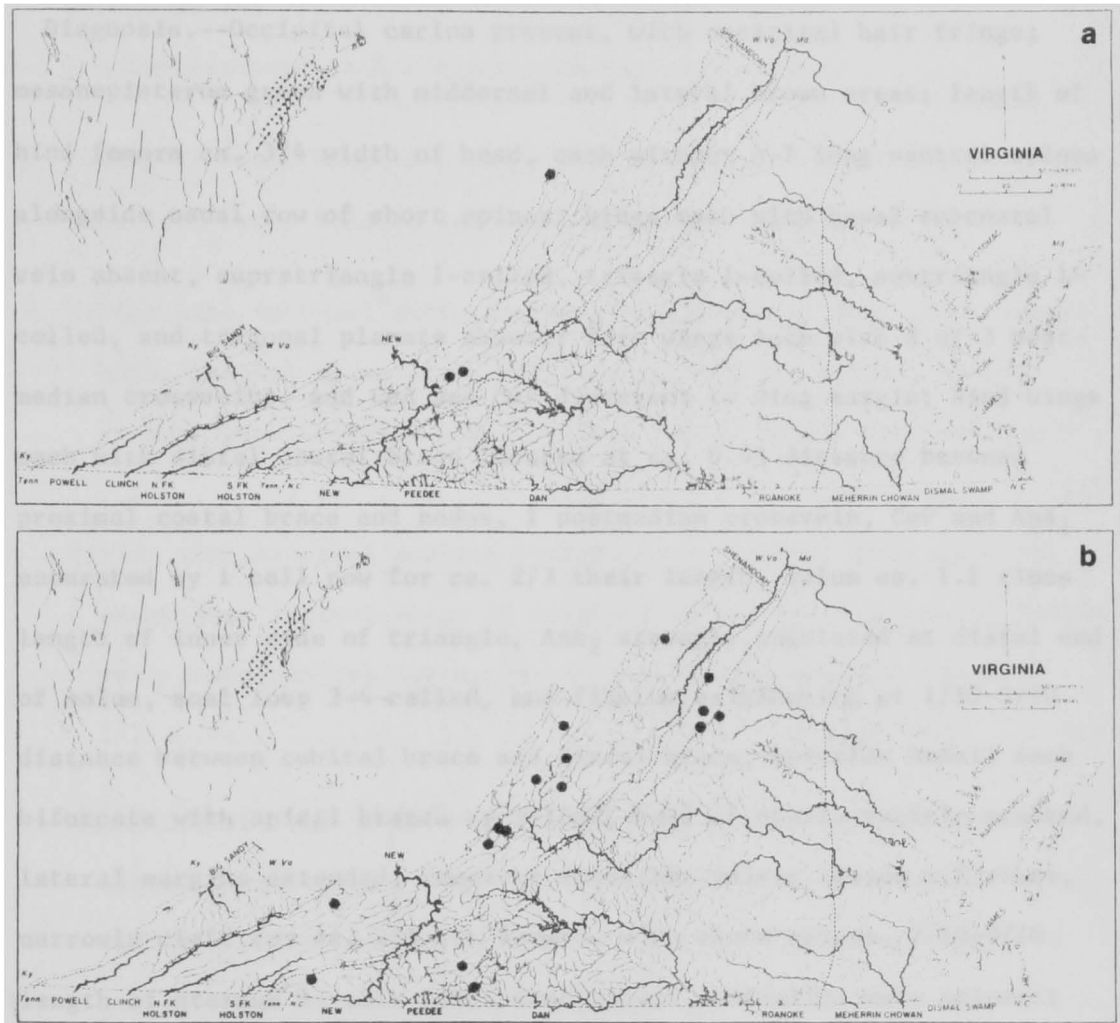


Figure 48. Geographic distribution of *Lanthus*: (a) *L. parvulus*; (b) *L. vernalis*.

Genus *Ophiogomphus* Selys 1854

Selys 1854. Bull. Acad. Belg. 21:39.

Type Species.--*Aeshna serpentina* Charpentier.

Diagnosis.--Occipital carina present, with occipital hair fringe; mesanepisterna green with middorsal and lateral brown areas; length of hind femora ca. $3/4$ width of head, each without 4-7 long ventral spines alongside usual row of short spines; wings each with basal subcostal vein absent, supratriangle 1-celled, triangle 1-celled, subtriangle 1-celled, and trigonal planate absent; fore wings each with 2 or 3 postmedian crossveins, and CuA and CuP divergent to wing margin; hind wings each with distal costal brace located at ca. 0.43 distance between proximal costal brace and nodus, 1 postmedian crossvein, CuP and AnA₁ separated by 1 cell row for ca. $2/3$ their length, solum ca. 1.1 times length of inner side of triangle, AnA₂ strongly angulated at distal end of solum, anal loop 2-4-celled, and fibulum originating at $1/10$ - $3/10$ distance between cubital brace and discal brace; anterior hamuli each bifurcate with apical branch cyclelike; hood of penile vesicle stalked, lateral margins extended, receiver dishlike; vulvar lamina bifurcate, narrowly cleft for ca. $2/3$ its length, with acute apices, $7/10$ - $9/10$ length of sternum 9; male cerci denticulate ventrally; male epiproct bifurcate, apices not widely separated apically.

Species Key to Adult *Ophiogomphus* of Virginia

1. Antefrons and postclypeus transversely striped with black; metanepisterna each with transverse brown band . *O. anomalus* p. 354
Antefrons and postclypeus not transversely striped with black;
metanepisterna each without transverse brown band 2
2. Middorsal brown band of mesanepisterna vestigial or absent 3
Middorsal brown band of mesanepisterna well developed 4
3. Tibiae with external surface predominantly black; male cerci acuminate; lateral spine of epiproct at ca. 1/2 its length; female without postoccipital horns, vulvar lamina longer than sternum 9 *O. acuminatus* p. 353
Tibiae with external surface predominantly yellow; male cerci not acuminate; lateral spine of epiproct at ca. 4/5 its length; female with postoccipital horns, vulvar lamina shorter than sternum 9 *O. rupinsulensis* p. 362
4. Basal 2/3 of hind wings tinted with yellow; male epiproct abruptly angled dorsally near base, ca. 1/2 length of cerci; female occipital crest with small erect horns separated by ca. 4/5 length of postfrontal suture, vulvar lamina ca. as long as wide *O. howei* p. 358
Basal 2/3 of hind wings not tinted with yellow; male epiproct not abruptly angled dorsally near base, at least 4/5 as long as cerci; female occipital crest without small erect horns separated by ca. 4/5 length of postfrontal suture, vulvar lamina longer than wide . 5

5. Male cerci inflated, each wider at midlength than at base, longer than epiproct; female with postoccipital horns
 *O. aspersus* p. 355
- Male cerci not inflated, each not wider at midlength than at base, slightly shorter than epiproct; female without postoccipital horns 6
6. Tibiae each with yellow streak along external carinae; basal 2/3 of femora yellow; thorax without brown bands along metapleural sulci *O. incurvatus* p. 359
- Tibiae each without yellow streak along external carinae; basal 2/3 of femora not yellow; thorax with brown bands along metapleural sulci 7
7. Dorsal mesanepisternal pale stripes parallel-sided, separated by ca. 4/5 their maximum width; gap of anterior hamuli subcircular; lateral flange of penile hood ca. 1/4 as wide as long
 *O. edmundo* p. 357
- Dorsal mesanepisternal pale stripes widened ventrally, separated by ca. 2/5 their maximum width; gap of anterior hamuli not subcircular; lateral flange of penile hood ca. 1/3 as wide as long . . . 8

8. Distal margin of labrum not black; male epiproct with apical cleft ca. 2 times as long as wide, anterior hamuli each with apical branch more than 3 times as long as basal branch; female occiput level posteriorly, without or with small widely separated horns anteriorly; vulvar lamina parallel-sided, apices directed posterolaterally *O. carolus* p. 356
- Distal margin of labrum black; male epiproct with apical cleft more than 3 times as long as wide, anterior hamuli each with apical branch less than 2 times as long as basal branch; female occiput bilobate posteriorly, with large contiguous horns anteriorly; vulvar lamina constricted near base, apices directed posteriorly *O. mainensis* p. 361

Ophiogomphus acuminatus Carle

Carle 1981. *Odonatologica* 10:271.

Length 48.5–53.0 mm; abdomen 35.5–39.0 mm; hind wings 28.5–33.5 mm.

Diagnosis.--Face yellow green without dark band along fronto-clypeal suture; female occiput with stout horns on anterior face, occipital crest without definite hair fringe, posterior surface of head without horns near lateral margin of occiput; middorsal brown band of mesanepisterna vestigial; lateral pale areas of metathorax confluent; tibiae predominantly black with external carina and base yellow; basal half of hind wing hyaline; male cerci slightly concave ventrally and acuminate apically, epiproct narrowly divided to apices of paraprocts and with obtuse lateral tooth on each side.

Distribution.--Known from the state of TN.

Flight Season.--June 17 (TN) to June 18 (TN).

Biology.--The nymphs have only been collected from small, spring-fed streams in western Tennessee. Carl Cook (personal communication) writes that the nymphal habitat is "sparse gravel pockets in the fissures of the rock stream bed". Adults have been collected only from a sunlit portion of Jacks Branch, a small 2-3 m wide stream.

Remarks.--*Ophiogomphus acuminatus* is perhaps the rarest of the ophiogomphines; it may occur in Virginia.

Ophiogomphus anomalus Harvey

(Figures 49a, 51a, 53a)

Harvey 1898. Entomol. News 9:60.

Length 39-46 mm; abdomen 26-33 mm; hind wings 24-28 mm.

Diagnosis.--Face yellowish-green with dark band along frontoclypeal suture; female occiput with horns on anterior face, occipital crest without definite hair fringe, posterior surface of head with horns near lateral margin of occiput; middorsal brown band of mesanepisterna present; lateral pale areas of metathorax not confluent; tibiae entirely black externally; basal half of hind wings hyaline; male cerci each with ventral surface convex, epiproct sharply upcurved at midlength.

Distribution.--Known from the states of ME, NY, and WI, and the provinces of Ont. and Que.

Flight Season.--June 6 (ME) to Aug. 7 (Que.).

Biology.--Nymphs inhabit rapid-flowing streams and rivers.

Remarks.--This northern species is apparently very local in occurrence. The isolated record from southern New York indicates that isolated populations may occur further south along the Appalachian mountains.

Ophiogomphus aspersus Morse

(Figures 49b, 51b, 53b)

Morse 1895. Psyche 7:209.

Length 44-49 mm; abdomen 26-35 mm; hind wings 24-32 mm.

Diagnosis.--Face yellow-green without dark band along frontoclypeal suture; female occiput without horns on anterior face, occipital crest without definite hair fringe, posterior surface of head with horns near lateral margin of occiput; middorsal brown band of mesanepisterna well developed; lateral pale areas of metathorax not confluent; tibiae predominantly black externally; basal half of hind wings hyaline; male cerci inflated, each wider at midlength than at base; male epiproct decurved apically with square-cut apical notch narrowed apically.

Distribution.--Known from the states of CT, KY, ME, MA, MI, NH, NY, NC, VT, VA, and WI, and the provinces of N.B., N.S., and Que. Known from the Virginia counties of Carroll, Floyd, and Grayson. Known distribution among the counties of neighboring states include: Kentucky-Green.

Virginia Records.--Carroll Co.; New R. at Rt. 606, 23 May 1978, 1 nymphal exuviae, FLC. Floyd Co.; Little R. at Rt. 615, 21 May 1977, 1 male (as prey of *G. lineatifrons*), BCK, FLC Collection; Little R. at Rt. 615, 25 May 1977, 1 female, FLC; Little R. at Rt. 615, 28 May 1975,

1 male, FLC; Little R. at Rt. 615, 3 June 1977, 1 male, FLC; Little R. at Rt. 615, 5 June 1977, 1 male, 1 female (in tandem), FLC. Grayson Co.; New R. at Rt. 810, 30 Apr. 1977, 1 male (teneral), H. B. White, (Det. H. B. White, personal communication); New R. at Rt. 810, 12 May 1977, 1 male (teneral), FLC; New R. at Rt. 810, 23 May 1978, 7 nymphal exuviae, FLC.

Flight Season.--Apr. 30 (VA) to Aug. 29 (New England); in Virginia Apr. 30 to June 5. Known season in neighboring states are: Kentucky--June to July 31.

Biology.--*Ophiogomphus aspersus* nymphs inhabit streams and rivers with substantial rapids. Adult males frequently hover at the head of rapids and infrequently alight upon rocks or streamside vegetation. The female oviposits in fast-moving water while flying in an upstream direction, tapping the abdomen from 3-5 times at a stop.

Remarks.--Although this species has not been collected in northwestern Virginia it undoubtedly occurs there.

Ophiogomphus carolus Needham

(Figures 49c, 51c, 53c)

Needham 1897. Can. Entomol. 29:183.

Length 40-45 mm; abdomen 28-33 mm; hind wings 24-28 mm.

Diagnosis.--Face yellow-green without dark band along frontoclypeal suture; female occiput occasionally with minute horns on anterior face, occipital crest with definite hair fringe, posterior surface of head without horns near lateral margin of occiput; middorsal brown band of

mesanepisterna well developed; lateral pale areas of metathorax not confluent; tibiae entirely black externally; basal half of hind wings hyaline; male cerci concave ventrally, epiproct apically with square-cut apical notch widened apically.

Distribution.--Known from the states of ME, MI, NH, NY, PA, VT, VA, WV, and WI, and the provinces of N.B., N.S., Ont., and Que. Known from the Virginia counties of Augusta and Highland. Known distribution among the counties of neighboring states include: Pennsylvania-- Centre, Clinton, Columbia, Lycoming, Pike, Sullivan, Susquehanna, and Wayne. West Virginia-- Hardy.

Virginia Records.--Augusta Co.; Calfpasture R. at Rt. 688, 4 June 1977, 1 male, FLC; Calfpasture R. at Rt. 688, 13 June 1980, 3 males, FLC; Calfpasture R. at Rt. 688, 23 June 1978, 1 male (old), FLC. Highland Co.; Bullpasture R. nr. Williamsville, 8 June 1975, 1 male, FLC.

Flight Season.--May 21 (NY) to Aug. 8 (Ont.); in Virginia June 4 to 23. Known season in neighboring states are: Pennsylvania-- June 1 to 23; West Virginia-- May 31.

Biology.--Nymphs inhabit rapid streams and small rivers. Males frequently alight upon emergent and streamside stones along rapids.

Remarks.--*Ophiogomphus carolus* has not been reported south of the New River but probably occurs further south because *G. brevis*, with which this species is often associated, has been collected in North Carolina.

Ophiogomphus edundo Needham

Needham 1951. Entomol. News 62:41-3.

Length 42.0-45.0 mm; abdomen 30.0-32.0 mm; hind wings 24.0-25.0 mm.

Diagnosis.--Face yellow green without dark band along fronto-clypeal suture; female occiput probably with small horns on anterior face, occipital crest probably without hair fringe, posterior surface of head probably without horns near lateral margin of occiput; middorsal brown band of mesanepisterna present; lateral pale areas of metathorax not confluent; tibiae predominantly black externally; basal half of hind wing hyaline; male cerci convex ventrally, epiproct narrowly divided apically to apices of paraprocts and angulated ventrally at ca. mid-length.

Distribution.--Known from the state of NC.

Flight Season.--Unknown (the allotype was collected on June 3, but it is generally considered to be a female of *O. aspersus*).

Biology.--Unknown, although probably similar to that of *O. carolus*.

Remarks.--*Ophiogomphus edmodo* is known from only two male specimens, both from an unknown locality in North Carolina.

Ophiogomphus howei Bromley

(Figures 50a, 52a, 54a)

Bromley 1924. Entomol. News 35:343.

Length 31-34 mm; abdomen 22-24 mm; hind wings 19-21 mm.

Diagnosis.--Face yellow green without dark band along frontoclypeal suture; female occiput without horns on anterior face, occipital crest with definite hair fringe, posterior surface of head without horns near lateral margin of occiput; middorsal brown band of mesanepisterna

present; lateral pale areas of metathorax not confluent; tibiae predominantly black externally; basal half of hind wings tinged with saffron; male cerci level ventrally, epiproct upcurved.

Distribution.--Known from the states of KY, MA, NY, NC, PA, and VA. Known from the Virginia counties of Carroll and Grayson. Known distribution among the counties of neighboring states include: North Carolina-Alleghany; Pennsylvania-Cumberland and Susquehanna.

Virginia Records.--Carroll Co.; New R. at Fries-Galax bridge, 2 Mar. 1977, 1 female nymph, J. H. Kennedy, BCK Collection; New R. at Rt. 606, 1 May 1977 (emerged 2 to 13 May 1977), 8 nymphs, FLC. Grayson Co.; New R. at Rt. 810, 30 Apr. 1977, 11 males, 6 females (teneral), FLC; New R. at Rt. 810, 12 May 1977, 6 males, 2 females (teneral), FLC; New R. at Rt. 810, 23 May 1978, 721 nymphal exuviae, FLC.

Flight Season.--Apr. 30 (VA) to June 1 (MA); in Virginia Apr. 30 to May 23. Known season in neighboring states are: Pennsylvania- May 20.

Biology.--Nymphs inhabit pools of rivers. The habits of the adults are somewhat of a mystery as most specimens of this species are teneral when captured.

Remarks.--*Ophiogomphus howei* is easily identified by its small size and tinted hind wings.

Ophiogomphus incurvatus n. sp.

Length 40.0-48.5 mm; abdomen 30.0-36.0 mm; hind wings 23.5-30.0 mm.

Diagnosis.--Face yellow green without dark band along frontoclypeal suture; female occiput with horns on anterior face, occipital crest

without definite hair fringe, posterior surface of head without horns near lateral margin of occiput; middorsal brown band of mesanepisterna present; lateral pale areas of metathorax confluent; tibiae predominantly black externally with external carinae yellow; basal half of hind wing faintly yellowish; male cerci incurved with ventral margin concave, epiproct narrowly divided to apices of paraprocts and with lateral tooth on each side.

Distribution.--Known from the states of AL, GA, MD, NC, SC, TN, VA, and WV. Known from the Virginia counties of Bedford, Charlotte, and Giles. Known distribution among the counties of neighboring states include: Maryland- Baltimore; North Carolina- Wilkes and Yadkin; West Virginia- Monroe.

Virginia Records.--Bedford Co.; Five Forks Cr. at Rt. 819, 16 May 1979, 1 male, BCK. Charlotte Co.; Spring Cr. at Rt. 654, 1 May 1975, 1 nymph (1 male emerged 16 May 1975), FLC; Spring Cr. at Rt. 654, 14 Sept. 1975, 5 nymphs, FLC; Spring Cr. at Rt. 654, 20 Apr. 1976, 3 nymphs, FLC; Spring Cr. at Rt. 654, 18 May 1978, 1 male, FLC. Giles Co.; Rich Cr. nr. Peterstown, 12 June 1974, 2 nymphs, FLC.

Flight Season.--May 16 (NC and VA) to June 14 (WV); in Virginia May 16 to 18. Known season in neighboring states are: Maryland- May 28 to June 8; North Carolina- May 16 to 28; West Virginia- June 12 to 14.

Biology.--The nymphs inhabit the shallow riffle areas of small piedmont streams, gravel being the preferred substrate. The adults commonly rest on vegetation 1 or 2 m above the stream.

Remarks.--*Ophiogomphus incurvatus* has been confused with *O. carolinus* Hagen which is a synonym of *O. rupinsulensis* Walsh. It has also been misidentified as *O. mainensis* by Fisher (1942).

Ophiogomphus mainensis PackardSyn.: *johannus* Needham

Packard 1863. Proc. Entomol. Soc. Phila. 2:255.

Length 42.0-46.0 mm; abdomen 28.0-34.0 mm; hind wings 25.0-31.0 mm.

Diagnosis.--Face yellow green without dark band along frontoclypeal suture; female occiput with long contiguous horns on anterior face, occipital crest without definite hair fringe, posterior surface of head without horns near lateral margin of occiput; middorsal brown band of mesanepisterna present; lateral pale areas of metathorax not confluent; tibiae entirely black externally; basal half of hind wing hyaline; male cerci nearly level ventrally and truncate apically, epiproct narrowly divided to apices of paraprocts and with acute lateral tooth on each side.

Distribution.--Known from the states of CT, ME, MA, NH, NJ, NY, NC, PA, SC, TN, VT, VA, and WV, and the provinces of N.B. and Que. Known from the Virginia county of Highland. Known distribution among the counties of neighboring states include: North Carolina- Yancey; Pennsylvania- Butler, Clearfield, Clinton, Huntingdon, Lycoming, Monroe, Perry, Pike, Somerset, and Sullivan; Tennessee- Blount; West Virginia- Mineral, Nicholas, Pendleton, and Pocahontas.

Virginia Records.--Highland Co.; Back Cr. at Campbell Run at Rt. 600, 4 June 1977, 1 male, FLC.

Flight Season.--May 16 (PA) to July 23 (PA); in Virginia June 4. Known season in neighboring states are: North Carolina- June 12; Pennsylvania- May 16 to July 23; West Virginia- May 21 to June 25.

Biology.--The nymphs inhabit rapid streams and small rivers. Adults are most abundant at the head of rapids.

Remarks.--*Ophiogomphus mainensis* is local in occurrence. It is closely related to *O. incurvatus* but has a more boreal distribution, occurring only in mountainous regions south of Pennsylvania.

Ophiogomphus rupinsulensis (Walsh)

Syn.: *carolinus* Hagen, *pictus* Needham

(Figures 50c, 52c, 54c)

Walsh 1862. Proc. Acad. Phila., p. 388 (in *Erpetogomphus*).

Length 45-54 mm; abdomen 32-39 mm; hind wings 27-32 mm.

Diagnosis.--Face yellow-green without dark band along frontoclypeal suture; female occiput with minute horns on anterior face, occipital crest with definite hair fringe, posterior surface of head with horns near lateral margin of occiput; middorsal brown band of mesanepisterna absent; lateral pale areas of metathorax confluent; tibiae entirely yellow externally; basal half of hind wings hyaline; male cerci concave ventrally, epiproct with transverse ridge apically.

Distribution.--Known from the states of CT, IL, IN, KS, KY, ME, MD, MI, MN, MO, NH, NJ, NY, ND, OH, PA, TN, VT, VA, WV, and WI, and the provinces of Man., N.B., Ont., Que., and Sask. Known from the Virginia counties of Alleghany, Botetourt, and Lee. Known distribution among the counties of neighboring states include: Kentucky- Adair, Allen, Breckinridge, Green, and Harrison; Maryland- Montgomery; Pennsylvania- Allegheny, Cumberland, Dauphin, Forest, Perry, Pike, and Wyoming;

Tennessee- Davidson; West Virginia- Hampshire.

Virginia Records.--Alleghany Co.; James R. at Lowmoor, 13 Nov. 1973, 1 nymph, FLC. Botetourt Co.; Craig Cr. at Patterson Cr., 29 May 1977, 2 males, FLC; Craig Cr. at Patterson Cr., 18 June 1978, 1 male, FLC; Craig Cr. at Rt. 706 nr. Oriskany, 10 July 1973, 1 male, FLC. Lee Co.; Powell R. at Fletcher Ford, 30 Apr. 1981, 1 nymph, K. J. Tennessen.

Flight Season.--May 1 (IN) to Sept. 23 (Ont.); in Virginia May 29 to July 10. Known season in neighboring states are: Kentucky- May to July 10; Maryland- July 3; Pennsylvania- May 8 to Aug. 7; Tennessee- May 16; West Virginia- June 13.

Biology.--Nymphs inhabit slow-moving streams and rivers with occasional rapids. This species seems more tolerant of siltation than other species of the genus. Oviposition typically occurs during a low rapid flight in which the abdomen intermittently taps the water surface.

Remarks.--*Ophiogomphus rupinsulensis* is the most widespread of American *Ophiogomphus*, being more tolerant to changes caused by the activities of man than other species of the genus.

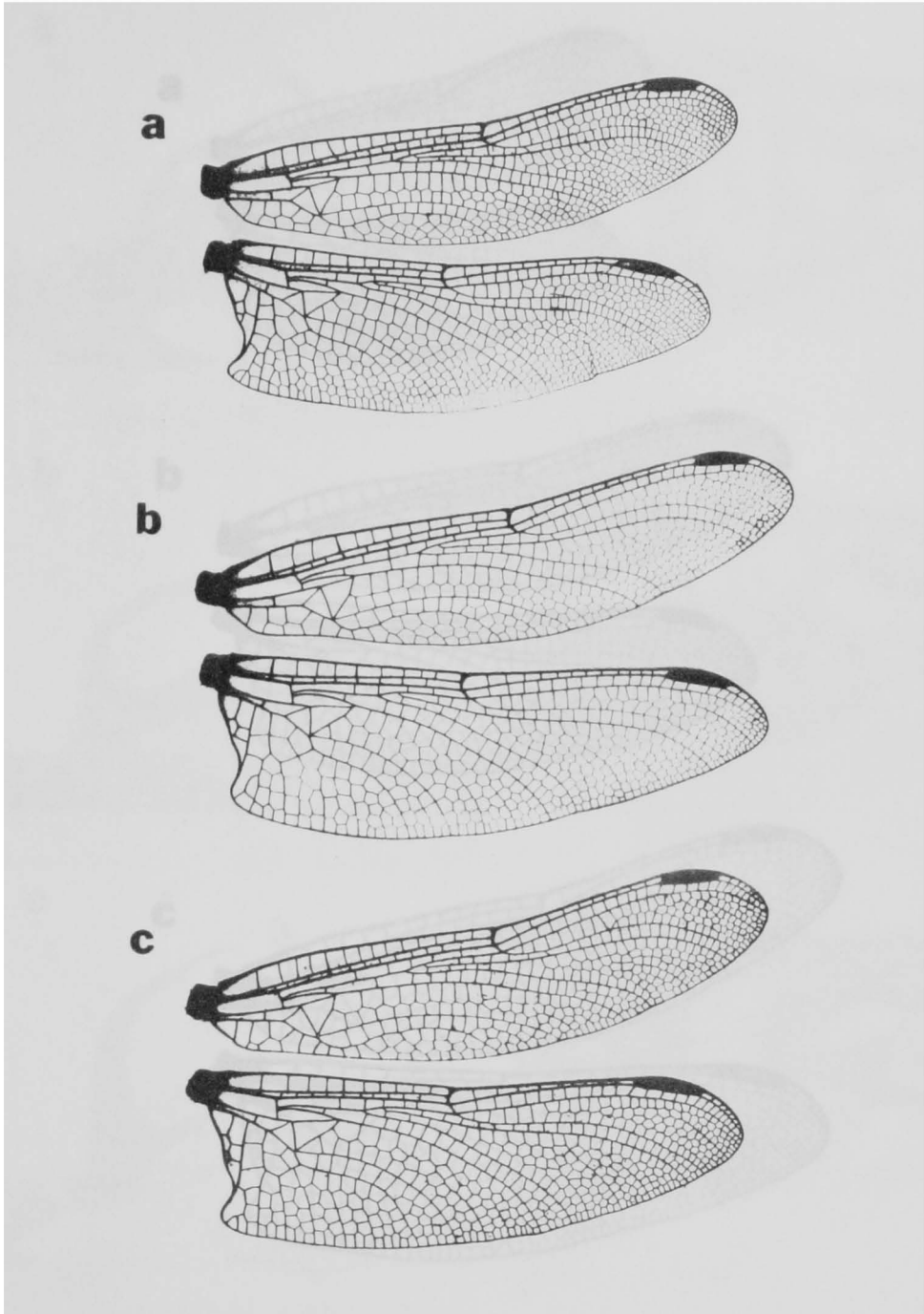


Figure 49. Wings of *Ophiogomphus* x3: (a) *O. anomalus*; (b) *O. aspersus*; (c) *O. carolus*.

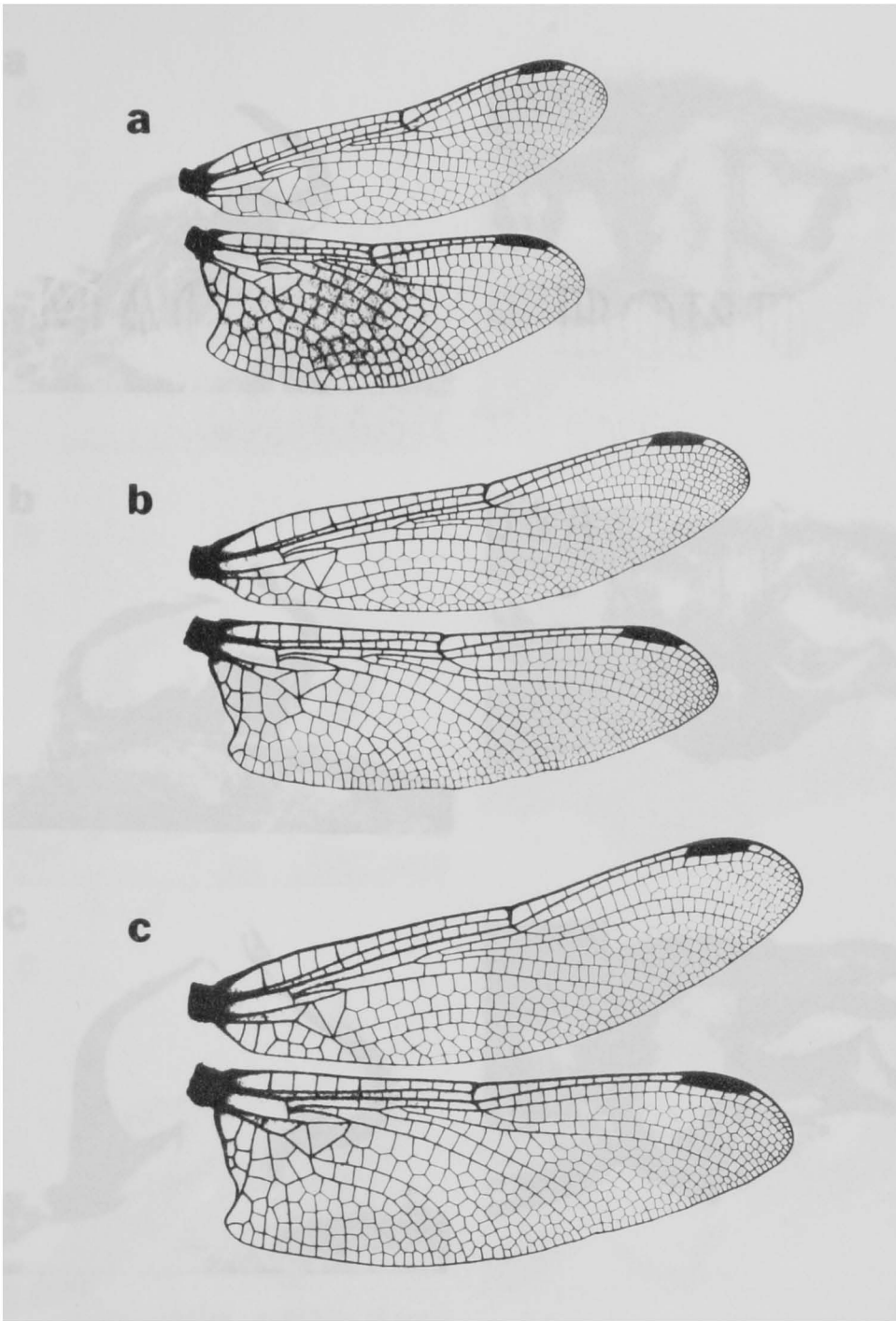


Figure 50. Wings of *Ophiogomphus* x3: (a) *O. howei*; (b) *O. mainensis*; (c) *O. rapinsulensis*.

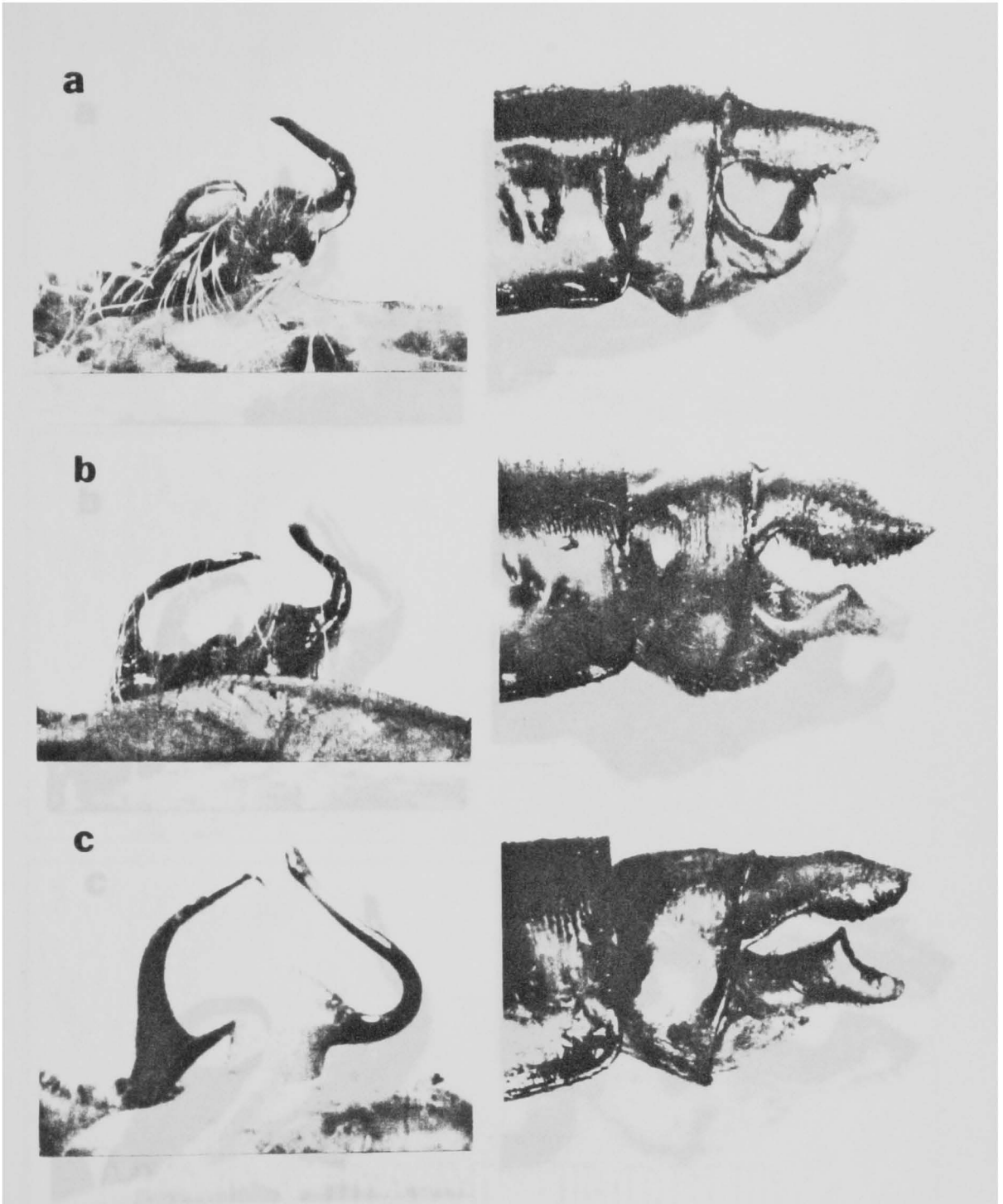


Figure 51. Male secondary genitalia x25 and terminalia x20 in lateral view of *Ophiogomphus*: (a) *O. anomalus*; (b) *O. aspersus*; (c) *O. carolus*.

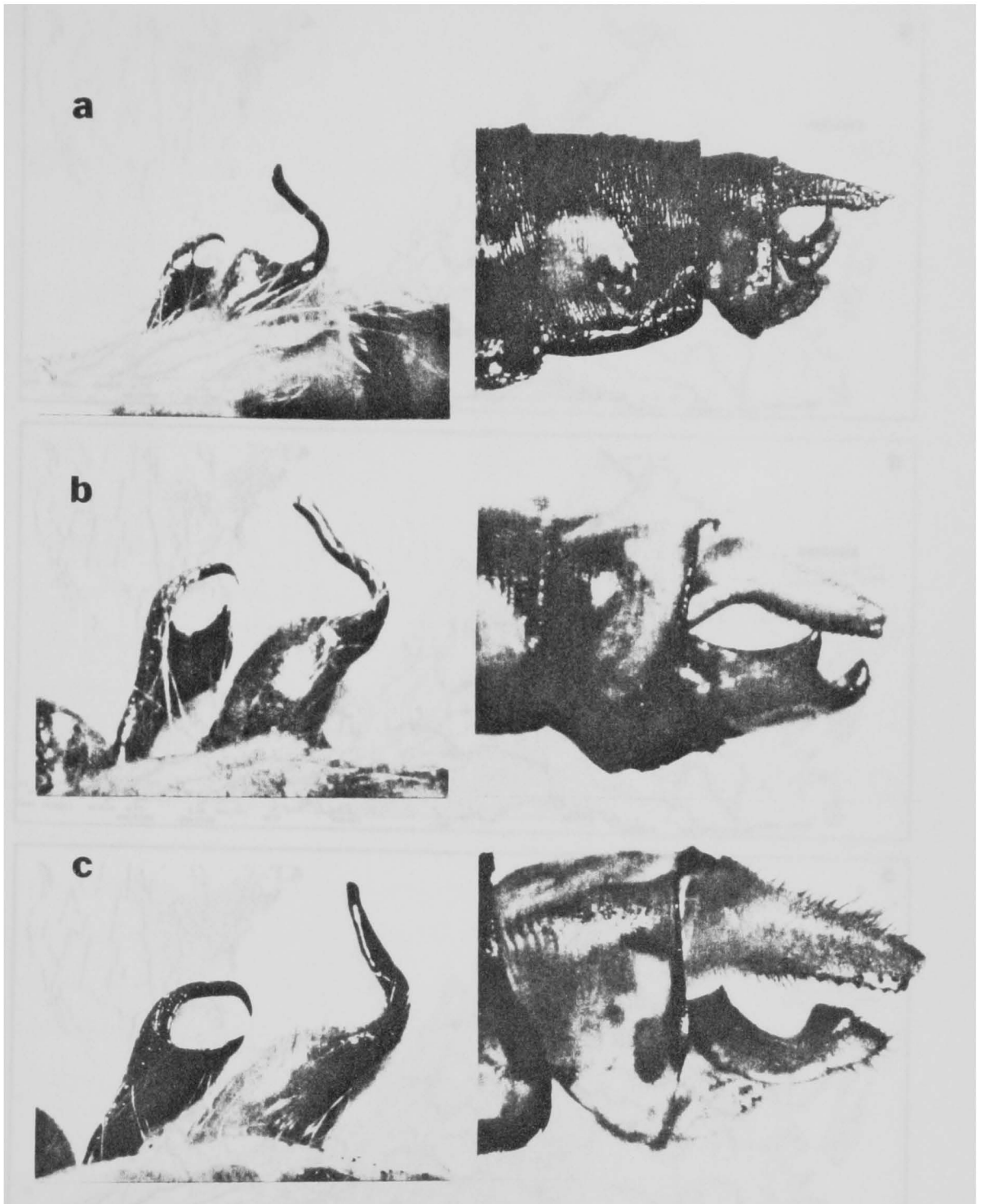


Figure 52. Male secondary genitalia x25 and terminalia x20 in lateral view of *Ophiogomphus*: (a) *O. howei*; (b) *O. mainensis*; (c) *O. rupinsulensis*.

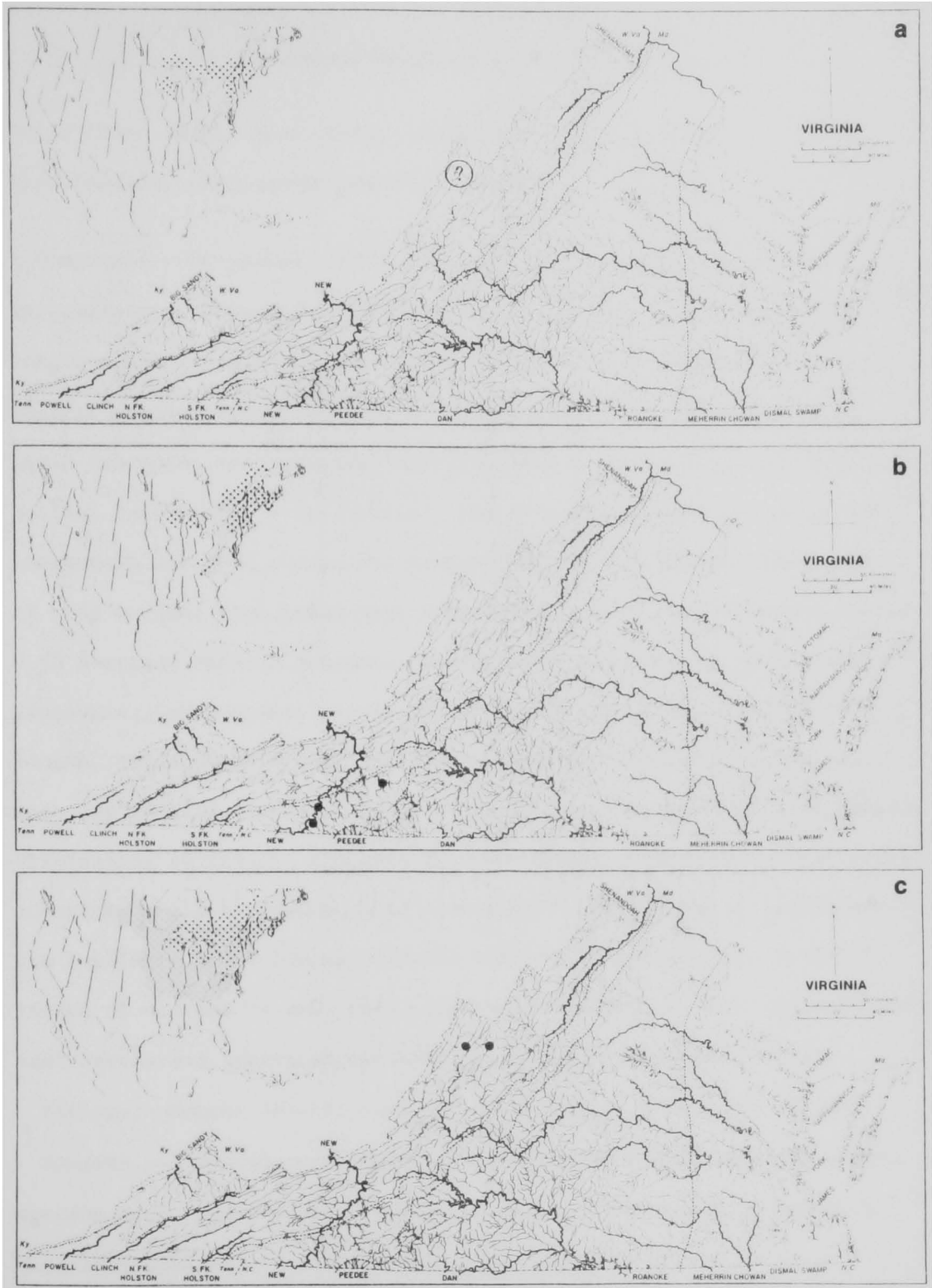


Figure 53. Geographic distribution of *Ophiogomphus*: (a) *O. anomalus*; (b) *O. aspersus*; (c) *O. carolus*.

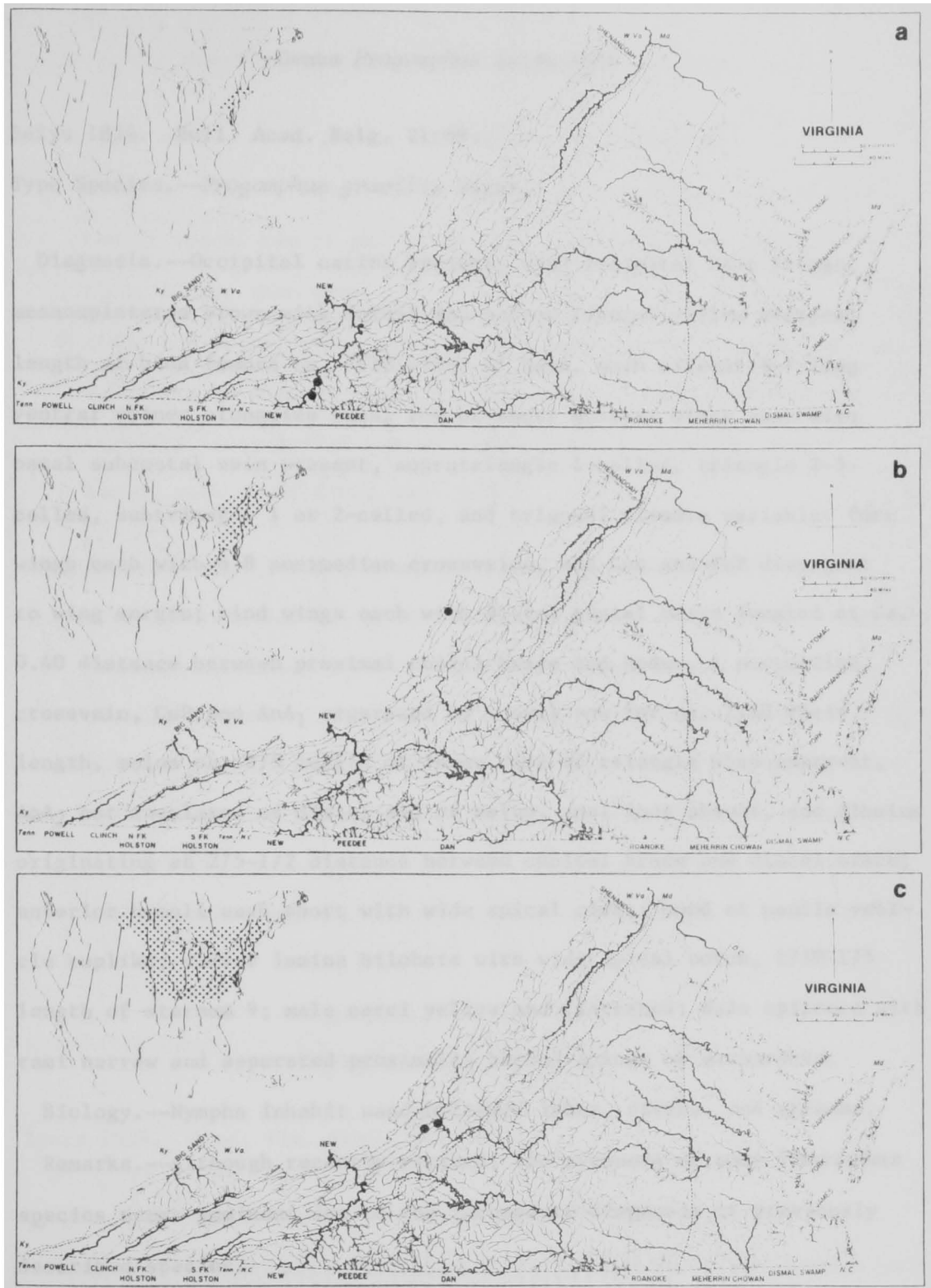


Figure 54. Geographic distribution of *Ophiogomphus*: (a) *O. howei*; (b) *O. mainensis*; (c) *O. rupinsulensis*.

Genus *Progomphus* Selys 1854

Selys 1854. Bull. Acad. Belg. 21:69.

Type Species.--*Progomphus gracilis* Hagen.

Diagnosis.--Occipital carina present, with occipital hair fringe; mesanepisterna brown with dorsal and narrow lateral yellow stripes; length of hind femora ca. 7/10 width of head, each without 4-7 long ventral spines alongside usual row of short spines; wings each with basal subcostal vein present, supratriangle 1-celled, triangle 2-5-celled, subtriangle 1 or 2-celled, and trigonal planate variable; fore wings each with 6-8 postmedian crossveins, and CuA and CuP divergent to wing margin; hind wings each with distal costal brace located at ca. 0.40 distance between proximal costal brace and nodus, 1 postmedian crossvein, CuP and AnA₁ separated by 1 cell row for ca. 7/10 their length, solum ca. 2/5 length of inner side of triangle when apparent, AnA₂ not angulated at distal end of solum, anal loop absent, and fibulum originating at 2/5-1/2 distance between cubital brace and discal brace; anterior hamuli each short with wide apical cleft; hood of penile vesicle cuplike; vulvar lamina bilobate with wide apical notch, 1/10-1/5 length of sternum 9; male cerci yellow and flattened; male epiproct with rami narrow and separated proximally beyond apices of paraprocts.

Biology.--Nymphs inhabit sand-bottomed lakes, rivers, and streams.

Remarks.--Although recently revised, the synonymy of some *Progomphus* species seems imminent due to the incomplete diagnosis of previously described species.

Species Key to Adult *Progomphus* of Virginia

1. Occiput erect, crest convex anteriorly; male cerci each ca. 2.5 times as long as wide with denticles of ventrobasal carina scattered; apical rim of penile vesicle rounded; vulvar lamina with cleft longer than wide *P. obscurus* p. 373
- Occiput not erect, crest not convex anteriorly; male cerci each ca. 4.0 times as long as wide with denticles of ventrobasal carina in straight line; apical rim of penile vesicle angulate; vulvar lamina with cleft wider than long 2
2. Abdominal terga 8 and 9 brown with diffuse yellow areas; cerci brown ventromedially; medial process of male epiproct not extended posteriorly beyond paraprocts; vulvar lamina with apical notch parallel-sided *P. alachuensis* p. 371
- Abdominal terga 8 and 9 black with well-defined yellow spots; cerci yellow ventromedially; medial process of male epiproct extended posteriorly beyond paraprocts; vulvar lamina with apical notch divergent posteriorly *P. bellei* p. 372

Progomphus alachuensis Byers

(Figures 55a, 56a, 57a)

Byers 1939. Proc. Fla. Acad. Sci. 4:50.

Length 52-58 mm; abdomen 37-43 mm; hind wings 30-37 mm.

Diagnosis.--Face pale with narrow brown band along frontoclypeal sulcus; female vertex strongly inflated behind lateral ocelli; occiput not

erect, crest slightly convex anteriorly; lateral mesanepisternal pale stripes vestigial; apical portion of genital lobe not visible in lateral view; apical rim of penile vesicle angulate; vulvar lamina ca. 1/5 length of sternum 9, with apical cleft slightly divergent posteriorly; male cerci each ca. 4.0 times as long as wide, ventrally not concave, and with denticles of ventrobasal carina in straight line.

Distribution.--Known from the states of FL and NC. Known distribution among the counties of neighboring states include: North Carolina- Bladen.

Flight Season.--Feb. (FL) to Aug. 8 (FL). Known season in neighboring states are: North Carolina- June 28.

Biology.--Nymphs inhabit sand-bottomed ponds and lakes.

Remarks.--The darker and somewhat larger northern form of this species has recently been described as a distinct species. However, the specific identity of specimens from Bladen county, North Carolina remains somewhat in doubt. This species may occur in sandbottomed lakes of the Virginia coastal plain.

Progomphus bellei Knopf and Tennesen

(Figures 55b, 56b, 57b)

Knopf and Tennesen 1979. *Odonatologica* 9:247.

Length 55-62 mm; abdomen 41-48 mm; hind wings 36-38 mm.

Diagnosis.--Face pale with narrow diffuse brown band along frontoclypeal sulcus; female vertex moderately inflated behind lateral ocelli; occiput not erect, crest slightly convex anteriorly; lateral mesanepisternal pale stripes vestigial; apical portion of genital lobe visible

in lateral view; apical rim of penile vesicle angulate; vulvar lamina ca. $1/5$ length of sternum 9, with apical cleft strongly divergent posteriorly; male cerci each ca. 4.0 times as long as wide, ventrally not concave, and with denticles of ventrobasal carina in straight line.

Distribution.--Known from the states of FL and NC(?). Known distribution among the counties of neighboring states include: North Carolina-Bladen.

Flight Season.--May 24 (FL) to Aug. 6 (FL). Known season in neighboring states are: North Carolina- June 28.

Biology.--Nymphs inhabit small sand-bottomed streams and clear lakes.

Remarks.--This recently described species may occur in the small sandy streams of eastern Virginia.

Progomphus obscurus Rambur

(Figures 55c, 56c, 57c)

Rambur 1842. Ins. Neur., p. 170 (in *Diastatomma*).

Length 45-56 mm; abdomen 33-41 mm; hind wings 27-32 mm.

Diagnosis.--Face pale with wide diffuse brown band along frontoclypeal sulcus; female vertex slightly inflated behind lateral ocelli; occiput erect, crest convex anteriorly; lateral mesanepisternal pale stripes present; apical portion of genital lobe visible in lateral view; apical rim of penile vesicle rounded; vulvar lamina ca. $1/5$ length of sternum 9, with narrow apical cleft parallel-sided; male cerci each ca. 2.5 times as long as wide, ventrally concave, and with denticles of ventrobasal carina not in straight line.

Distribution.--Known from the states of AL, AR, CO, FL, GA, IL, IN, IO, KS, KY, IA, ME, MD, MA, MI, MS, MO, NE, NV, NH, NJ, NY, NC, OH, OK, PA, SC, TN, TX, VA, WV, WI, and WY. Known from the Virginia counties of Buchanan, Carroll, Charlotte, Culpeper, Floyd, Giles, Grayson, Hanover, Henrico, Louisa, Wythe, and the city of Virginia Beach. Known distribution among the counties of neighboring states include: Kentucky-Allen, Bell, Butler, Carter, Edmonson, Grayson, Green, Harrison, Marion, McCreary, Metcalfe, Nelson, Pulaski, Robertson, Rockcastle, Todd, Trigg, and Warren; Maryland- Worcester; North Carolina- Moore and Wake; Pennsylvania- Allegheny, Dauphin, Fayette, Perry, and Juniata; Tennessee- Campbell, Clay, Monroe, Morgan, Sevier, and Sullivan.

Virginia Records.--Buchanan Co.; Russell Prater Cr. at Rt. 83, 12 July 1978, 1 male, FLC. Carroll Co.; New R. at Rt. 606, 11 June 1980, 1 female, BCK; Chestnut Cr. at Rt. 721 nr. Galax, 19 June 1977, 1 male, FLC. Charlotte Co.; Twittys Cr. at Rt. 642, 23 May 1977, 8 nymphal exuviae, 8 males, 3 females, FLC; Twittys Cr. at Rt. 642, 23 May 1977, 4 males, SWB, FLC Collection; Spring Cr. at Rt. 654, 10 June 1975, 1 male with nymphal exuviae (teneral), FLC; Spring Cr. at Rt. 654, 10 June 1975, 1 male, FLC; Twittys Cr. at Rt. 642, 10 June 1975, 1 male, FLC; Twittys Cr. at Rt. 642, 18 June 1975, 2 males, 1 female, FLC; Twittys Cr. at Drakes Branch, 18 June 1975, 1 male, FLC; Twittys Cr. at Rt. 642, 12 July 1974, 6 males, 1 female, FLC; Twittys Cr. at Rt. 642, 13 July 1974, 1 male, FLC, VPI&SU; Twittys Cr. at Rt. 642, 22 July 1978, 1 male, FLC; Twittys Cr. at Rt. 642, 25 Aug. 1975, 1 male, FLC. Culpeper Co.; Hazel R. at Rt. 707, 7 July 1979, 1 male, BCK; Rapidan R. 1.5 miles S. of Rt. 681, 15 July 1980, 1 male, BCK. Floyd Co.; Little R. at Rt.

615, 3 June 1977, 2 males (teneral), FLC. Giles Co.; New R. Park, 12 June 1974, 1 male, FLC; New R. Park, 12 July 1974, 1 male, FLC. Grayson Co.; New R. at Elk Cr. at Rt. 58, 19 June 1977, 1 male, FLC; New R. at Fox Cr. at Rt. 58, 19 June 1977, 1 male, 1 female, FLC. Hanover Co.; Rt. 1 behind dam, 7 July 1978, 1 male, FLC. Henrico Co.; James R. nr. Richmond, date unknown, nymph, J. J. Roback, (Det. M. J. Westfall, Roback and Westfall, 1967). Louisa Co.; N. Anna R. at Rt. 208, date unknown, nymph, J. J. Roback, (Det. M. J. Westfall, Roback and Westfall, 1967); N. Anna R., June 1964, 1 male, H. Rhodes, VPI&SU; S. Anna R. at Rt. 522, 3 June 1977, 2 males, BCK, VPI&SU; S. Anna R. at Rt. 522, 21 June 1977, 2 males, BCK; S. Anna R. at Rt. 601, 6 July 1977, 1 male, BCK; N. Anna R. at Rt. 601, 7 July 1977, 1 female, BCK; S. Anna R. at Rt. 522, 21 July 1977, 1 male, 1 female, BCK; S. Anna R. at Rt. 601, 19 Sept. 1970, 1 female, D. Minter, VPI&SU. Nelson Co.; Tye R. 0.25 mile above junction of Rts. 56 and 151, 20 July 1978, 1 male, JRV and TJV, (Det. JRV), VPI&SU. Wythe Co.; Wytheville, 26 June 1935, 1 male, CA, (Det. MDR), MZUM. City of Virginia Beach; Twin Creek, 14 Aug. 1973, 1 male, W. I. Knausenberger, VPI&SU.

Flight Season.--Feb. (FL) to Sept. 19 (VA); in Virginia May 23 to Sept. 19. Known season in neighboring states are: Kentucky- June to Aug.; Maryland- July 10; North Carolina- May to July; Pennsylvania- May 24 to July 7; Tennessee- June 27 to Aug. 14.

Biology.--Nymphs inhabit sand-bottomed lakes, streams, and rivers. Adult males commonly alight upon sandbars, occasionally in considerable numbers.

Remarks.--This species is found throughout Virginia although much more common in the lowlands.

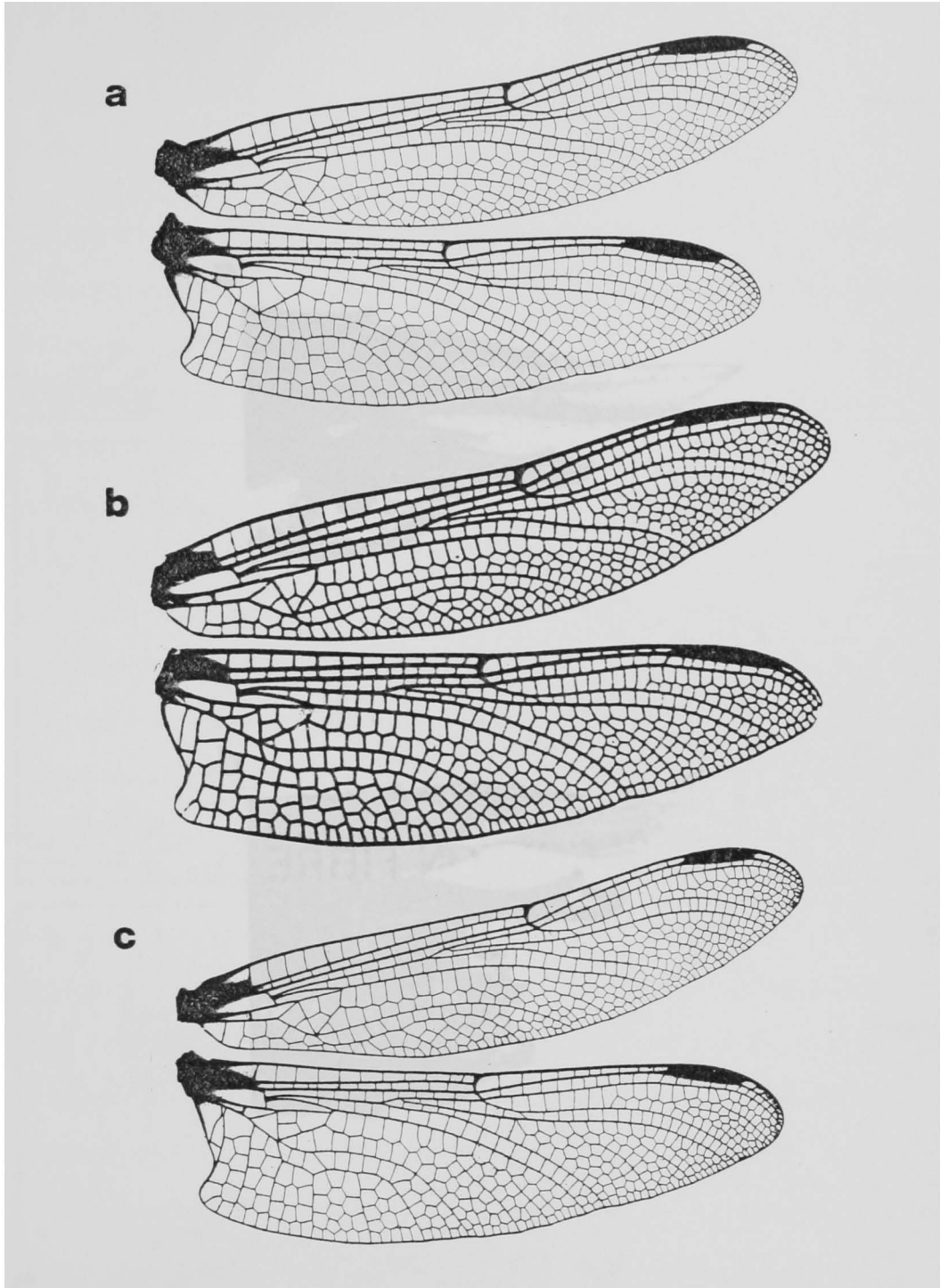


Figure 55. Wings of *Progomphus* x3: (a) *P. alachuensis*; (b) *P. bellei*; (c) *P. obscurus*.

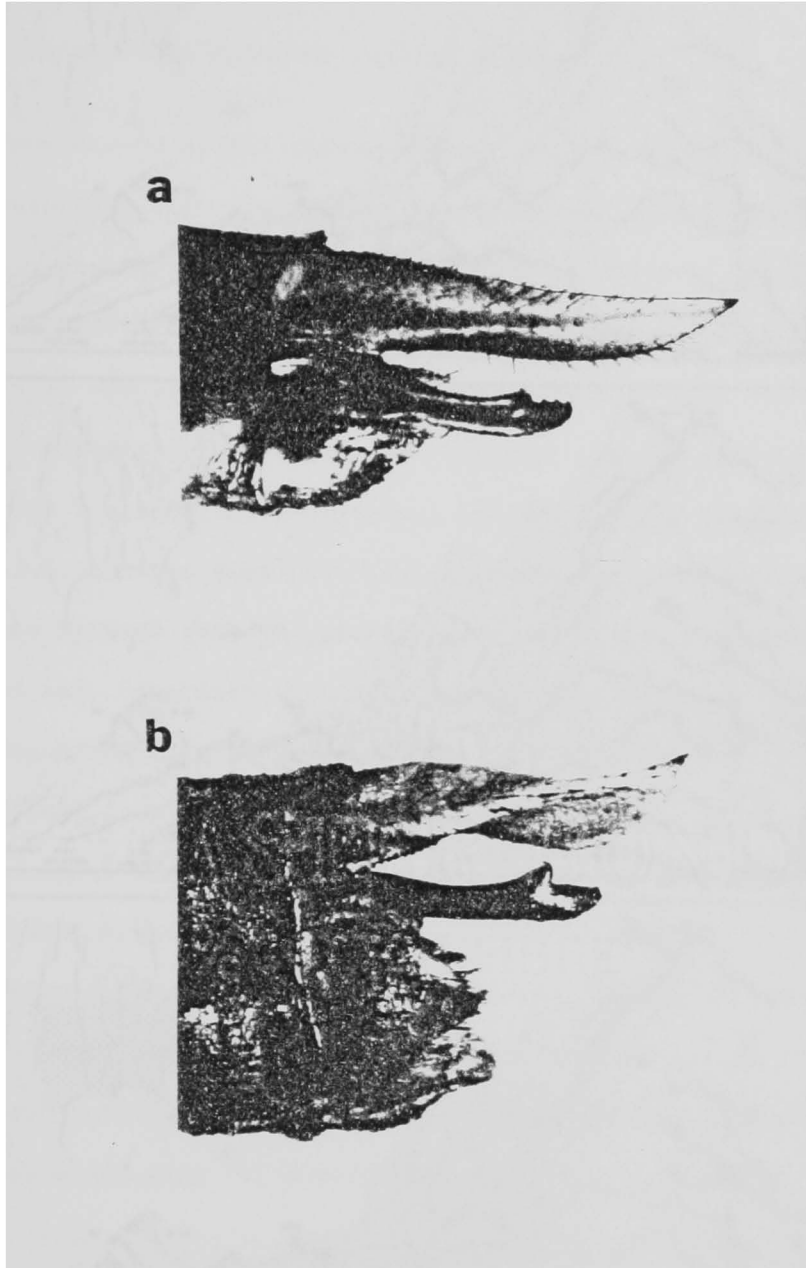


Figure 56. Male terminalia in lateral view of *Progomphus* x23:
(a) *P. alachuensis*; (b) *P. obscurus*.

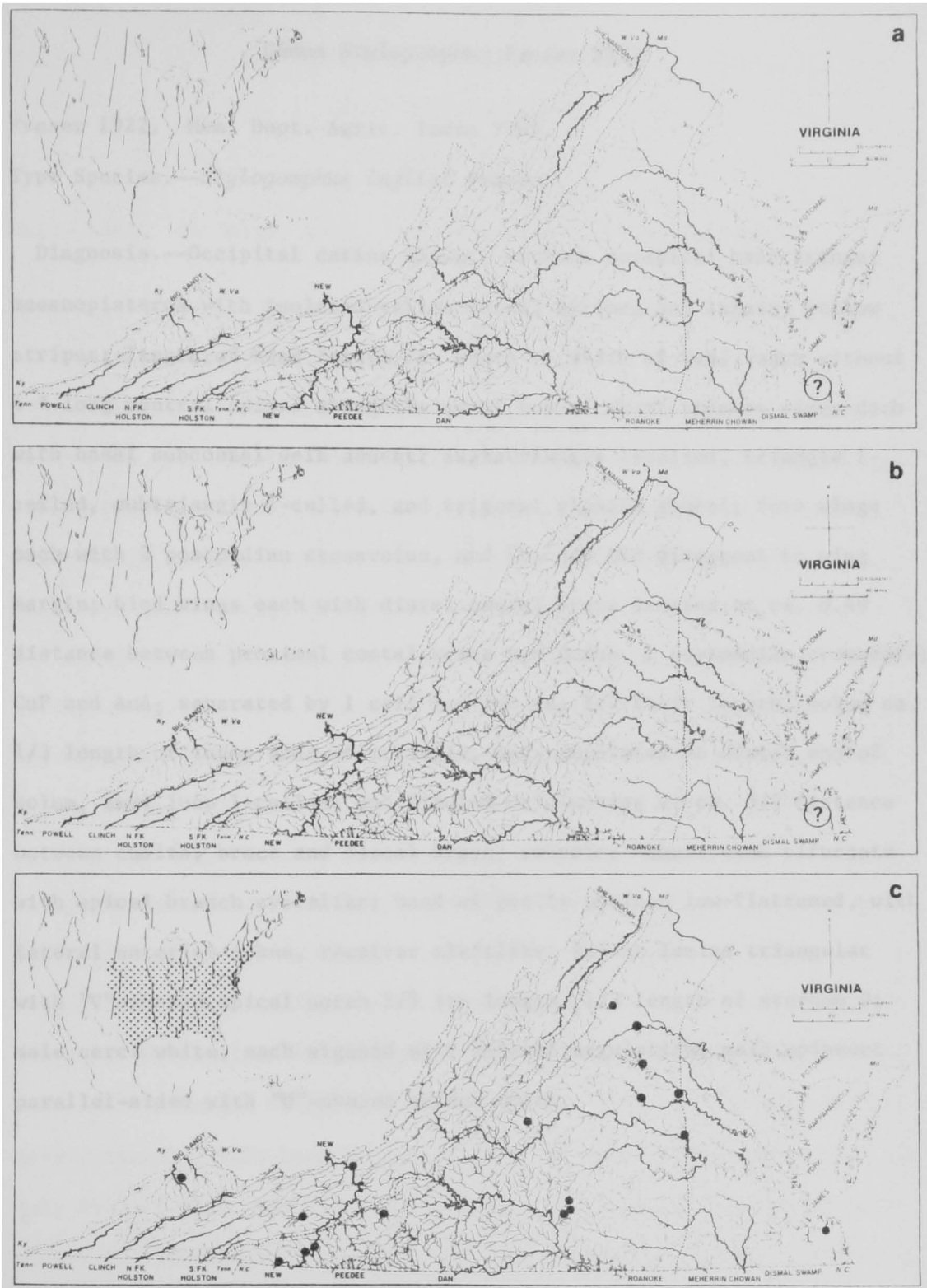


Figure 57. Geographic distribution of *Progomphus*: (a) *P. alachuensis*; (b) *P. bellei*; (c) *P. obscurus*.

Genus *Stylogomphus* Fraser 1922

Fraser 1922. Mem. Dept. Agric. India 7:69.

Type Species.--*Stylogomphus inglisi* Fraser.

Diagnosis.--Occipital carina absent, without occipital hair fringe; mesanepisterna with isolated yellow dorsal stripes and lateral yellow stripes; length of hind femora ca. equal to width of head, each without 4-7 long ventral spines alongside usual row of short spines; wings each with basal subcostal vein absent; supratriangle 1-celled, triangle 1-celled, subtriangle 1-celled, and trigonal planate absent; fore wings each with 2 postmedian crossveins, and CuA and CuP divergent to wing margin; hind wings each with distal costal brace located at ca. 0.49 distance between proximal costal brace and nodus, 1 postmedian crossvein; CuP and AnA₁ separated by 1 cell row for ca. 1/2 their length, solum ca. 1/3 length of inner side of triangle, AnA₂ angulated at distal end of solum, anal loop 1-celled, and fibulum originating at ca. 3/5 distance between cubital brace and discal brace; anterior hamuli each bifurcate with apical branch cyclelike; hood of penile vesicle low-flattened, with lateral anterior lobes, receiver cleftlike; vulvar lamina triangular with "V"-shaped apical notch 3/5 its length, 1/3 length of sternum 9; male cerci white, each sigmoid with lateral angulation; male epiproct parallel-sided with "U"-shaped apical notch.

Stylogomphus albistylus (Hagen)Syn.: *naevius* Hagen

(Figures 58, 59)

Hagen 1878. In Selys, Bull. Acad. Belg. 46:460 (in *Gomphus*).

Length 31-36 mm; abdomen 21-27 mm; hind wings 20-23 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AL, AR, CT, GA, KY, ME, MD, MA, MI, MS, MO, NH, NJ, NY, NC, OH, OK, PA, TN, VT, VA, WV, and WI, and the provinces of N.B., N.S., Ont., and Que. Known from the Virginia counties of Alleghany, Augusta, Bath, Botetourt, Craig, Fairfax, Giles, Highland, Mecklenburg, Montgomery, Pittsylvania, Rockbridge, Spotsylvania, and Washington. Known distribution among the counties of neighboring states include: Kentucky- Bell and Letcher; Maryland- Charles and Montgomery; North Carolina- Macon and Moore; Pennsylvania- Beaver, Berks, Bucks, Centre, Delaware, Elk, Fayette, Huntingdon, Jefferson, Lehigh, Lycoming, McKean, Northumberland, Perry, Pike, Potter, Somerset, Union, Westmoreland, and York; Tennessee- Cheatham, Cocke, Hardin, and Sullivan; West Virginia- Hampshire, Monroe, Pendleton, and Randolph.

Virginia Records.--Alleghany Co.; Dunlap Cr. at Rt. 311 nr. Earlhurst, 9 Aug. 1978, 1 male, FLC. Augusta Co.; Calfpasture R. at Deerfield, 23 June 1978, 2 males, FLC. Bath Co.; Back Cr. at Rt. 39, 18 June 1978, 1 male (teneral), FLC; Back Cr. at Rt. 600 1.3 miles N. of Mtn. Grove, 20 July 1973, 1 male, FLC, VPI&SU; Cowpasture R. 1 mile N. of Nimrod Hall at Rt. 42, 20 July 1973, 1 male, FLC; Cowpasture R. 1 mile N. of Nimrod Hall at Rt. 42, 25 July 1973, 4 males, FLC; Back Cr. at Rt. 600 1.3

miles N. of Mtn. Grove, 25 July 1973, 1 male, FLC. Botetourt Co.; Cow-pasture R. at Rt. 60, 4 June 1977, 1 male (teneral), FLC. Craig Co.; Johns Cr. at Rt. 311, 14 June 1974, 1 male, FLC; Craig Cr. at Rt. 691, 30 June 1978, 1 female, BCK; Craig Cr. at Rt. 621, 10 Aug. 1973, 1 male, FLC, VPI&SU. Fairfax Co.; Great Falls, 2 June 1914, 1 male, RPC, USNM; Great Falls, 2 June 1914, 1 female, collector unknown, USNM. Giles Co.; New R. at Spruce Run, 12 June 1977, 1 female, BCK; Walker Cr. at Rt. 100 2 miles S. of Poplar Hill, 26 June 1973, 1 male, SWD; Mtn. Lk., 11 Aug. 1949, 1 male (observed), C. F. Byers, (Byers 1951). Highland Co.; Bullpasture R. at head of gorge, 30 May 1977, 1 female, FLC; Shaws Fork, 30 May 1977, 2 males, FLC; Back Cr., 1 Aug. 1973, 1 male, FLC. Mecklenburg, tributary of Allens Cr., 31 May 1980, 1 female, BCK. Montgomery Co.; Mill Cr. at Rt. 785, 29 Mar. 1977 (emerged 18 Apr. 1977), 1 female P. K. Powell, BCK Collection; Pedlar Hollow at Rt. 603, 13 June 1978, 1 female, FLC; Toms Cr. 0.2 miles downstream from Rt. 655, 5 Aug. 1974, 1 male, FLC. Pittsylvania Co.; McGuff Cr. at Rt. 863, 14 Apr. 1978, 1 female nymph, FLC. Rockbridge Co.; Maury R. at Goshen Pass, 6 June 1977, 1 female, FLC; Goshen Pass, 23 June 1978, 1 male, FLC. Spotsylvania Co.; small tributary of Matta R. at Rt. 617, 7 July 1978, 1 male, FLC. Washington Co.; Spoon Gap at Rt. 670, 15 June 1980, 1 male, FLC.

Flight Season.--May 16 (PA) to Aug. 11 (VA); in Virginia May 30 to Aug. 11. Known season in neighboring states are: Kentucky- June to July; Maryland- May 25 to June; North Carolina- June 28; Pennsylvania- May 16 to Aug. 7; Tennessee- June 5 to July 31; West Virginia- May 21 to July 5.

Biology.--Nymphs inhabit small rills to large rivers with rapids. Males alight upon emergent rocks among rapids from which they seemingly disap-

pear upon taking flight and instantly reappear upon alighting.

Remarks.--This species has been previously incorrectly placed in the genus *Lanthus* (e.g. Needham and Heywood 1929, Needham and Westfall 1955, Walker 1958). Its nearest relatives are found in China, India, and Japan.

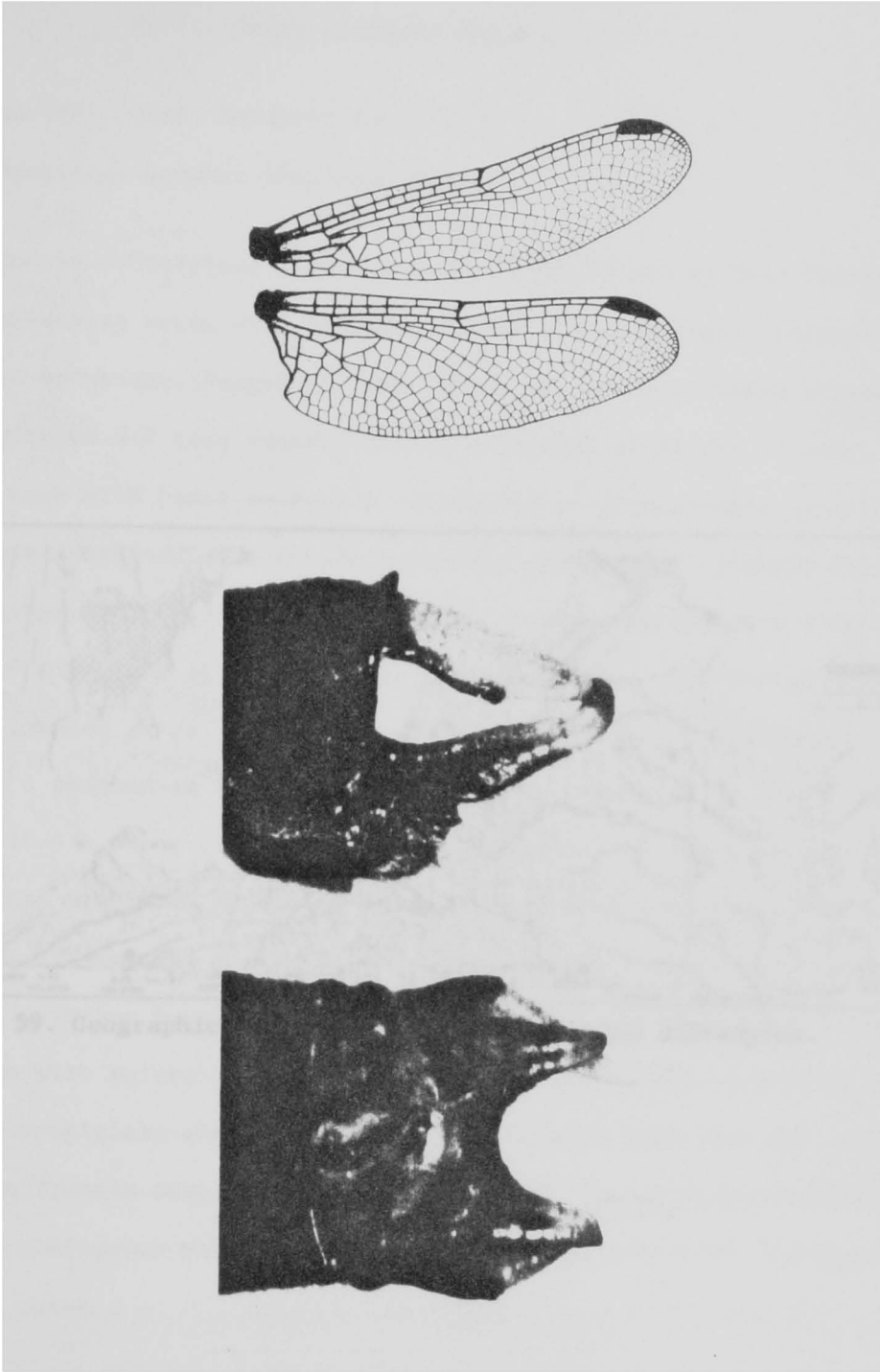


Figure 58. Wings x3 and male terminalia in lateral and ventral view x35 of *Stylogomphus albistylus*.

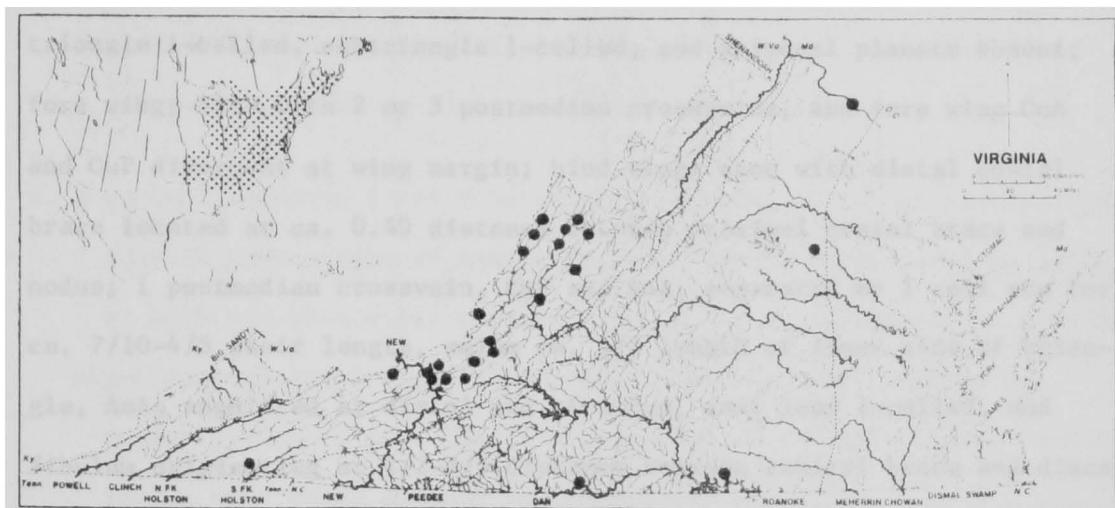


Figure 59. Geographic distribution of *Stylogomphus albistylus*.

Genus *Stylurus* Needham 1897

Needham 1897. Can. Entomol. 29:167.

Type Species.--*Gomphus plagiatus* Selys.

Diagnosis.--Occipital carina present, with occipital hair fringe; mesanepisterna brown with isolated dorsal yellow stripes, lateral stripes present or absent; length of hind femora ca. equal to width of head, each without 4-7 long ventral spines alongside usual row of short spines; wings each with basal subcostal vein absent, supratriangle 1-celled, triangle 1-celled, subtriangle 1-celled, and trigonal planate absent; fore wings each with 2 or 3 postmedian crossveins, and fore wing CuA and CuP divergent at wing margin; hind wings each with distal costal brace located at ca. 0.40 distance between proximal costal brace and nodus; 1 postmedian crossvein, CuP and AnA₁ separated by 1 cell row for ca. $7/10-4/5$ their length, solum ca. $1/2$ length of inner side of triangle, AnA₂ angulated at distal end of solum, anal loop 1-celled, and fibulum originating at $1/2-3/5$ distance between cubital brace and discal brace; anterior hamuli vestigial, each rodlike; hood of penile vesicle globose with anterolateral margins produced, receiver cleftlike; vulvar lamina vestigial, cleft for ca. $1/2$ its length, less than $1/5$ length of sternum 9; male cerci each acuminate without spines or denticulations, nearly contiguous basally; male epiproct divaricate with "U"-shaped apical notch.

Species Key to Adult *Stylurus* of Virginia

1. Posterior hamuli each without shoulder; vulvar lamina less than 1/7
length of sternum 9 2
- Posterior hamuli each with shoulder; vulvar lamina more than 1/7
length of sternum 9 4
2. Abdominal segments 7-10 yellowish-brown; male cerci each laterally
angulate; vulvar lamina ca. 1/3 as long as wide
. *S. plagiatus* p. 393
- Abdominal segments 7-10 yellowish-brown; male cerci each not later-
ally angulate; vulvar lamina ca. 1/6 as long as wide 3
3. Abdominal segments 8 and 9 subequal in length; posterior hamuli each
shorter than height of penile vesicle; female vertex without spine
at each end of ocellar ridge *S. notatus* p. 391
- Abdominal segment 9 distinctly longer than abdominal segment 8;
posterior hamuli each longer than height of penile vesicle; female
vertex with spine at each end of ocellar ridge
. *S. spiniceps* p. 396
4. Abdominal segments 3-7 with basal yellow annulations; male epiproct-
tal rami convexly upcurved without subapical dorsal pits; female
vertex with spine at each end of ocellar ridge
. *S. sculleri* p. 394
- Abdominal segments 3-7 without basal yellow annulations; male epi-
proctal rami convexly upcurved with subapical dorsal pits; female
vertex without spine at each end of ocellar ridge 5

5. Face greenish-yellow, abdominal segments 8-10 orange-yellow; posterior hamuli each with anterior edge semicircular between shoulder and apex; female ocellar ridge extended to lateral margin of vertex *S. ivae* p. 389

Face not greenish-yellow, abdominal segments 8-10 brown and yellow; posterior hamuli each with anterior edge not semicircular between shoulder and apex; female ocellar ridge not extended to lateral margin of vertex 6

6. Dorsal mesanepisternal pale stripes at midlength separated from dorsal carina by less than their width; apical pits of male epi-proctal rami open posteriorly; female vulvar lamina ca. as long as sternum 10 *S. amnicola* p. 388

Dorsal mesanepisternal pale stripes at midlength separated from dorsal carina by more than their width; apical pits of male epi-proctal rami not open posteriorly; female vulvar lamina not as long as sternum 10 7

7. Abdominal segment 9 slightly shorter than segment 8, yellow of segment 9 narrowly extended to posterior margin; apices of male cerci not needlelike, posterior hamuli each widest at shoulder; vulvar lamina shorter than sternum 10 *S. laurae* p. 390

Abdominal segment 9 distinctly shorter than segment 8, yellow of segment 9 not extended to posterior margin; apices of male cerci needlelike, posterior hamuli each widest at middle; vulvar lamina longer than sternum 10 *S. townesi* p. 398

Stylurus ammicola (Walsh)Syn.: *abditus* Butler

(Figures 60a,64a,66a)

Walsh 1862. Proc. Acad. Phila., p. 396 (in *Gomphus*).

Length 43-53 mm; abdomen 30-38 mm; hind wings 27-35 mm.

Diagnosis.--Face greenish with dark areas variously developed; female vertex with small lateral spines, female ocellar ridge not extended to lateral margin of vertex and without erect horns at each end; mesanepisternal middorsal carina yellow, and dorsal stripes slightly divergent; posterior hamuli each with shoulder; abdominal segments 3-6 without basal annulations, segments 7-9 dark brown and yellow; segment 8 longer than segment 9; vulvar lamina ca. 1/4 length of sternum 9; male cerci each without sharp lateral angulation, apices not needlelike; male epiproctal rami not convex ventrally, apical pits open posteriorly.

Distribution.--Known from the states of AL, IL, IN, IO, KS, KY, LA, MD, MA, MI, MN, MO, NE, NY, NC, OH, PA, VA, and WI, and the province of Que. Known from the Virginia counties of Grayson and Nelson. Known distribution among the counties of neighboring states include: Kentucky-Campbell and Robertson. North Carolina- Buncombe, Cumberland, and Roberson. Pennsylvania- Dauphin and Perry.

Virginia Records.--Grayson Co.; New R. at Rt. 810, 19 June 1977, 1 female, FLC. Nelson Co.; locality unknown, 8 July 1928, 1 female, (Det. MED, MDR notes), USNM.

Flight Season.--May 5 (OH) to Sept. (NC); in Virginia June 19 to July 8. Known season in neighboring states are: Kentucky- July; North

Carolina- June 22 to Sept.

Biology.--Inhabits pools of rivers.

Remarks.--The adult habits of this species are unknown; apparently most specimens previously collected have been teneral.

Stylurus ivae Williamson

(Figures 60b,64b,66b)

Williamson 1932. Occ. Pap. Mus. Zool. Univ. Mich. 247:12.

Length 58-62 mm; abdomen 42-47 mm; hind wings 35-41 mm.

Diagnosis.--Face greenish-yellow without dark areas variously developed; female vertex with small lateral spines, female ocellar ridge extended to lateral margin of vertex and without erect horns at each end; mesanepisternal middorsal carina brown, and dorsal stripes divergent; posterior hamuli each with shoulder; abdominal segments 3-6 without distinct yellow annulations, segments 7-9 yellowish-orange; segment 8 longer than segment 9; vulvar lamina ca. 3/10 length of sternum 9; male cerci each without sharp lateral angulation, apices not needlelike; male epiproctal rami not convex ventrally, apical pits open posteriorly.

Distribution.--Known from the states of FL, GA, NC, and SC. Known distribution among the counties of neighboring states include: North Carolina- Bladen, Columbus, Cumberland, Moore, Robeson, and Sampson. South Carolina- Barnwell.

Flight Season.--Aug. 18 (NC) to Oct. 29 (FL). Known season in neighboring states are: North Carolina- Aug. 18 to Oct.; South Carolina- Oct. 11.

Biology.--Nymphs inhabit sand-bottomed rivers and streams.

Remarks.--Although this species is not previously reported from Virginia it possibly occurs in slow-moving, sandy streams of the piedmont and coastal plain.

Stylurus laurae Williamson

(Figures 61a, 64c, 66c)

Williamson 1932. Occ. Pap. Mus. Zool. Univ. Mich. 247:3.

Length 56-64 mm; abdomen 41-48 mm; hind wings 34-42 mm.

Diagnosis.--Face yellowish-green with dark areas variously developed; female vertex with small lateral spines, female ocellar ridge not extended to lateral margin of vertex and without erect horns at each end; mesanepisternal middorsal carina brown, and dorsal stripes divergent; posterior hamuli each with shoulder; abdominal segments 3-6 without basal annulations, segments 7-9 dark brown and yellow; segment 8 ca. as long as segment 9; vulvar lamina ca. 3/10 length of sternum 9; male cerci each without sharp lateral angulation, apices not needlelike; male epi-proctal rami not convex ventrally, apical pits not open posteriorly.

Distribution.--Known from the states of AL, FL, GA, IN, KY, MD, MI, MS, NC, OH, SC, TN, TX, and VA, and the province of Que.(?). Known from the Virginia counties of Charlotte, Fairfax, Henrico, Louisa, Montgomery, and Nelson. Known distribution among the counties of neighboring states include: Kentucky- Casey and Green; North Carolina- Orange, Transylvania, Wilkes, and Yadkin; Tennessee- Fentress.

Virginia Records.--Charlotte Co.; Twittys Cr. at Rt. 642, 22 July 1978,

1 male, FLC; Twittys Cr. at Rt. 642, 24 July 1973, 2 males, FLC. Fairfax Co.; Fort Belvoir, 1 July 1932, 1 male (reared), TWD, (Det. TWD), FSCA. Henrico Co.; Richmond, 2 Aug. 1931, 1 female, C. F. Byers, FSCA. Louisa Co.; N. Anna R. at Rt. 208, date unknown, nymph, (Roback and Westfall, 1967). Montgomery Co.; Toms Cr. 1 mile downstream from Rt. 655 bridge, 15 July 1973, 1 male (in emergence), FLC; Toms Cr. at Rt. 655, 2 Sept. 1974, 11 males, 1 female, FLC. Nelson Co.; 6 miles N. of Lovington, 26 Sept. 1948, 1 male, R. L. Hoffman, (Det. LKG).

Flight Season.--July 2 (MD) to Oct. 6 (SC); in Virginia July 15 to Sept. 26. Known season in neighboring states are: North Carolina- July 28 to Sept. 7; Tennessee- Aug. 9.

Biology.--Nymphs inhabit streams and small rivers.

Remarks.--*Stylurus laurae* is among the most beautiful of dragonflies. Males rest on vegetation near the swifter parts of slow-moving streams. This species seems to prefer shade, the bright yellow of the apical abdominal segments appearing as a bright lantern in shaded situations.

Stylurus notatus (Rambur)

Syn.: *fluvialis* Walsh, *jucundus* Needham

(Figures 61b, 64d, 67a)

Rambur 1842. Ins. Neur., p. 162.

Length 51-64 mm; abdomen 37-42 mm; hind wings 30-35 mm.

Diagnosis.--Face dusky brown with dark areas variously developed; female vertex with small lateral spines, female ocellar ridge extended to lateral margin of vertex and without erect horns at each end; mesan-

episternal middorsal carina brown, and dorsal stripes divergent; posterior hamuli each without shoulder; abdominal segments 3-6 without basal annulations; segments 7-9 dark brown and yellow; segment 8 ca. as long as segment 9; vulvar lamina ca. 1/10 length of sternum 9; male cerci each without sharp lateral angulation, apices not needlelike; male epiproctal rami not concave ventrally, apical pits not open posteriorly.

Distribution.--Known from the states of AL, GA, IL, IN, IA, KY, MD, MA, MI, NY, NC, OH, PA, TN, VA, WV, and WI, and the provinces of Man., Ont., and Que. Known from the Virginia county of Loudoun. Known distribution among the counties of neighboring states include: Kentucky- Bell, Breckinridge, Butler, Cumberland, Edmonson, Green, Harrison, Letcher, Marion, Mason, Monroe, Muhlenburg, Rockcastle, Russell, and Whitley; Maryland- Montgomery; North Carolina- Wake; Pennsylvania- Allegheny; Tennessee- Davidson and Hardin; West Virginia- Jefferson.

Virginia Records.--Loudoun Co.; Potomac R. at Rt. 287, 3 Aug. 1975, 1 male, FLC.

Flight Season.--May 30 (TN) to Oct. 12 (Ont.); in Virginia Aug. 3. Known season in neighboring states are: Kentucky- July 5 to Oct. 4; Maryland- July 2; North Carolina- July; Tennessee- May 30 to Sept. 30; West Virginia- Sept. 9.

Biology.--Nymphs inhabit pools of large rivers.

Remarks.--Although apparently abundant at several locations judging from the number of nymphal exuviae found, the adults are rarely collected. The single Virginia specimen was collected near shore while "flying in" from midstream.

Stylurus plagiatus (Selys)Syn.: *elongatus* Selys

(Figures 62a, 65a, 67b)

Selys 1854. Bull. Acad. Belg. 21:57 (in *Gomphus*).

Length 56-66 mm; abdomen 40-50 mm; hind wings 30-40 mm.

Diagnosis.--Face yellow with diffuse dark areas variously developed; female vertex with small lateral spines, female ocellar ridge extended to lateral margin of vertex and without erect horns at each end; mesanepisternal middorsal carina brown, and dorsal stripes divergent; posterior hamuli each without shoulder; abdominal segments 3-6 without basal annulations, segments 7-9 orange-yellow; segment 8 shorter than segment 9; vulvar lamina ca. 1/10 length of sternum 9; male cerci each with sharp lateral angulation, apices not needlelike; male epiproctal rami obtusangulate ventrally, apical pits absent.

Distribution.--Known from the states of AL, AR, CA, DC, FL, GA, IL, IN, IA, KS, KY, LA, MD, MI, MO, NJ, NM, NY, NC, OH, OK, PA, SC, TN, TX VA, and WV, and the province of Ont., and from Mexico. Known from the Virginia counties of Fairfax, Henrico, James City, King William, Patrick, Southampton, and Sussex, and the city of Chesapeake. Known distribution among the counties of neighboring states include: Kentucky- Cumberland, Monroe, and Russell; Maryland- Charles, Montgomery, and Prince Georges; North Carolina- Columbus and Transylvania; Pennsylvania- Delaware and Philadelphia; Tennessee- Blount, Clay, Davidson, Jackson, Jefferson(?), and Wilson; West Virginia- Jefferson.

Virginia Records.--Fairfax Co.; Difficult Run at Potomac R., 19 Sept.

1978, 1 male (observed), FLC. Henrico Co.; James R. at Richmond, date unknown, nymph, collector unknown, (Det. Roback, Roback and Westfall 1967); Richmond, date unknown, 1 male, O. A. Stecker, (Det. E. B. Williamson, Williamson 1901), MCZ. James City Co.; Williamsburg, 20 Aug. 1967, 1 male, MDR, VPI&SU. King William Co.; Pamunkey R., 26 Aug. 1975, 1 male, 1 female, collector unknown, VPI&SU. Patrick Co.; Dan R. at Rt. 103, 21 May 1978, nymph, FLC. Southampton Co.; Nottoway R. at Rt. 653, 10 Oct. 1978, 5 males, 1 female, FLC. Sussex Co.; Nottoway R. at Rt. 40 nr. Homeville, 15 Apr. 1978 (emerged 15 July 1978), 2 males, FLC. City of Chesapeake; L. Drummond feeder ditch, 13 Aug. 1974, 1 male, FLC.

Flight Season.--May 13 (FL) to Nov. 13 (FL); in Virginia Aug. 13 to Oct. 10. Known season in neighboring states are: District of Columbia- Sept. 27; Maryland- June 11 to Sept. 10; North Carolina- Aug. 29 to Sept.; Pennsylvania- July 1 to Aug. 31; Tennessee- Sept. 7 to 30; West Virginia- Sept. 9.

Biology.--Nymphs inhabit pools of slow-moving rivers. Adult males hover over the swifter portions of slow rivers, and alight upon stream-side vegetation.

Remarks.--Seemingly the most morphologically variable species of the genus, *Stylurus plagiatus* is easily recognized by the angulate lateral margins of the male cerci.

Stylurus scudderi (Selys)

(Figures 62b, 65b, 67c)

Selys 1873. Bull. Acad. Belg. 35:752 (in *Gomphus*).

Length 52-61 mm; abdomen 37-44 mm; hind wings 29-39 mm.

Diagnosis.--Face yellowish-green with dark areas variously developed; female vertex with small lateral spines, female ocellar ridge extended to lateral margin of vertex and with erect horns at each end; mesanepisternal middorsal carina brown, and dorsal stripes divergent; posterior hamuli each with shoulder; abdominal segments 3-6 with basal yellow annulations, segments 7-9 dark brown and yellowish-green; segment 8 ca. as long as segment 9; vulvar lamina ca. 1/5 length of sternum 9; male cerci each without sharp lateral angulation, apices not needlelike; male eiproctal rami convex ventrally, apical pits absent.

Distribution.--Known from the states of CT, GA, ME, MA, MI, NH, NY, NC, PA, SC, TN, VT, VA, WV, and WI, and the provinces of N.S., Ont., and Que. Known from the Virginia county of Roanoke. Known distribution among the counties of neighboring states include: North Carolina- Jackson, Swain, and Transylvania; Pennsylvania- Clarion, Clearfield, and Jefferson; West Virginia- Randolph and Tompkins.

Virginia Records.--Roanoke Co.; small stream nr. Roanoke, 10 Sept. 1974, 1 female, Hopkins, VPI&SU.

Flight Season.--June 25 (Ont.) to Oct. 6 (SC); in Virginia Sept. 10. Known season in neighboring states are: North Carolina- July 8 to Aug.; Pennsylvania- July 16 to Sept. 30; West Virginia- July 5.

Biology.--Nymphs inhabit pools of streams and rivers. Adults are most abundant near swift water along slow, meandering, sand-bottomed rivers. Males frequently land on sandbars and vegetation. Oviposition occurs at the head of swift water where the female repeatedly taps her abdomen in about the same place before moving on.

Remarks.--*Stylurus scudderi* is a robust species with annulate abdomen and greatly expanded apical abdominal segments.

Stylurus spiniceps (Walsh)

Syn.: *segregans* Needham

(Figures 63a, 65c, 68a)

Walsh 1862. Proc. Acad. Phila., p. 389 (in *Macrogomphus*).

Length 54-68 mm; abdomen 42-51 mm; hind wings 33-39 mm.

Diagnosis.--Face dusky brown with dark areas variously developed; female vertex with small lateral spines, female ocellar ridge extended to lateral margin of vertex and with erect horns at each end; mesanepisternal middorsal carina brown, and dorsal stripes divergent; posterior hamuli each without shoulder; abdominal segments 3-6 without basal annulations; segments 7-9 dark brown and yellow; segment 8 shorter than segment 9; vulvar lamina ca. 1/12 length of sternum 9; male cerci each without sharp lateral angulation, apices not needlelike; male epiproctal rami not convex ventrally, apical pits not open posteriorly.

Distribution.--Known from the states of IL, IN, KY, MD, MA, MI, MO, NH, NY, NC, OH, PA, SC, TN, VA, WV, and WI, and the provinces of Ont. and Que. Known from the Virginia counties of Carroll, Culpeper, Fairfax, Floyd, Grayson, Henrico, Montgomery, and Pittsylvania. Known distribution among the counties of neighboring states include: Kentucky- Adair, Green, Harrison, Marion, and Russell; Maryland- Montgomery; North Carolina- Buncombe, Swain, and Transylvania; Pennsylvania- Allegheny, Berks, Chester, Cumberland, Delaware, Forest, Jefferson, Perry, and

Philadelphia; Tennessee- Anderson, Claiborne, Hancock, Sevier, and Union(?).

Virginia Records.--Carroll Co.; New R. at bridge nr. Fries, 26 Aug. 1976, 1 male, C. R. Parker, VPI&SU; Culpeper Co.; Rt. 707, 21 Aug. 1979, 1 male, G. Firth, BCK Collection. Hazel R., 4 Sept. 1980, 3 males, BCK. Fairfax Co.; Potomac R. 0.5 miles above the Great Falls, 17 Apr. 1978 (emerged 18,29 June 1978), 1 male nymph, 1 female nymph, FLC. Floyd Co.; Little R. at Rt. 615, 1 Jan. 1978 (emerged 12 Apr. 1978), 1 female nymph, FLC. Grayson Co.; New R. at Rt. 810 nr. Galax, 19 June 1977, 1 male, BCK, FLC Collection; New R. at Elk Cr. W. of Galax, 28 Aug. 1952, 1 male, R. L. Hoffman, (Det. R. H. Gibbs). Henrico Co.; James R. at Richmond, date unknown, 1 nymph, (Roback and Westfall, 1967). Montgomery Co.; Webb St. in Blacksburg, 8 Aug. 1977, 1 female, C. J. Carle, FLC Collection; locality unknown, 21 Aug. 1968, 1 female, T. Mullins, VPI&SU. Pittsylvania Co.; Sandy R. at Hinesville, 25 Aug. 1975, 1 male, FLC.

Flight Season.--June 19 (VA) to Oct. 15 (PA); in Virginia June 19 to Sept. 4. Known season in neighboring states are: Kentucky- July 17 to Oct.; Maryland- Sept. 19-28; North Carolina- July 28 to Aug. 29; Pennsylvania- June 24 to Oct. 15; Tennessee- July 4 to Aug. 14.

Biology.--Inhabits mud bottoms of rivers and streams.

Remarks.--An elongate, dark species, apparently the most common

Stylurus in Virginia.

Stylurus townesi Gloyd

(Figures 63b, 65d, 68b)

Gloyd 1936. Occ. Pap. Mus. Zool. Univ. Mich. 226:5.

Length 50-54 mm; abdomen 37-39 mm; hind wings 32-34 mm.

Diagnosis.--Face dusky green with dark areas variously developed; female vertex with small lateral spines, female ocellar ridge not extended to lateral margin of vertex and without erect horns at each end; mesanepisternal middorsal carina brown or yellow, and dorsal stripes divergent; posterior hamuli each with shoulder; abdominal segments 3-6 without basal annulations; segments 7-9 dark brown and yellow; segment 8 longer than segment 9; vulvar lamina ca. $\frac{2}{5}$ length of sternum 9; male cerci each without sharp lateral angulation, apices needlelike; male epiproctal rami not convex ventrally, apical pits not open posteriorly.

Distribution.--Known from the states of AL, FL, MS, NC, and SC. Known distribution among the counties of neighboring states include: North Carolina- Columbus.

Flight Season.--June 9 (FL) to Sept. 20 (NC). Known season in neighboring states are: North Carolina- Sept. 20.

Biology.--Nymphs inhabit small rivers. This species is apparently the most active species of *Stylurus* towards dusk. Females seem to be more evident at streamside than those of other species.

Remarks.--*Stylurus townesi* is a brownish species which may occur in streams of the coastal plain in Virginia.

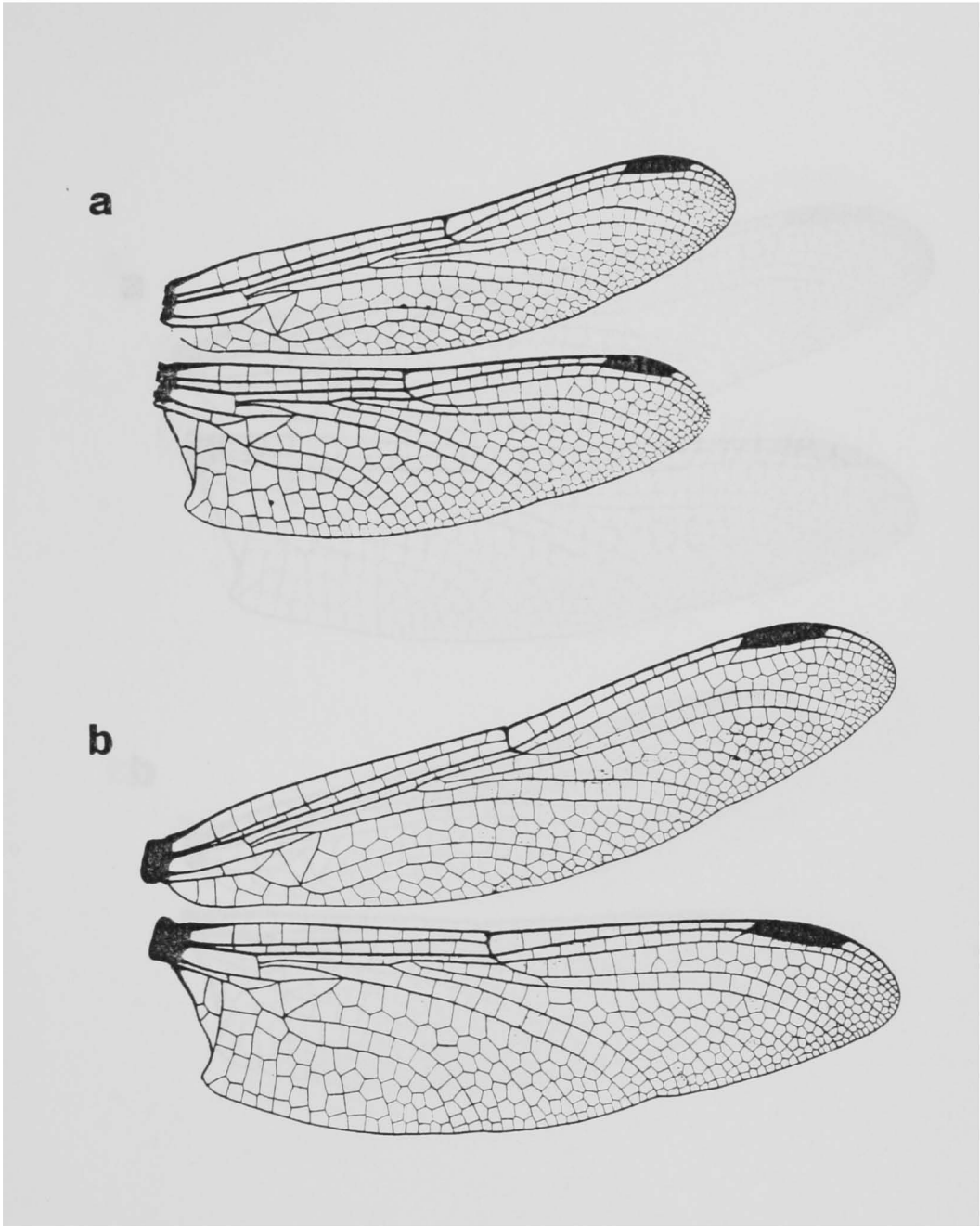


Figure 60. Wings of *Stylurus* x3: (a) *S. amnicola*; (b) *S. ivae*.

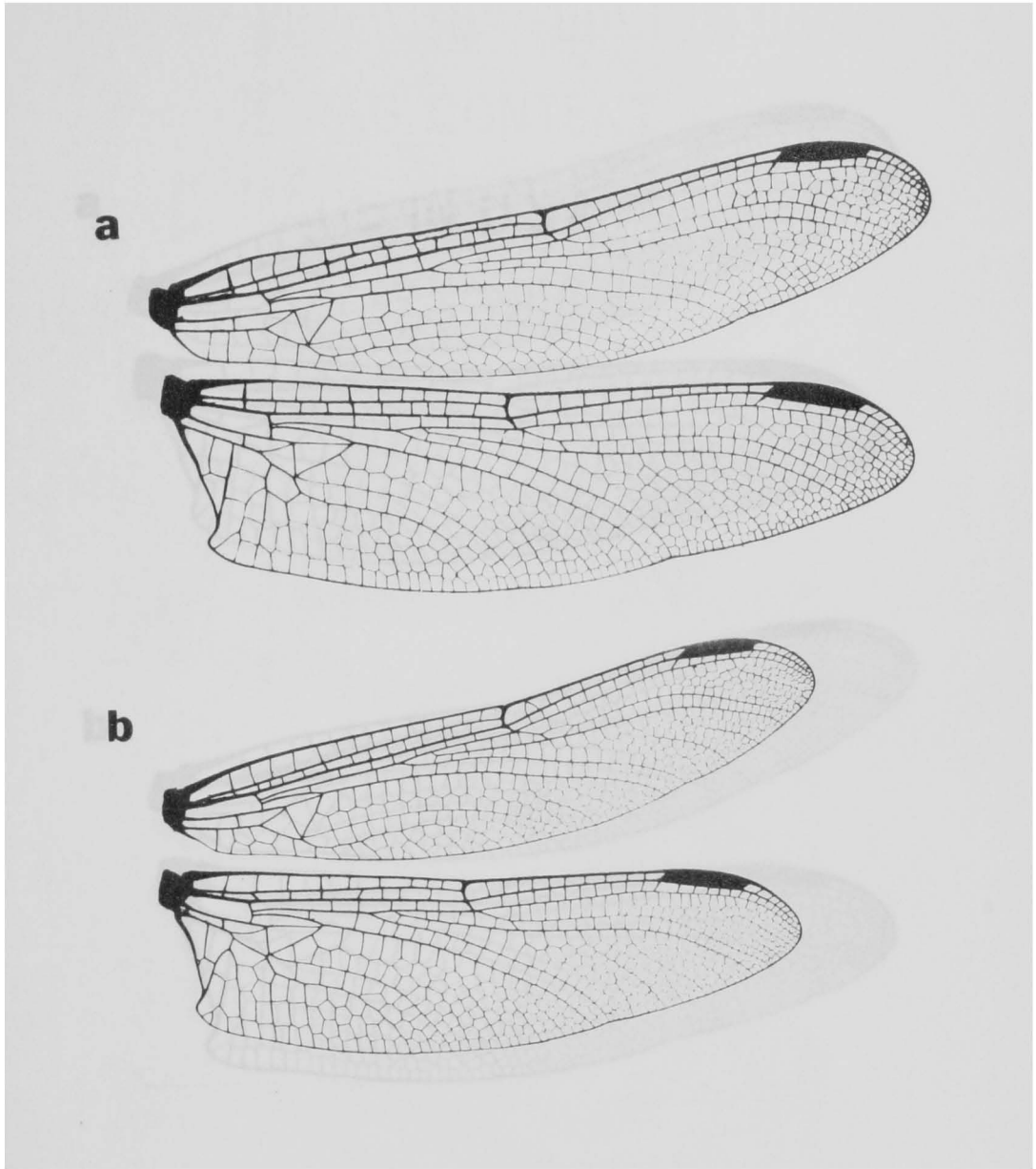


Figure 61. Wings of *Stylurus* x3: (a) *S. laurie*; (b) *S. notatus*.

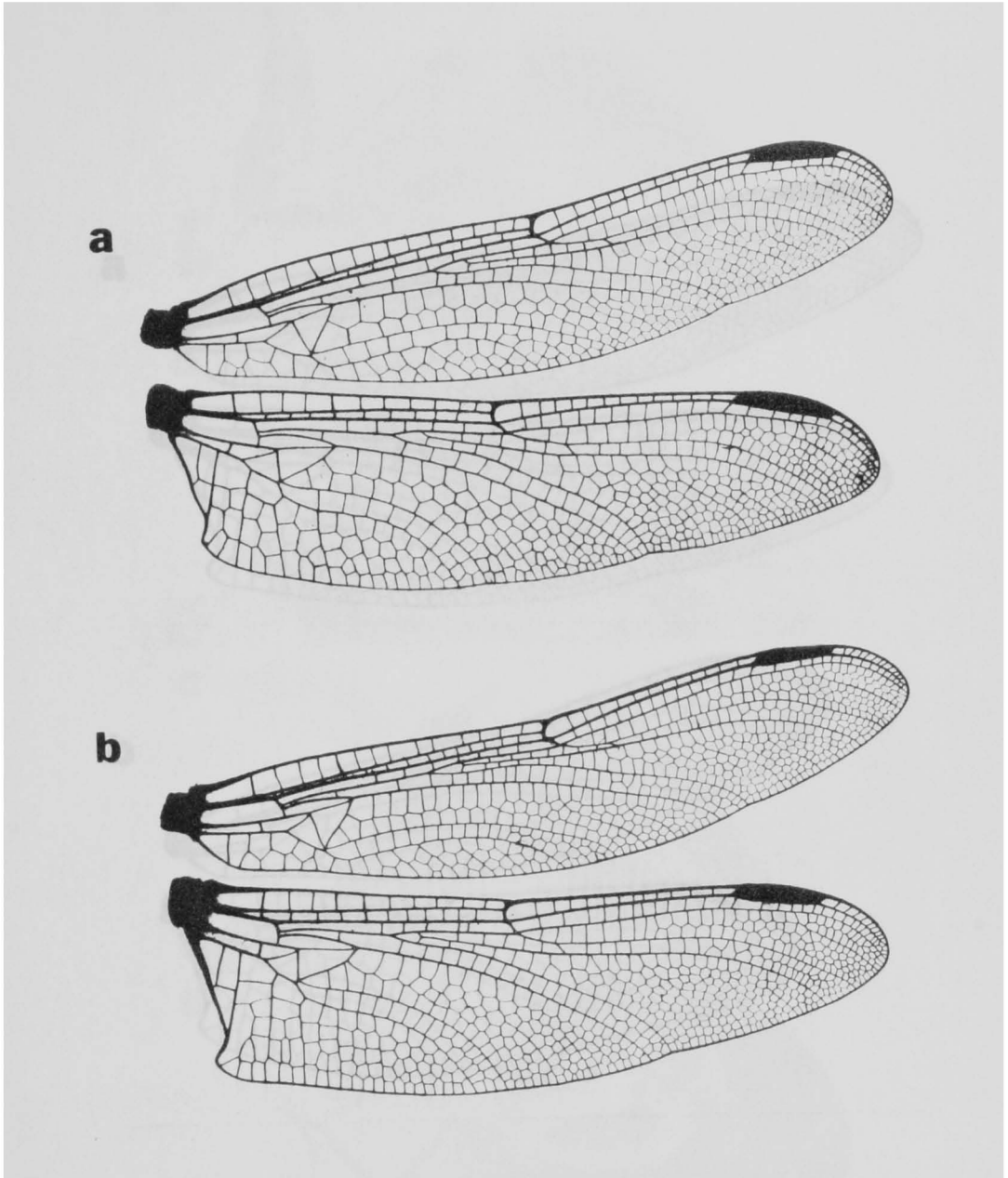


Figure 62. Wings of *Stylurus* x3: (a) *S. plagiatus*; (b) *S. scudderi*.

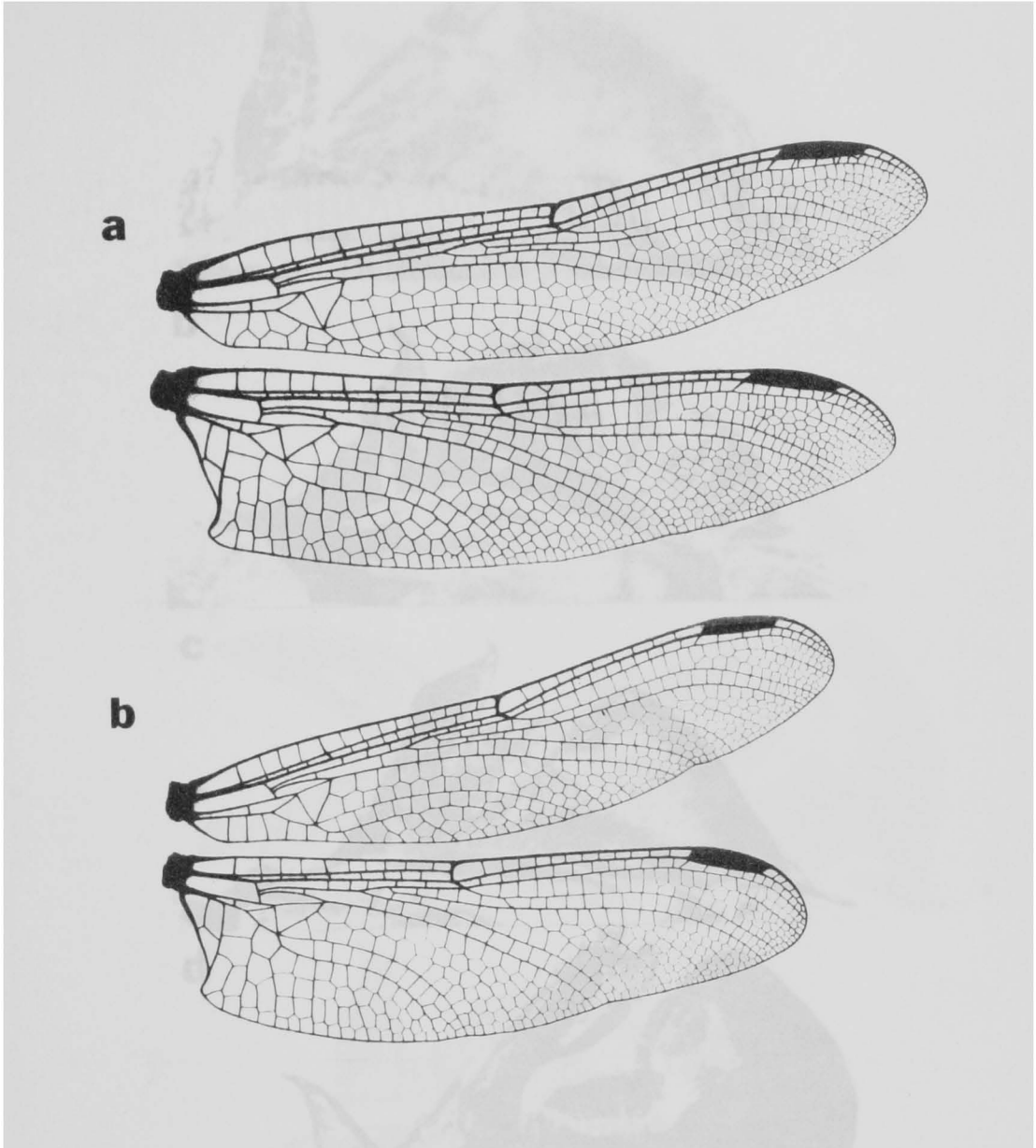


Figure 63. Wings of *Stylurus* x3: (a) *S. spiniceps*; (b) *S. townesi*.

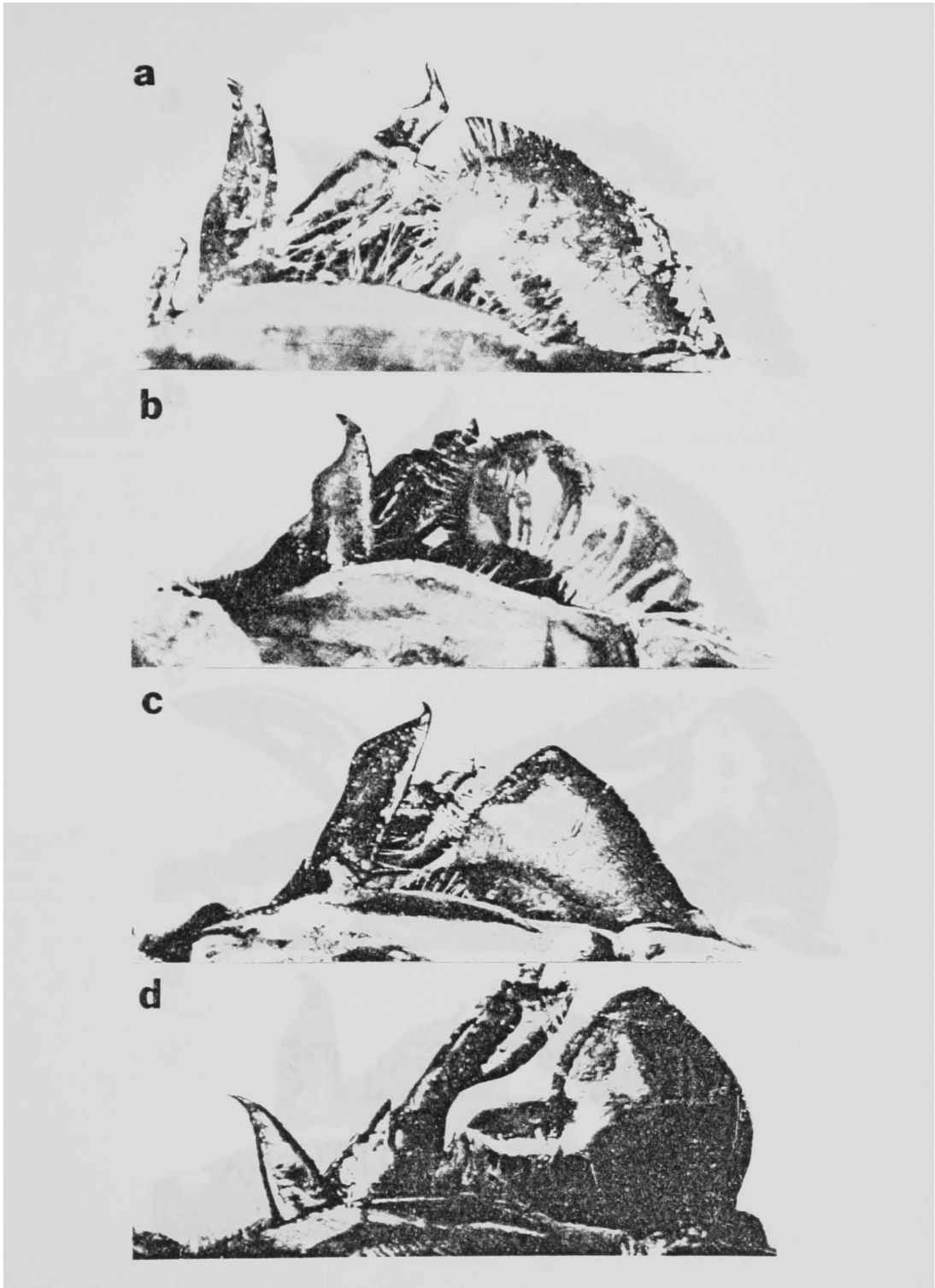


Figure 64. Secondary genitalia in lateral view of *Styburus* x20:
(a) *S. ammicola*; (b) *S. ivae*; (c) *S. laurae*; (d) *S. notatus*.



Figure 65. Secondary genitalia in lateral view of *Stylurus* x20:
(a) *S. plagiatus*; (b) *S. scudleri*; (c) *S. spiniceps*;
(d) *S. townesi*.

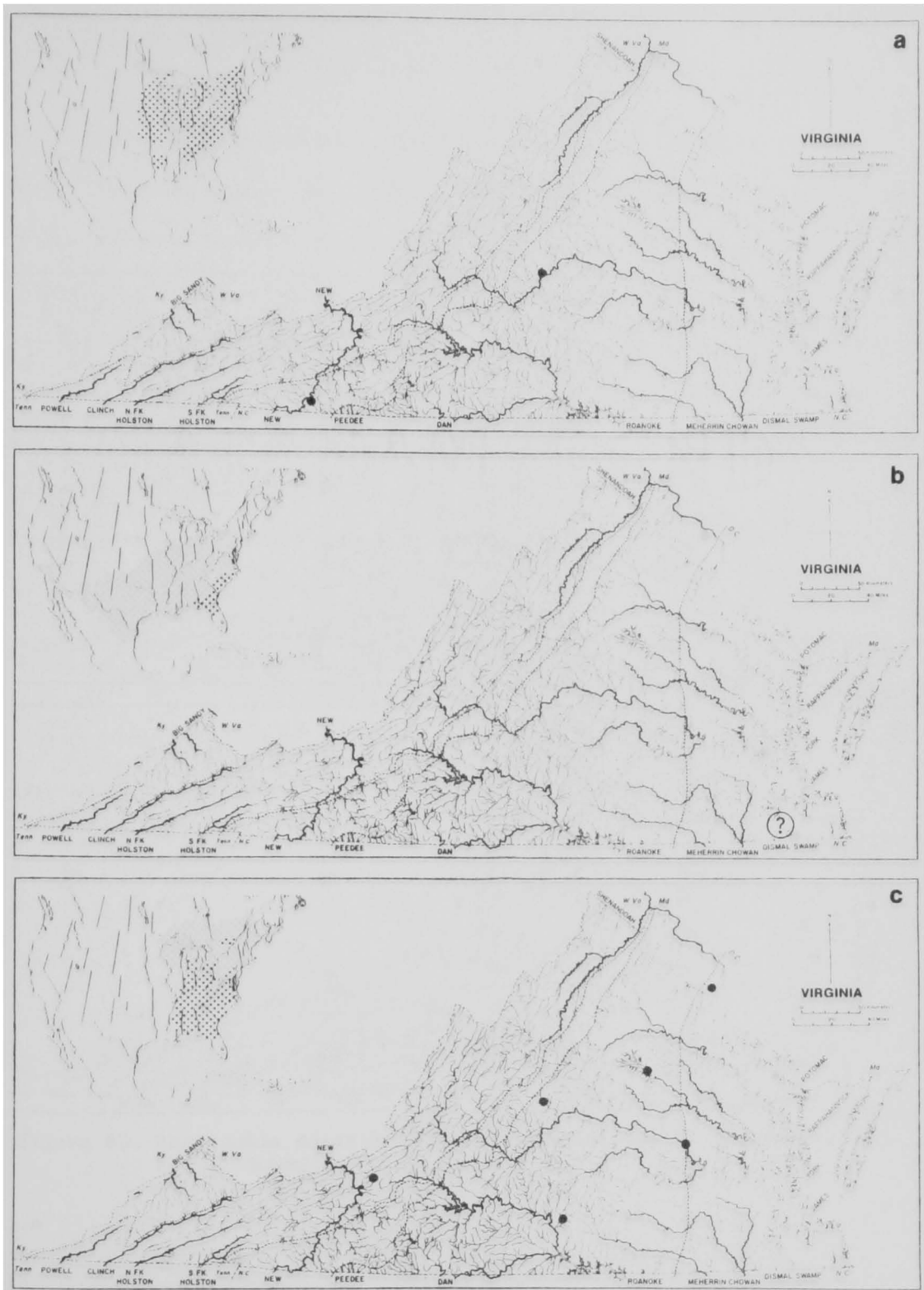


Figure 66. Geographic distribution of *Stylurus*: (a) *S. amnicola*; (b) *S. ivae*; (c) *S. laurae*.

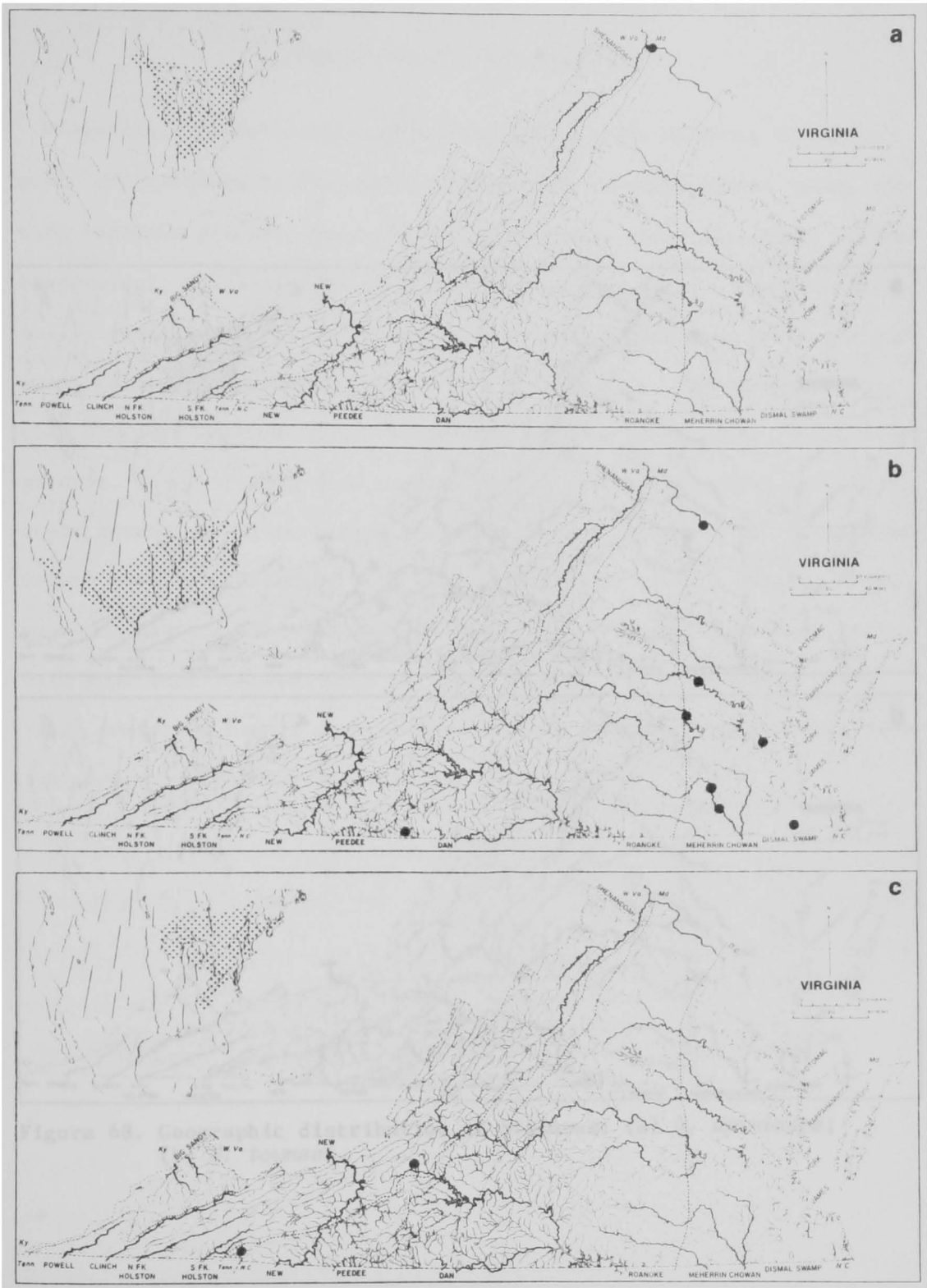


Figure 67. Geographic distribution of *Stylurus*: (a) *S. notatus*; (b) *S. plagiatus*; (c) *S. scudderi*.

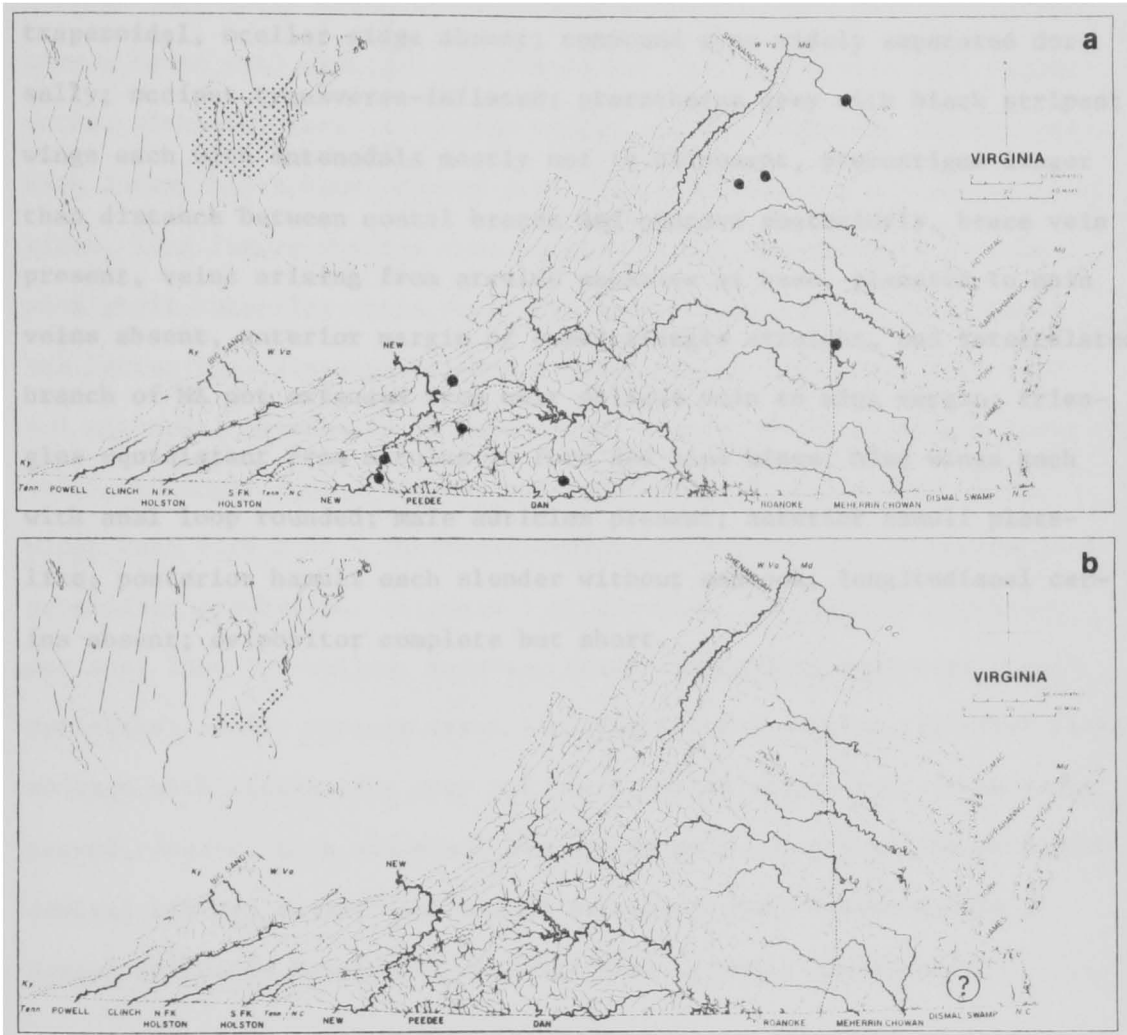


Figure 68. Geographic distribution of *Stylurus*: (a) *S. s. iniceps*; (b) *S. townesi*.

Family PETALURIDAE Needham

Diagnosis.--Distal margin of labium cleft; first segments of labial palpi not approximate distally and each with incurved apical spine, second segments present; face (frons and clypeus) wider than high; vertex trapezoidal, ocellar ridge absent; compound eyes widely separated dorsally; occiput transverse-inflated; pterothorax grey with black stripes; wings each with antenodals mostly not in alignment, pterostigma longer than distance between costal braces and concave posteriorly, brace vein present, veins arising from arculus separate at base, planates to main veins absent, anterior margin of supertriangle straight, and intercalated branch of MA not extended from near oblique vein to wing margin; triangles equidistant from arculus in fore and hind wings; hind wings each with anal loop rounded; male auricles present; anterior hamuli plate-like; posterior hamuli each slender without endhook; longitudinal carina absent; ovipositor complete but short.

Genus *Tachopteryx*: Selys 1859

Selys 1859. Bull. Acad. Belg. 7:551.

Type Species.--*Uropetala thoreyi* Hagen.

Diagnosis.--Face white with black band across lower half of clypeus; labrum white with proximal and distal margins, and median spot black; vertex without spines or ocellar ridge; occiput inflated, whitish grey with dorsal black band; thorax grey with black bands along sulci; legs black, hind femora shorter than width of head; metathoracic sternum with small tubercle; wings each with pterostigma concave posteriorly and longer than distance between costal braces; fore wings each with 4-6 antenodal crossveins between costal braces, 8-10 postmedian crossveins, triangle 2 or 3-celled, and subtriangle 2 or 3-celled; hind wings each with 3 or 4 antenodal crossveins between costal braces, 4-6 postmedian crossveins, triangle 1 or 2-celled, subtriangle 1-celled, and anal loop 3-7-celled; anterior hamuli platelike; posterior hamuli cyclelike; penile vesicle erect with low lateral margins, receiver flat; abdomen with alternating grey and black spots; ovipositor strongly up-curved, shorter than abdominal segment 8; male cerci leaflike each with central rib and asymmetrical medial expansion; male epiproct with 2 dorsal spines in basal half and with rami apically divaricate.

Tachopteryx thoreyi (Hagen)

(Figures 69,70)

Hagen 1857. In Selys, Mon. Gomph., p. 373 (in *Uropetala*).

Length 70-80 mm; abdomen 50-61 mm; hind wings 47-53 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AL, AR, FL, GA, IN, KY, LA, MD, MA, MI, MS, MO, NH, NJ, NY, NC, OH, PA, SC, TN, TX, VA, and WV, and the province of Que. Known from the Virginia counties of Augusta, Craig, Fairfax, Fauquire, Giles, Hanover, James City, Nelson, Orange, Patrick, Prince William, Tazewell, and Warren. Known distribution among the counties of neighboring states include: Kentucky- Fayette, Green, Jessamine, McCreary, Powell, Wayne, and Whitley; Maryland- Frederick, Montgomery, and Prince Georges; North Carolina- Transylvania, Wake, and Wilkes; Pennsylvania- Allegheny, Beaver, Centre, Cumberland, Dauphin, Delaware, Fayette, Huntingdon, Lawrence, and Westmoreland; Tennessee- Fentress, Lewis, and Morgan; West Virginia- Hampshire.

Virginia Records.--Augusta Co.; nr. Calfpasture R. at Rt. 689, 13 June 1980, 1 female, FLC. Craig Co.; Dry Branch at Rt. 609, 17 June 1978, 13 males, 2 females, FLC. Fairfax Co.; Great Falls, "May 22-July 6" (Donnelly 1961): Great Falls, 2 June 1914, 1 male, RPC, USNM; Great Falls, 16 June 1910, 1 male, WTD, USNM; Great Falls, 9 July 1910, 1 male, C. T. Greene, USNM. Fauquier Co.; Horsepen Run, 3 Aug. 1973, 1 male, JFM, ODU. Giles Co.; nr. Riopel Pd., Mt. Lake Bio. Sta., 26 June 1977, 1 male, FLC. Hanover Co.; nr. N. Anna Falls, 22 June 1977, 1 male, BCK. James City Co.; nr. Jollys Pd., 22 May 1938, 1 female, MED, MZUM;

Jamestown Rd., 7 June 1938, 1 female, MED, MZUM; nr. Lake Matoaka, 9 June 1937, 1 male, CC, MZUM. Nelson Co.; locality unknown, 11 July 1928, 1 male, 2 females, WR, USNM; locality unknown, 15 July 1923, 1 male, WR, USNM; locality unknown, 20 July 1917, 1 female, WR, USNM; locality unknown, 20 July 1928, 1 female, WR, USNM; locality unknown, 28 July 1919, 1 male, WR, USNM. Orange Co.; Mine Run 1/2 mile W. of Rt. 603, 15 July 1980, 1 male, BCK. Patrick Co.; Rock Castle seep at Rt. 605, 6 June 1976, 1 male, Hammond; Rock Castle Seep at Rt. 605, 11 June 1978, 3 males, FLC. Prince William Co.; Colchester, "May 22-July 6", (Donnelly 1961); Colchester, 17 June 1923, 1 female, D. K. Currie, USNM. Tazewell Co.; Tributary of Cove Cr. at Rt. 662, 10 June 1978, 1 male, FLC; Cove Branch Bog, 11 July 1977, 1 male, C. R. Parker, VPI&SU. Warren Co.; nr. Surber's Pd. at Rt. 634, 29 May 1974, 1 male (teneral), E. W. Surber, VPI&SU; Spring Seep S. of Rt. 634, 6 June 1977, 3 males, FLC; nr. Surber's Pd. at Rt. 634, 6 June 1976, 1 male, SWB; nr. Surber's Pd. at Rt. 634, 5 July 1975, 3 males, FLC; nr. Surber's Pd. at Rt. 634, 5 July 1975, 1 male, SWB; Spring seep S. of Rt. 634, 23 July 1978, 2 males, FLC; Tributary of Lands Run at Rt. 622, 23 July 1978, 1 male, FLC.

Flight Season.--Apr. 3 (FL) to Aug. 19 (NC); in Virginia May 22 to Aug. 3. Known flight season in neighboring states are: Kentucky- June 4 to Aug. 8; Maryland- May 22 to July 6; Pennsylvania- June 1 to July 31; North Carolina- May 14 to Aug. 19; Tennessee- July 15 to Aug. 5; West Virginia- June 12.

Biology.--The adults are most often observed clinging vertically on sunlit tree trunks where, owing to their color and body shape, they are hardly discernible. Although *Tachopteryx thoreyi* has the most extensive

range among the petalurines, the adults are seldom found more than 20 m from small isolated seepage areas which provide nymphal habitats. The adults are swift, fearless flyers and will frequently alight upon a collector's shoulder as he enters "*Tachopteryx* territory". Prey is eaten at rest and often includes large crane flies, butterflies, and dragonflies. Oviposition takes place among the wet roots, mosses, and detrital material of seepage areas where the nymphs later develop. Although contrary to current thought, the nymphs apparently do not live in burrows as do most Petaluridae.

Remarks.--Limited in distribution to eastern North America, this species is the largest of the Tachopterinae, representing the sole member of the genus *Tachopteryx*.

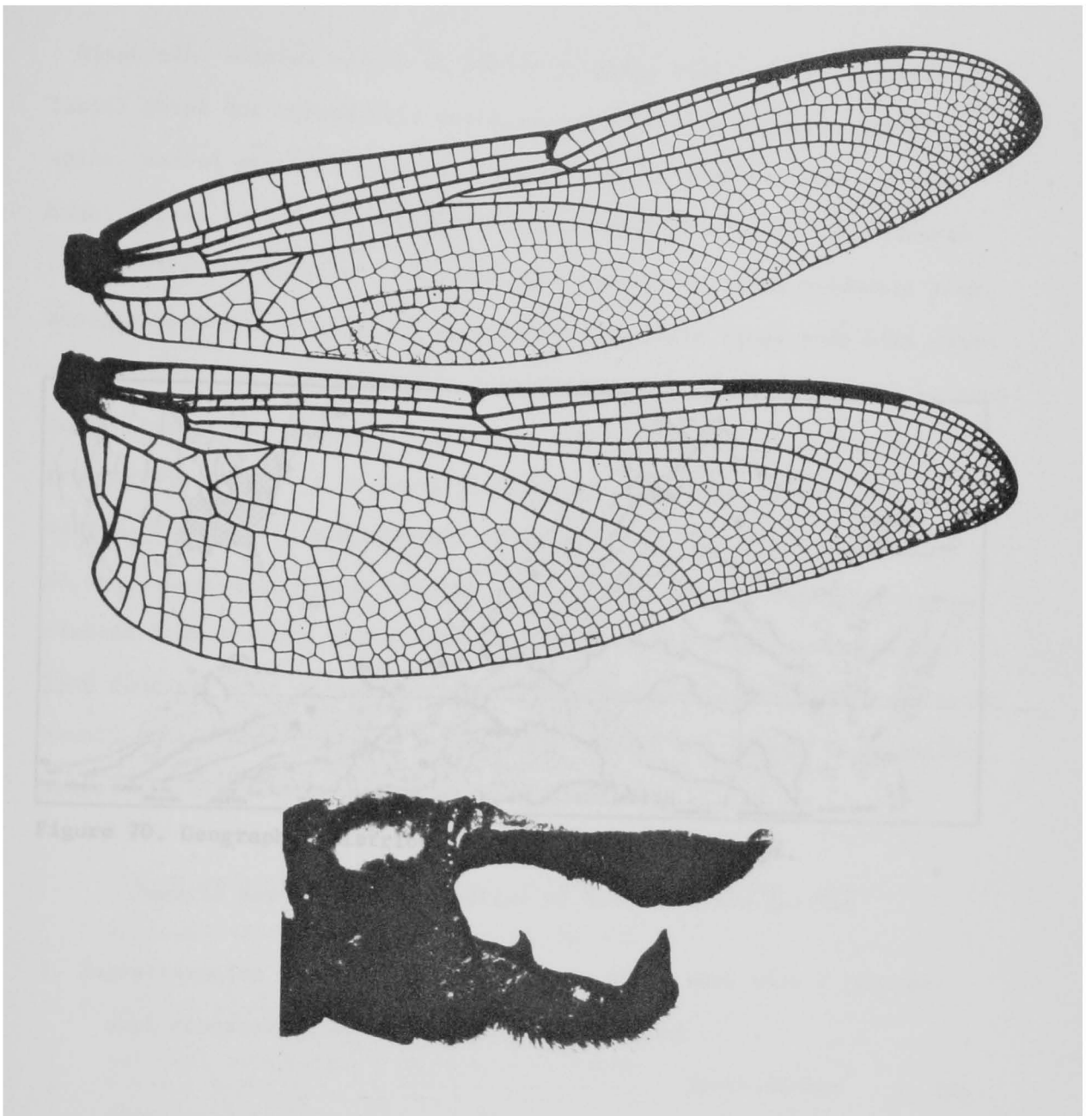


Figure 69. Wings x3 and male terminalia in lateral view x14 of *Tachopteryx thoreyi*.

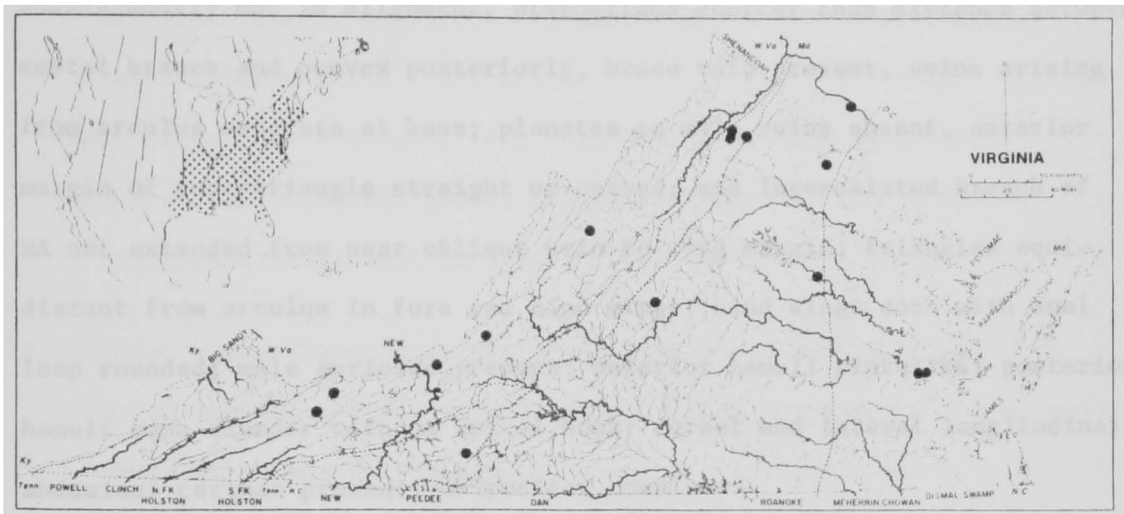


Figure 70. Geographic distribution of *Tachopteryx thoreyi*.

Family AESHNIDAE Selys

Diagnosis.--Distal margin of labium slightly cleft; first segments of labial palpi not approximate distally and each with incurved apical spine, second segments present; face (frons and clypeus) narrower than high; vertex triangular, ocellar ridge present, hoodlike, with lateral ocelli situated on crest; compound eyes contiguous along middorsal seam; occipit triangular, color of pterothorax variable; wings each with antenodals mostly not in alignment, pterostigma shorter than distance between costal braces and convex posteriorly, brace vein present, veins arising from arculus separate at base; planates to main veins absent, anterior margin of supertriangle straight or curved, and intercalated branch of MA not extended from near oblique vein to wing margin; triangles equidistant from arculus in fore and hind wings; hind wings each with anal loop rounded; male auricles present; anterior hamuli platelike; posterior hamuli each slender without apical hook; dorsal and lateral longitudinal abdominal carinae present; ovipositor complete.

Generic Key to Adult Aeshnidae of Eastern North America

1. Supratrangles without crossveins; fore wings each with 2 cubital-anal crossveins; male epiproct deeply forked
 *Gomphaeschna* p. 490
- Supratriangle with crossveins; fore wings each with 3-10 cubital-anal crossveins; male epiproct not deeply forked 2

2. Wings each with 3-6 midbasal crossveins, and 2 cell rows between RP_1 and RP_2 proximal to pterostima; thorax laterally with only 2 rounded pale spots *Boyeria* p. 468
- Wings each without or with 1 midbasal crossvein, and 1 cell row between RP_1 and RP_2 proximal to pterostigma; thorax laterally not with only 2 rounded pale spots 3
3. Fore wings each with gaff as long as inner side of triangle; thorax uniformly green; abdominal segments 7 and 8 with supplementary lateral carinae *Anax* p. 449
- Fore wings each with gaff less than 0.6 inner side of triangle; thorax not uniformly green; abdominal segments 7 and 8 without supplementary lateral carinae 4
4. Ocellar ridge biconically elevated; hind wings each with gaff and solum together shorter than portion of AnA_2 beyond anal loop; male anterior hamuli "L"-shaped 5
- Ocellar ridge not biconically elevated; hind wings each with gaff and solum together longer than portion of AnA_2 beyond anal loop; male anterior hamuli not "L"-shaped 6
5. Frons not produced anteriorly beyond clypeus; wings each with Mpl and $Cup1$ subtending 2 or 3 rows of cells; anterior lamina with spines *Epiaeschna* p. 484
- Frons produced anteriorly beyond clypeus; wings each with Mpl and $Cup1$ subtending 1 row of cells; anterior lamina without spines *Nasiaeschna* p. 503

6. Wings each with MA not branched, Mpl and Cupl not strongly sinuate, and basal opaque brown area extended to first antenodal crossvein *Basiaeschna* p. 462
- Wings each with MA branched, Mpl and Cupl strongly sinuate; and basal opaque brown area not extended to first antenodal crossvein 7
7. Wings each with one cell row between RP_1 and RP_2 below pterostigma, and CuA apparently ending on MP; hind wing trigonal interspaces each with 2 cell rows for distance of 3-5 cells
- *Coryphaeschna* p. 480
- Wings each with 2 or more cell rows between RP_1 and RP_2 below pterostigma, and CuA not apparently ending on MP; hind wing trigonal interspaces each without 2 cell rows for distance of 3-5 cells . 8
8. Hind wings each with supratriangle shorter than midbasal space; membranule of hind wings conspicuous, each widely connected to anal margin; female without long spines on posterior margin of sternum 10 *Aeshna* p. 419
- Hind wings each with supratriangle longer than midbasal space; membranule of hind wings inconspicuous, each narrowly connected to anal margin; female with long spines on posterior margin of sternum 10 9

9. Hind wings each with 2 cell rows between RP_1 and RP_2 below brace vein; fore wings each with 16-30 postnodal crossveins; female with 2 long spines on posterior margin of sternum 10
 *Gynacantha* p. 499
- Hind wings each with 1 cell row between RP_1 and RP_2 below brace vein; fore wings each with 8-15 postnodal crossveins; female with 3 long spines on posterior margin of sternum 10
 *Triacantha gyna* p. 507

Genus *Aeshna* Fabricius 1775

Fabricius 1775. Syst. Entomol., p. 424.

Type Species.--*Libellula grandis* Linnaeus.

Diagnosis.--Frons not produced anteriorly beyond clypeus; ocellar ridge not biconically elevated; thorax brown with yellow, green, or blue stripes; wings each with basal brown area absent, midbasal crossveins absent, 1 cell row between RP_1 and RP_2 distally to pterostigma, MA asymmetrically branched or occasionally not branched, maximum of 3-5 cell rows subtended by Mpl , supratriangle multicelled, and membranule broadly connected to anal margin; fore wings each with 10-16 postnodal crossveins, 3-8 cubital-anal crossveins, and gaff less than 1/2 length of inner side of triangle; hind wings each with minimum of 3 or 4 cell rows in trigonal interspace distal to apex of triangle, anal loop 7-14-celled, male anal triangle 2 or 3-celled, and male anal margin angulate; anterior lamina with spines, male auricles present; abdominal segments without supplementary lateral carinae; female without long spines on posteroventral margin of segment 10; male epiproct not divaricate, triangular.

Species Key to Adult Male *Aeshna* of Virginia

1. Hind wings each with anal triangle 3 or 4-celled; cerci each with subapical ventral spine; spines of anterior lamina robust, directed inward apically 2
- Hind wings each with anal triangle 2-celled; cerci each without subapical ventral spine; spines of anterior lamina vestigial, not directed inward apically 4

2. Abdominal segment 3 with lateral carinae; wings each with MA symmetrically branched; cerci forked apically . . . *A. mutata* p. 430
 Abdominal segment 3 without lateral carinae; wings each with MA asymmetrically branched; cerci not forked apically 3
3. Abdominal segments 4-6 without paired ventral pale spots; lateral carinae of abdominal segment 7 not sinuate; posterior surface of head black *A. constricta* p. 427
 Abdominal segments 4-6 with paired ventral pale spots; lateral carinae of abdominal segment 7 sinuate; posterior surface of head predominantly yellow *A. umbrosa* p. 433
4. Frontoclypeal sulcus with black band 5
 Frontoclypeal sulcus without black band 6
5. Mesanepimeral pale stripes cyclelike, metanepimeral pale stripes wedgelike; abdominal segments 4-7 with large ventrobasal pale spots; cerci each with dorsomedial carina not visible in lateral view *A. clepsydra* p. 425
 Mesanepimeral and metanepimeral pale stripes each represented by two spots; abdominal segments 4-7 without ventrobasal spots; cerci each with dorsomedial carinae visible in lateral view
 *A. interrupta* p. 429

- 6. Dorsum of abdominal segment 10 black; anterior margin of mesanepimeral pale stripes not sinuate; cerci each with ventrobasal tubercle *A. tuberculifera* p. 431
- Dorsum of abdominal segment 10 not black; anterior margin of mesanepimeral pale stripes sinuate; cerci each without ventrobasal tubercle 7
- 7. Mesanepimeral pale stripe abruptly constricted at midlength to ca. 1/3 width of lower portion; apices of anterior hamuli directed anteriorly; cerci each with dorsomedial carina denticulate apically *A. canadensis* p. 424
- Mesanepimeral pale stripe slightly constricted at midlength to ca. 1/2 width of lower portion; apices of anterior hamuli directed medially; cerci each with dorsomedial carina not denticulate apically *A. verticalis* p. 439

Species Key to Adult Female *Aeshna* of Virginia

- 1. Frontoclypeal sulcus with black band 2
- Frontoclypeal sulcus without black band 3

2. Mesanepimeral pale stripe cycle-shaped, metanepimeral pale stripe wedge-shaped; abdominal segments 4-7 with ventrobasal spots; posterior surface of head with 2 small tubercles
 *A. clepsydra* p. 425
- Mesanepimeral and metanepimeral pale stripes each represented by 2 spots; abdominal segments 4-7 without ventrobasal spots; posterior surface of head without 2 small tubercles
 *A. interrupta* p. 429
3. Metagonostyli longer than tergum 10; cerci each with dorsolateral edge convex basally 4
- Metagonostyli shorter than tergum 10; cerci each with dorsolateral edge level basally 5
4. Abdominal segment 3 without lateral carinae; upper end of metanepimeral pale stripes extended ventrally to cover posterior edge of metanepimera; posterior surface of head without 2 small tubercles
 *A. constricta* p. 427
- Abdominal segment 3 with lateral carinae; upper end of metanepimeral pale stripes not extended ventrally to cover posterior edge of metanepimera; posterior surface of head with 2 small tubercles
 *A. tuberculifera* p. 431

5. Abdominal segment 1 with small ventral tubercle; wings each with MA symmetrically branched; lateral carina of metagonocoxae weakly developed *A. mutata* p. 430
- Abdominal segment 1 without small ventral tubercle; wings each with MA asymmetrically branched; lateral carina of metagonocoxae strongly developed 6
6. Anterior margin of mesanepimeral pale stripes straight; posterior surface of head predominantly yellow; metagonocoxae without apical tuft of hair *A. umbrosa* p. 433
- Anterior margin of mesanepimeral pale stripes sinuate; posterior surface of head predominantly black; metagonocoxae with apical tuft of hair 7
7. Mesanepimeral pale stripes abruptly constricted at midlength to ca. 1/3 width of lower portion; metanepimeral pale stripes constricted at midlength; lateral ridge of metagonocoxae weakly developed in basal third *A. canadensis* p. 424
- Mesanepimeral pale stripes constricted at midlength to ca. 1/2 width of lower portion; metanepimeral pale stripes not constricted at midlength; lateral ridge of metagonocoxae well developed in basal third *A. verticalis* p. 439

Aeshna canadensis Walker

(Figures 71a, 75a, 76a)

Walker 1908. Can. Entomol. 40:384,389.

Length 64-74 mm; abdomen 47-57 mm; hind wings 42-48 mm.

Diagnosis.--Frontoclypeal suture without black band; posterior surface of head black, without 2 small tubercles in female; mesanepimeral pale stripes sinuate, strongly constricted at midlength, metanepimeral pale stripes wedge-shaped, slightly constricted at midlength; wings each with MA branched asymmetrically; hind wings each with anal triangle of male 2-celled; abdominal segment 1 without small ventral tubercles; spines of anterior lamina vestigial, apices directed posteroventrally; anterior hamuli each with anterior portion elongate, not approximate medially, apices directed anteriorly; abdominal segment 3 with lateral carinae posterior to antecostal suture; in male lateral carinae of abdominal segment 7 not sinuate; metagonocoxae each with lateral ridge well developed in apical 2/3, apically with small hair tuft; metagonostyli ca. 3/5 lateral length of segment 10; male cerci each without ventro-basal tubercle, with dorsomedial carina visible apically in lateral view with apical denticulations, and each without subapical ventral spine; female cerci each with dorsolateral edge level basally, and apex blunt.

Distribution.--Known from the states of CT, IL, IN, IA, ME, MA, MI, MN, MT, MO, NB, NH, NJ, NY, OH, PA, VT, VA, WA, WV, and WI, and the provinces of Alta., B.C., Man., N.B., Nfld., N.S., Ont., P.E.I., Que., and Sask. Known from the Virginia county of Highland. Known distri-

bution among the counties of neighboring states include: Pennsylvania-Bradford, Bucks, Butler, Cambria, Centre, Clearfield, Clinton, Fayette, Huntingdon, Juniata, Luzerne, Monroe, Perry, Somerset, Warren, Wayne, and Westmoreland. West Virginia- Preston and Randolph.

Virginia Records.--Highland Co.; Buck Run Beaver Ponds, 12 June 1980, 1 nymphal exuviae, FLC; Buck Run Beaver Ponds, 8 Aug. 1978, 1 male, FLC; Buck Run Beaver Ponds, 20 Aug. 1978, 1 male, FLC; Buck Run Beaver Ponds, 31 Aug. 1973, 1 male, OSF, USNM; Buck Run Beaver Ponds, 2 Sept. 1973, OSF, USNM; Buck Run Beaver Ponds, 4 Sept. 1976, 2 males, OSF, USNM; Buck Run Beaver Ponds, 12 Sept. 1979, 2 males, JRV, VPI&SU; Buck Run Beaver Ponds, 12 Sept. 1979, 1 male, BCK.

Flight Season.--June 12 (VA) to Oct. 7 (PA); in Virginia June 12 (exuviae) to Sept. 12. Known season in neighboring states are: Pennsylvania- July 1 to Oct. 7; West Virginia- Aug. 8 to 28.

Biology.--Inhabits marshy borders of ponds and lakes. Males patrol at from 50-150 cm above marshy areas, pausing and dropping to investigate possible oviposition sites in search of females. Oviposition occurs in emergent vegetation 0-2 cm below the water surface.

Remarks.--The southernmost record for this species is apparently from Highland Co., Virginia.

Aeshna clepsydra Say

Syn.: *arundinacea* Selys, *maxima* Hisinger

(Figures 71b, 75b, 76b)

Say 1839. J. Acad. Phila. 8:12.

Length 64-70 mm; abdomen 49-54 mm; hind wings 40-47 mm.

Diagnosis.--Frontoclypeal suture with black band; posterior surface of head black, with 2 small tubercles in female; mesanepimeral pale stripes cycle-shaped, narrowed dorsally, metanepimeral pale stripes wedge-shaped, slightly constricted at midlength; wings each with MA branched asymmetrically; hind wings each with anal triangle of male 2-celled; abdominal segment 1 without small ventral tubercle; spines of anterior lamina vestigial, apices directed posteroventrally; anterior hamuli each with anterior portion stout, not approximate medially, apices directed mesad; abdominal segment 3 with lateral carinae posterior to antecostal suture; in male lateral carinae of abdominal segment 7 slightly sinuate; metagonocoxae each with lateral ridge well developed, apically with small hair tuft; metagonostyli ca. $\frac{3}{5}$ lateral length of segment 10; male cerci each without ventrobasal tubercle, with dorso-medial carina not visible in lateral view with apical denticulations, and each without subapical ventral spine; female cerci each with dorso-lateral edge level basally and apex blunt.

Distribution.--Known from the states of CT, IN, IA, ME, MA, MI, NH, NJ, NY, OH, PA, VA(?), and WI, and the provinces of N.S., Ont., and Que. Known from the Virginia city of Elizabeth (?). Known distribution among the counties of neighboring states include: Pennsylvania- Bradford, Pike, and Sullivan.

Virginia Records.--City of Elizabeth; Fort Wool, Aug. 1878, 1 male, P. R. Uhler, (Det. P. R. Uhler, Uhler 1879).

Flight Season.--June (NY) to Oct. 12 (New England); in Virginia Aug. Known season in neighboring states are: Pennsylvania- July 16 to Aug. 23.

Biology.--Inhabits marsh-bordered lakes and ponds. Males patrol at from 30-70 cm above water. Oviposition (one female observed) occurs in emergent vegetation or in decayed sticks in areas infiltrated by seepage waters.

Remarks.--Uhler (1879) reported this species as *A. elepsydra* but it was possibly the then undescribed *A. umbrosa*. However, *A. elepsydra* may occur in northeastern Virginia.

Aeshna constricta Say

(Figures 72a, 75c, 76c)

Say 1839. J. Acad. Phila. 8:11.

Length 64-79 mm; abdomen 49-57 mm; hind wings 40-47 mm.

Diagnosis.--Frontoclypeal suture without black band; posterior surface of head black, without 2 small tubercles in female; mesanepimeral pale stripes slightly sinuate, slightly constricted at midlength, metanepimeral pale stripes straight, greatly widened dorsally; wings each with MA branched asymmetrically; hind wings each with anal triangle of male 3-celled; abdominal segment 1 without small ventral tubercle; spines of anterior lamina well developed, apices directed posterodorsally; anterior hamuli each with anterior portion robust, approximate medially, apices directed anteriorly; abdominal segment 3 without lateral carinae posterior to antecostal suture; in male lateral carinae of abdominal segment 7 slightly sinuate; metagonocoxae each with lateral ridge well developed, apically without small hair tuft; metagonostyli ca. 1.3 times lateral length of segment 10; male cerci each without ventrobasal

tubercle or dorsomedial carina, each with subapical ventral spine; female cerci each with dorsolateral edge convex basally and apex acute.

Distribution.--Known from the states of CA, CO, CT, ID, IL, IN, IA, KS, KY, ME, MD, MA, MI, MN, MO, NB, NV, NH, NJ, NY, ND, OH, PA, SD, TN(?), UT, VT, VA, WA, and WI, and the provinces of B.C., Man., N.S., Ont., Que., and Sask., and also from Baja CA, Mexico. Known from the Virginia counties of Augusta and Frederick. Known distribution among the counties of neighboring states include: Kentucky- Breckinridge; Pennsylvania- Allegheny, Beaver, Butler, Centre, Crawford, Delaware, Fayette, and Somerset; Tennessee- Carter, Henry, and Smith.

Virginia Records.--Augusta Co.; Shenandoah Pd., 2 Oct. 1977, 1 male, FLC; Shenandoah Pd., 29 Oct. 1978, 1 male, FLC. Frederick Co.; Turkey Run at Rt. 671, 27 Oct. 1978, 1 male, FLC.

Flight Season.--May 30 (MI) to Oct. 29 (VA); in Virginia Oct. 2 to 29. Known season in neighboring states are: Kentucky- Sept.; Pennsylvania- Aug. 24 to Oct. 15.

Biology.--*Aeshna constricta* nymphs inhabit marsh-bordered streams, marshes, and marsh-bordered ponds infiltrated by seepage waters. Males patrol at from 40-80 cm above the marsh. Oviposition occurs from 10-90 cm above the water or above dry portions of ponds. The adults often hang low (1-4 m) on trees and other vegetation.

Remarks.--Williamson (1903) reported *A. constricta* from Tennessee but this was possibly the then undescribed *A. umbrosa*. This species is probably more common in western Virginia than previous records indicate. Virginia specimens are the smallest known.

Aeshna interrupta Walker

(Figures 72b, 75d, 77a)

Walker 1908. Can. Entomol. 40:381,387.

Length 66-77 mm; abdomen 47-59 mm; hind wings 41-49 mm.

Diagnosis.--Frontoclypeal suture with black band; posterior surface of head black, without 2 small tubercles in female; mesanepimeral pale stripes represented by 2 spots, metanepimeral pale stripes represented by 2 spots; wings each with MA branched asymmetrically; hind wings each with anal triangle of male 2-celled; abdominal segment 1 without small ventral tubercle; spines of anterior lamina vestigial, apices directed posteroventrally; anterior hamuli each with anterior portion robust, not approximate medially, apices directed medially; abdominal segment 3 with lateral carinae posterior to antecostal suture; in male lateral carinae of abdominal segment 7 slightly sinuate; metagonocoxae each with lateral ridge well developed, apically with small hair tuft; metagonostyli ca. 2/3 lateral length of segment 10; male cerci each without ventrobasal tubercle, with dorsomedian carina visible in lateral view and with apical denticulations, and each without subapical ventral spine; female cerci each with dorsolateral edge level basally and apex blunt.

Distribution.--Known from the states of AK, ME, MA, MI, NH, NY, PA, VT, WV(?), and WI, and the provinces of B.C., N.B., Nfld., N.S., Ont., and Que. Known distribution among the counties of neighboring states include: Pennsylvania- Clinton; West Virginia- Raleigh(?).

Flight Season.--June 30 (Que.) to Sept. 18 (N.S.). Known season in neighboring states are: Pennsylvania- Sept. 15.

Biology.--*Aeshna interrupta* nymphs inhabit boggy or marshy ponds. Males patrol over marshes and along the shore line at from 30-150 cm. Oviposition occurs in emergent vegetation from 0-2 cm below the water.

Remarks.--Harwood (1976) reported *A. interrupta* nymphs from West Virginia but this record needs verification. This species doubtfully occurs in Virginia.

Aeshna mutata Hagen

(Figures 73a, 75e, 77b)

Hagen 1861. Syn. Neur. N. Amer., p. 124.

Length 67-76 mm; abdomen 47-59 mm; hind wings 44-51 mm.

Diagnosis.--Frontoclypeal suture without black band; posterior surface of head black, without 2 small tubercles in female; mesanepimeral pale stripes narrow, slightly sinuate, widened dorsally, metanepimeral pale stripes narrow, widened dorsally; wings each with MA branched symmetrically; hind wings each with anal triangle of male 3 or 4-celled; abdominal segment 1 with small ventral tubercle; spines of anterior lamina well developed, apices directed posterodorsally; anterior hamuli each with anterior portion robust, contiguous medially, apices directed medially; abdominal segment 3 with lateral carinae posterior to antecostal suture; in male lateral carinae of abdominal segment 7 basally sinuate; metagonocoxae each with lateral ridge weakly developed, apically with small hair tuft; metagonostyli ca. 2/3 lateral length of segment 10; male cerci each without ventrobasal tubercle, with dorsomedian carina visible apically in lateral view and without apical denticulations,

and each with subapical ventral spine; female cerci each with dorso-lateral edge level basally and apex blunt.

Distribution.--Known from the states of IN, KY, MA, MI, NY, OH, PA, and VA, and the province of Ont. Known from the Virginia counties of Augusta, Craig, and Highland. Known distribution among the counties of neighboring states include: Kentucky- Green; Pennsylvania- Cambria, Centre, Cumberland, Erie, and Huntingdon.

Virginia Records.--Augusta Co.; Shenandoah Pd., 13 June 1980, 28 males, 7 females, 25 nymphal exuviae, FLC. Craig Co.; Marsh along Rt. 635 1 mile S. of Paint Bank, 1 male, FLC. Highland Co.; Bullpasture R. Gorge, 30 May 1977, 1 female, FLC; Bullpasture R. Gorge, 7 June 1975, 1 male, FLC.

Flight Season.--May 17 (MI) to July 31 (PA); in Virginia May 30 to June 13. Known season in neighboring states are: Kentucky- May to June 16; Pennsylvania- June 1 to July 31.

Biology.--*Aeshna mutata* nymphs inhabit marsh-bordered ponds. Males patrol the pond margin at from 30-60 cm. Oviposition occurs in emergent vegetation below the water surface. Adults frequently rest on small trees and branches in sunlight during the day. On one occasion three males were netted from a single branch.

Remarks.--This species is easily recognized in life by its blue eyes and body markings.

Aeshna tuberculifera Walker

(Figures 73b, 75f, 77c)

Walker 1908. Can. Entomol. 40:385.

Length 71-80 mm; abdomen 52-63 mm; hind wings 44-51 mm.

Diagnosis.--Frontoclypeal suture without black band; posterior surface of head black, with 2 small tubercles in female; mesanepimeral pale stripes straight, slightly constricted at upper third, metanepimeral pale stripes straight, slightly widened dorsally; wings each with MA branched asymmetrically; hind wings each with anal triangle of male 2-celled; abdominal segment 1 without small ventral tubercle; spines of anterior lamina vestigial, apices directed posteroventrally; anterior hamuli each with anterior portion robust, not approximate medially, apices directed medially; abdominal segment 3 with lateral carinae posterior to antecostal suture; in male lateral carinae of abdominal segment 7 slightly sinuate; metagonocoxae each with lateral ridge well developed, apically with small hair tuft; metagonostyli ca. as long as lateral length of segment 10; male cerci each with ventrobasal tubercle, with dorsomedial carina slightly visible apically in lateral view and without apical denticulations, and each without subapical ventral spine; female cerci each with dorsolateral edge convex basally and apex blunt.

Distribution.--Known from the states of CT, IN, ME, MD, MA, MI, NH, NY, OH, PA, RI, VA, WA, WV, and WI, and the provinces of B.C., N.S., Ont., and Que. Known from the Virginia counties of Alleghany, Augusta, Giles, Highland, Russell, and Tazewell. Known distribution among the counties of neighboring states include: Maryland- Prince Georges; Pennsylvania- Butler, Cambria, Centre, Clearfield, Clinton, Delaware, Huntingdon, Somerset, Union, and Westmoreland; West Virginia- Raleigh

and Summers(?).

Virginia Records.--Alleghany Co.; Potts Bog, 30 June 1976, 1 female (teneral), FLC; Potts Bog, 20 Aug. 1973, 1 male, 2 females, FLC; Potts Bog, 28 Aug. 1973, 1 male, FLC; Pond Flat marsh off Rt. 600, 10 Sept. 1978, 3 males, 1 female, FLC. Augusta Co.; Maple Flat ponds, 2 Oct. 1977, 1 male, 1 female, FLC; Shenandoah Pd., 29 Oct. 1978, 1 male, FLC. Giles Co.; Sylvatica Pd. at Mtn. Lake Bio. Sta., 25 Sept. 1977, 3 males, 2 females, FLC; Sylvatica Pd. at Mtn. Lake Bio. Sta., 27 Oct. 1978, 2 males, 5 females, FLC. Highland Co.; Buck Run beaver ponds, 12 Sept. 1979, BCK. Russell Co.; Laurel Bed Lake, 25 Sept. 1979, 1 male, FLC; Laurel Bed Lake, 25 Sept. 1979, 1 male, BCK. Tazewell Co.; Goses Mill Pd. on Station Spring Cr., 1 Sept. 1979, 1 male, JRV, VPI&SU.

Flight Season.--June 30 (VA) to Oct. 29 (VA); in Virginia June 30 (teneral) to Oct. 29. Known season in neighboring states are: Maryland-- Sept. 18 to 20; Pennsylvania-- July 24 to Oct. 15; West Virginia-- Aug. 13 to Sept. 22.

Biology.--*Aeshna tuberculifera* inhabits boggy or marshy ponds. Males patrol at from 0.5-3 m above water. Oviposition occurs in emergent vegetation at from 30 cm above the water to 2 cm below it.

Remarks.--Although previously unreported from Virginia, this species is the most common blue *Aeshna* found in Virginia. The Russell Co. record is the southernmost record for the species.

Aeshna umbrosa Walker

(Figures 74a, 75g, 78a)

Walker 1908. Can. Entomol. 40:380,390.

Length 64-78 mm; abdomen 48-60 mm; hind wings 41-47 mm.

Diagnosis.--Frontoclypeal suture without black band; posterior surface of head predominantly yellow, without 2 small tubercles in female; mesanepimeral pale stripes straight, narrowed dorsally, metanepimeral pale stripes straight, not distinctly narrowed; wings each with MA branched asymmetrically; hind wings each with anal triangle of male 3-celled; abdominal segment 1 without small ventral tubercle; spines of anterior lamina well developed, apices directed posterodorsally; anterior hamuli each with anterior portion robust, approximate medially, apices directed anteriorly; abdominal segment 3 with weak lateral carinae posterior to antecostal suture; in male lateral carinae of abdominal segment 7 sinuate; metagonocoxae each with lateral ridge well developed, apically without small hair tuft; metagonostyli ca. 7/10 lateral length of segment 10; male cerci each without ventrobasal tubercle or dorso-medial carina, each with subapical ventral spine; female cerci each with dorsolateral edge level basally and apex blunt.

Distribution.--Known from the states of AK, AL, CT, DC, GA, IL, IA, KS, KY, ME, MD, MA, MI, MN, MS, MO, NE, NH, NJ, NY, NC, OH, OK, PA, RI, SC, SD, TN, VT, VA, WV, and WI, and the provinces of Alta., B.C., Lab., Man., N.B., Nfld., NW.Terr., N.S., Ont., P.E.I., Que., Sask., and Yukon. Known from the Virginia counties of Alleghany, Arlington, Augusta, Bath, Caroline, Craig, Fairfax, Fauquier, Franklin, Frederick, Giles, Greensville, Henrico, Highland, James City, Montgomery, Powhatan, Prince Edward, Pulaski, Roanoke, Rockbridge, Russell, Tazewell, Wise, and York.

Known distribution among the counties of neighboring states include:

Kentucky- Adair, Green, Jefferson, Metcalfe, and Trigg; North Carolina- Avery, Macon, Swain, Wake, and Watauga; Pennsylvania- Allegheny, Beaver, Berks, Blair, Bradford, Bucks, Butler, Cambria, Centre, Chester, Clarion, Clearfield, Clinton, Columbia, Crawford, Cumberland, Dauphin, Delaware, Elk, Fayette, Forest, Fulton, Greene, Huntingdon, Indiana, Jefferson, Lancaster, Lebanon, Luzerne, Lycoming, McKean, Mercer, Monroe, Northampton, Northumberland, Perry, Philadelphia, Schuylkill, Snyder, Somerset, Susquehanna, Union, Venango, Warren, Wayne, Westmoreland, and Wyoming; Tennessee- Cheatham, Davidson, Greene, Henry, Johnson, Putnam, Roane, and Sullivan; West Virginia- Logan, Pendleton, Raleigh, and Randolph.

Virginia Records.--Alleghany Co.; 1 mile SE of Clifton Forge, 19 Sept. 1934, 1 female, LKG and H. K. Gloyd, (Det. LKG), MZUM. Arlington Co.; Chain Bridge, 21 Sept. 1921, 1 male, 1 female (in tandem), M. T. Van Horn, USNM. Augusta Co.; Lake Sherando, 9 Oct. 1977, 2 males, FLC; Lake Sherando, 29 Oct. 1978, 1 male, FLC. Bath Co.; Cursey Springs Fish Hatchery, 20 Aug. 1973, 2 males, FLC; Marsh nr. Rt. 601, 11 Sept. 1979, 1 male, JRV, VPI&SU; Pond along Rt. 678, 2 Oct. 1977, 1 male, FLC; Beaver ponds along Rt. 600, 27 Oct. 1978, 2 males, FLC. Caroline Co.; locality unknown, 20 Oct. 1973, 1 female, R. Banks, VPI&SU. Craig Co.; Potts Mt. at Rt. 176, 16 July 1975, 1 male, SWB, VPI&SU; Pond along Rt. 635 2 miles SW of Paint Bank, 9 Aug. 1978, 1 male, FLC; Potts Cr., 20 Aug. 1973, 1 male, FLC, VPI&SU; Marsh along Rt. 635 1.5 miles SW of Paint Bank, 15 Oct. 1977, 3 males, FLC; Marsh along Rt. 635 1.5 miles SW of Paint Bank, 1 male, FLC; 1 mile S of Paint Bank, 6 Nov. 1978, 1

male, 1 female (in tandem), FLC. Fairfax Co.; Great Falls, 20 Sept. 1917, BPC, (Det. BPC), USNM. Frederick Co.; Turkey Run at Rt. 671, 27 Oct. 1978, 1 male, 1 female, FLC. Fauquier Co.; Paris, 4 Sept. 1916, 1 male, R. A. Emmons, (Det. Currie), USNM. Franklin Co.; locality unknown, 1 Nov. 1963, 1 male, Cummings, VPI&SU. Giles Co.; Little Stoney Cr., 27 July 1951, 1 nymph, C. Mann, (Det. C. F. Byers, MDR notes); Mountain Lake, 25 Aug. 1899, 1 male, 1 female, C. L. Pollard and W. R. Maxson, USNM; Mountain Lake, 25 Aug. 1899, 2 males, C. L. Pollard and W. R. Maxson, (Det. E. M. Walker, MDR notes); Sylvatica Pd. at Mt. Lake Bio. Sta., 25 Sept. 1977, 7 males, 2 females, FLC; Small swamp along Big Stoney Cr. and Rt. 722, 25 Sept. 1977, 4 males, FLC; Bailey Gap Pd. at Rt. 714, 25 Sept. 1977, 4 males, FLC; Sylvatica Pd. at Mt. Lake Bio. Sta., 27 Oct. 1978, 1 male, FLC; Mountain Lake, 29 Oct. 1978, 1 male, R. Zimmerman, FLC Collection. Greensville Co.; Emporia, 19 Oct. 1936, 1 male, collector unknown, (Det. MDR, MDR notes), W&M. Henrico Co.; Richmond, 20 Sept. 1935, 1 male, A. Walker, (Det. MDR, MDR notes), VSEC. Highland Co.; Buck Run beaver ponds, 1 July 1972, 1 female, OSF, USNM; Buck Run beaver ponds, 3,4 July 1971, 1 male, OSF, USNM; Bearwallow Run beaver ponds, 8 Aug. 1978, 1 female, JRV, VPI&SU; Buck Run beaver ponds, 8 Aug. 1978, 1 female, JRV, VPI&SU; Jackson R. at Rts. 220 and 606, 8 Aug. 1978, 1 female, BCK, VPI&SU; Buck Run beaver ponds, 8 Aug. 1978 2 males, FLC; Buck Run beaver ponds, 8 Aug. 1978, 1 female, BCK; Buck Run beaver ponds, 20 Aug. 1978, 11 males, 4 females, FLC; Buck Run beaver ponds, 31 Aug. to 2 Sept. 1973, 10 males, 1 female, OSF, USNM; Buck Run beaver ponds, 4 Sept. 1976, 6 males, OSF, USNM; Buck Run beaver ponds, 12 Sept. 1979, 2 males, JRV, VPI&SU; Buck Run beaver ponds, 12

Sept. 1979, 1 male, BCK; Back Creek beaver pond along Rt. 600, 2 Oct. 1977, 2 males, 2 female (1 pair in tandem), FLC; Back Creek at Rt. 250, 2 Oct. 1977, 1 male, 1 female, FLC; Buck Run beaver ponds, 2 Oct. 1977, 56 males, 3 females (1 pair in tandem), FLC and SWB, FLC Collection.

James City Co.; Williamsburg, 12 Sept. 1929, 1 female, MED, VPI&SU; Williamsburg, 21 Sept. 1929, 1 female, MED, (Det. MDR, MDR notes); Boundary St., 13 Oct. 1938, 1 female, D. S. Low, (Det. MDR, MDR notes); Williamsburg, 15 Oct. 1931, 1 female, collector unknown, VPI&SU; Williamsburg, 20 Oct. 1966, 1 female, A. Smith, VPI&SU; Williamsburg, 29 Oct., 1 female, collector unknown, VPI&SU; Williamsburg, 31 Oct. 1931, 1 male, collector unknown, VPI&SU; Williamsburg, 8 Nov. 1937, 1 female, collector unknown, VPI&SU.

Montgomery Co.; locality unknown, 20 July 1975, 1 male, C. Hopkins, VPI&SU; Radford Arsenal, 10 Aug. 1954, 1 male, R. L. Hoffman, (Det. Gibbs); Price Hall, 14 Aug. 1973, 1 female, B. Fay, VPI&SU; Craig Cr. nr. Rt. 460, 15 Aug. 1977, 1 female, Hammond; Toms Cr. at Rt. 655, 2 Sept. 1974, 1 male, FLC; Pandapas Pd., 2 Sept. 1979, 1 male, R. N. Story, VPI&SU; locality unknown, 10 Sept. 1969, 1 male, R. Ecklund, VPI&SU; Stroubles Cr. downstream from VPI&SU duck pond, 13 Sept. 1977, 1 male, 1 female, FLC; locality unknown, 2 Oct. 1975, 1 male, S. Fowler, VPI&SU; Brush Mt., 9 Oct. 1976, 1 female, K. F. Cannon, VPI&SU; 0.1 mile below VPI&SU duck pond, 11 Oct. 1977, 1 female (observation), FLC; Pond, 13 Oct. 1963, 1 male, Cummings, VPI&SU; locality unknown, 15 Oct. 1967, 1 male, J. H. Roberts, VPI&SU; locality unknown, 2 Nov. 1970, 1 female, Trower, VPI&SU.

Powhatan Co.; locality unknown, 1 Oct. 1970, 1 male, JRV, VPI&SU.

Prince Edward Co.; Rt. 696, 25 Oct. 1962, 1 male, R. R. Mills, VCU.

Pulaski Co.; locality unknown, 14 Oct.

1973, 1 female, G. Morgan, VPI&SU. Roanoke Co.; Roanoke, 6 Sept. 1973, 1 female, C. Hopkins, VPI&SU; Roanoke R., 17 Sept. 1973, 1 male, SWB, VPI&SU; Blue Ridge Parkway at Roanoke overlook, 17 Sept. 1973, 1 male, T. Bailey, VPI&SU; Blue Ridge Parkway at Roanoke R. overlook, 17 Sept. 1973, 1 male, SWB, VPI&SU. Rockbridge Co.; Guys Run, 27 June 1978, 1 male, 1 female, M. Meschter; Guys Run, 23 Sept. 1977, 1 male, M. Meschter; Guys Run, 12 Oct. 1977, 1 male, M. Meschter. Russell Co.; Laurel Bed Lake at Laurel Bed Cr., 25 Sept. 1977, 11 males, 1 female, BCK; Laurel Bed Lake, 26 Sept. 1977, 1 male, 3 females (pair in tandem), FLC; beaver dam 0.4 miles downstream from Laurel Bed Lake, 26 Sept. 1977, 3 males, 1 female, FLC. Tazewell Co.; Maiden Mtn. Bog, 16 Aug. 1977, 9 males (1 teneral), 1 female, FLC; Station Spring Cr. on Moore Brothers Ranch at base of Beartown Mtn., 1 Sept. 1979, 2 males, JRV, VPI&SU. Wise Co.; Big Stone Gap, 20 July 1936, 1 male, collector unknown, VPI&SU-MDR. York Co.; creek at Walter's Pond, 17 Sept. 1966, 1 female, MDR, VPI&SU-MDR; Naval Mine Depot at Yorktown, 31 Oct. 1935, 1 male, collector unknown, (Det. MED, Davis 1938).

Flight Season.--May 6 (New England) to Nov. 8 (VA); in Virginia June 27 to Nov. 8. Known season in neighboring states are: Kentucky- Aug. 5 to Oct.; North Carolina- Aug. to Nov.; Pennsylvania- June 16 to Nov. 7; Tennessee- Aug. 18 to Nov. 4; West Virginia- June 27 to Sept. 19.

Biology.--*Aeshna umbrosa* nymphs inhabit slow-flowing streams and stream-fed bays of lakes and ponds. Males patrol at from 10-120 cm above the water and frequently stop and hover while searching a likely oviposition site for ovipositing females. Oviposition occurs in wet or decayed wood usually at or below the water surface.

Remarks.--This is the most common *Aeshna* occurring in Virginia.

Aeshna verticalis Hagen

Syn.: *propinqua* Scudder

(Figures 74b, 75h, 78b)

Hagen 1861. Syn. Neur. N. Amer., p. 122.

Length 62-79 mm; abdomen 47-60 mm; hind wings 41-50 mm.

Diagnosis.--Frontoclypeal suture without black band; posterior surface of head black, without 2 small tubercles in female; mesanepimeral pale stripes slightly sinuate, slightly constricted at middle, metanepimeral pale stripes wedge-shaped, widened dorsally; wings each with MA branched asymmetrically; hind wings each with anal triangle of male 2-celled; abdominal segment 1 without small ventral tubercle; spines of anterior lamina vestigial, apices directed posteriorly; anterior hamuli each with anterior portion hooklike, not contiguous medially, apices directed mesad; abdominal segment 3 with lateral carinae posterior to antecostal suture; in male lateral carinae of abdominal segment 7 not sinuate; metagonocoxae each with lateral ridge well developed, apically with small hair tuft; metagonostyli ca. 3/5 lateral length of segment 10; male cerci each without ventrobasal tubercle, dorsomedial carina visible apically in lateral view and without apical denticulations, and each without subapical ventral spine; female cerci each with dorsolateral ridge level basally and apex blunt.

Distribution.--Known from the states of CT, IL, IN, IA, KY, ME, MD, MA, MI, MN, NY, NC, OH, PA, RI, VT, VA, WV, and WI, and the provinces

of N.B., N.S., Ont., and Que. Known from the Virginia county of Highland. Known distribution among the counties of neighboring states include: Kentucky- Harrison; Maryland- Prince Georges; North Carolina- Henderson; Pennsylvania- Adams, Allegheny, Berks, Bradford, Cambria, Centre, Clearfield, Clinton, Cumberland, Delaware, Elk, Fayette, Huntingdon, Jefferson, Luzerne, McKean, Monroe, Perry, Schuylkill, Wayne, and Westmoreland.

Virginia Records.--Highland Co.; Buck Run beaver ponds, 8 Aug. 1978, 1 male, FLC; Buck Run beaver ponds, 4 Sept. 1976, 1 male, OSF, USNM.

Flight Season.--June 13 (IL) to Oct. 23 (PA); in Virginia Aug. 8 to Sept. 4. Known season in neighboring states are: Kentucky- Sept.; Maryland- Sept. 9 to Oct. 6; North Carolina- Aug. 28; Pennsylvania- July 16 to Oct. 23.

Biology.--*Aeshna verticalis* nymphs inhabit marsh-bordered ponds fed by seepage waters. Males patrol at from 40-90 cm above the water. Oviposition (one female observed) occurs in emergent vegetation from 0-2 cm below the water surface.

Remarks.--Although infrequently collected in Virginia, this species occurs as far south as Transylvania county, North Carolina.

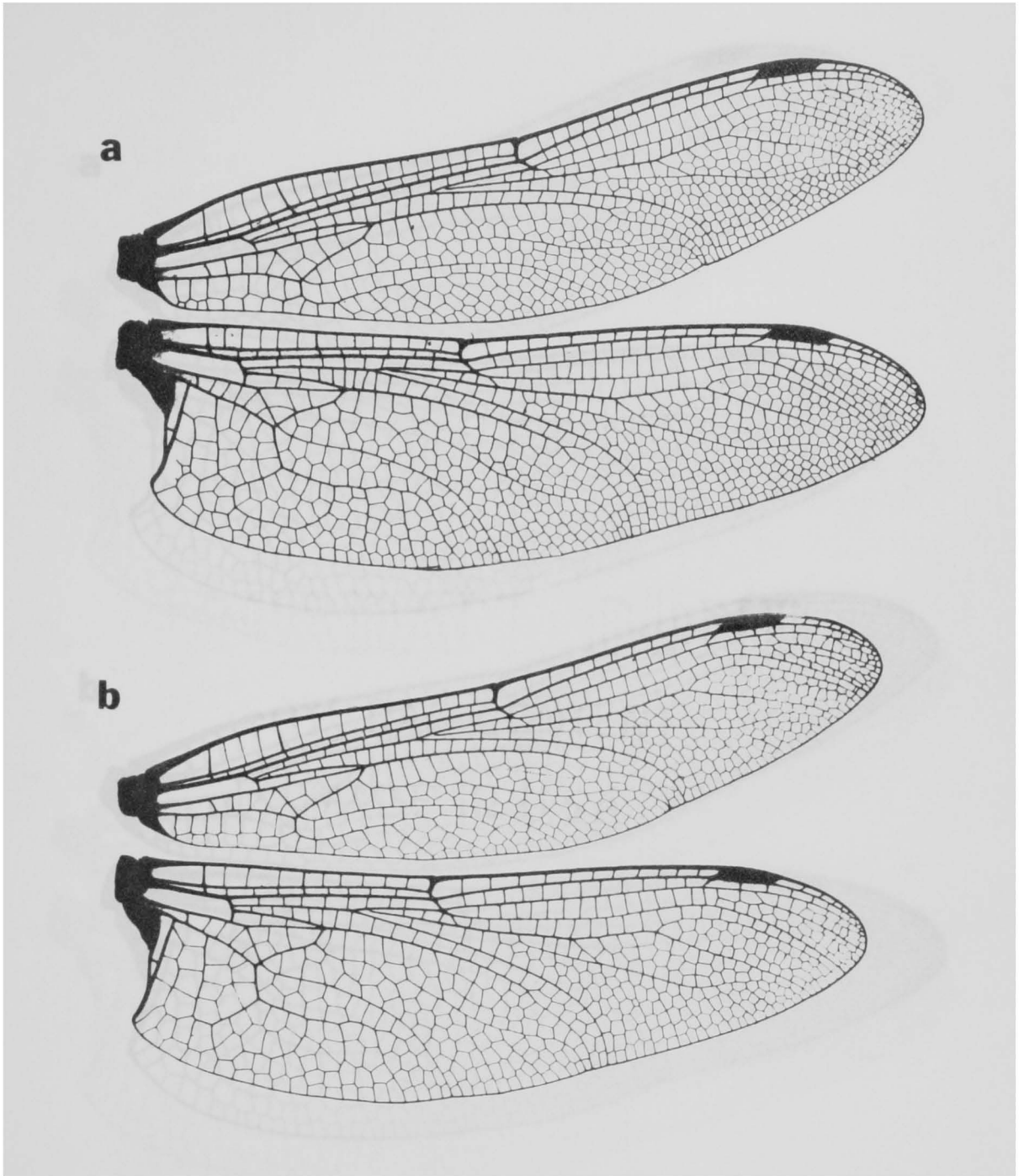


Figure 71. Wings of *Aeschna* x3: (a) *A. canadensis*, (b) *A. clepsydra*.

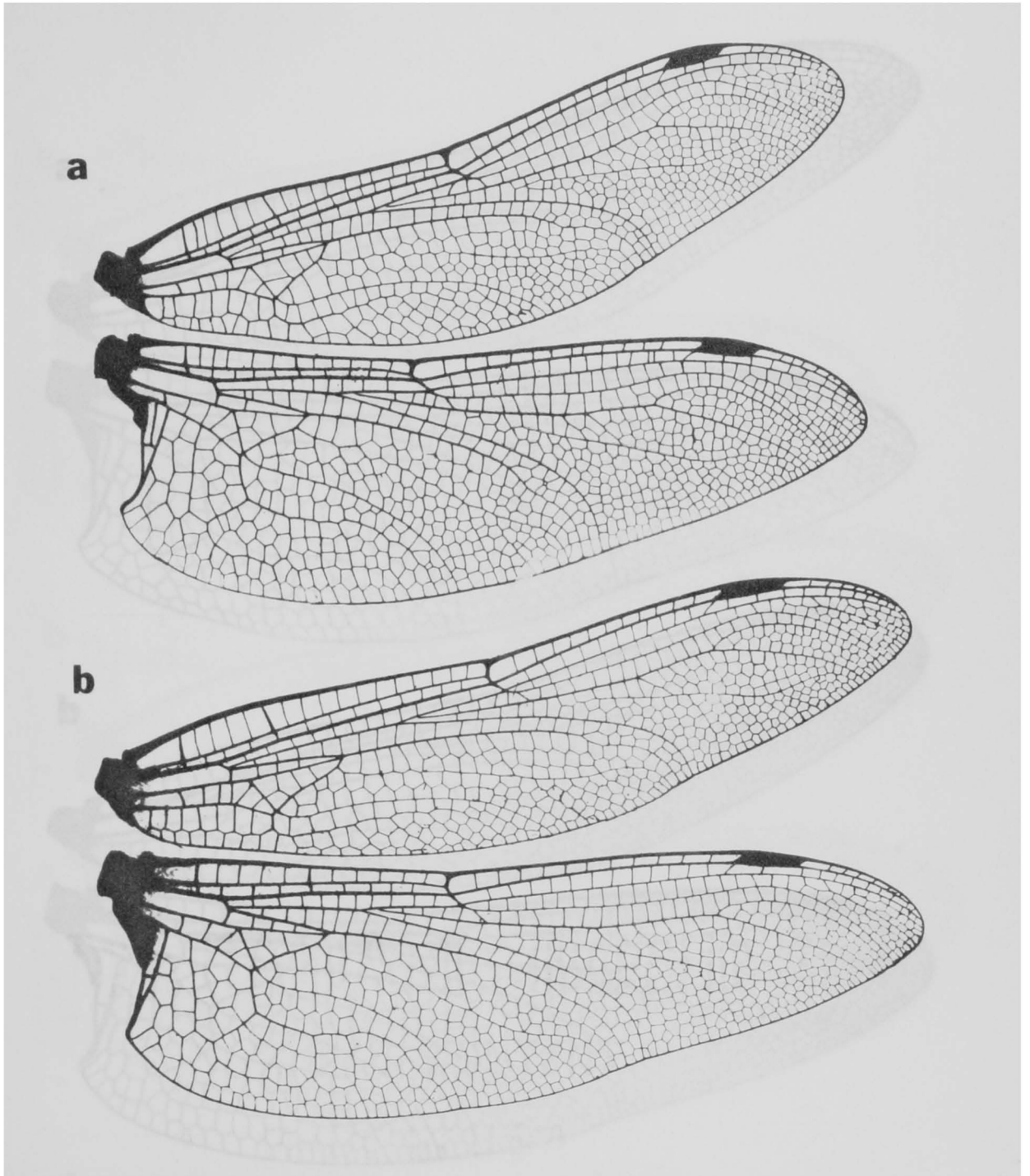


Figure 72. Wings of *Aeschna* x3: (a) *A. constricta*; (b) *A. interrupta*.

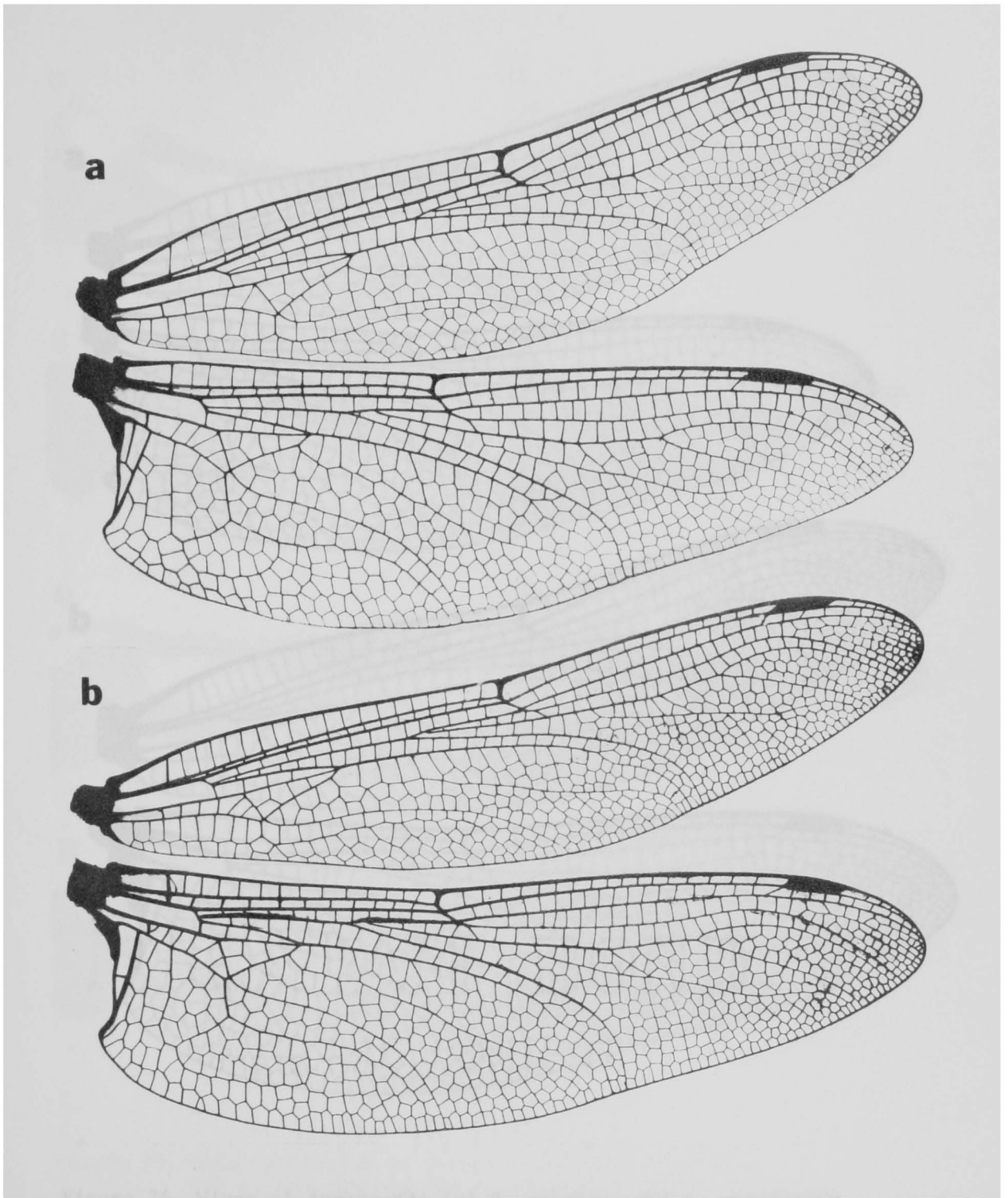


Figure 73. Wings of *Aeshna* x3: (a) *A. mutata*; (b) *A. tuberculifera*.

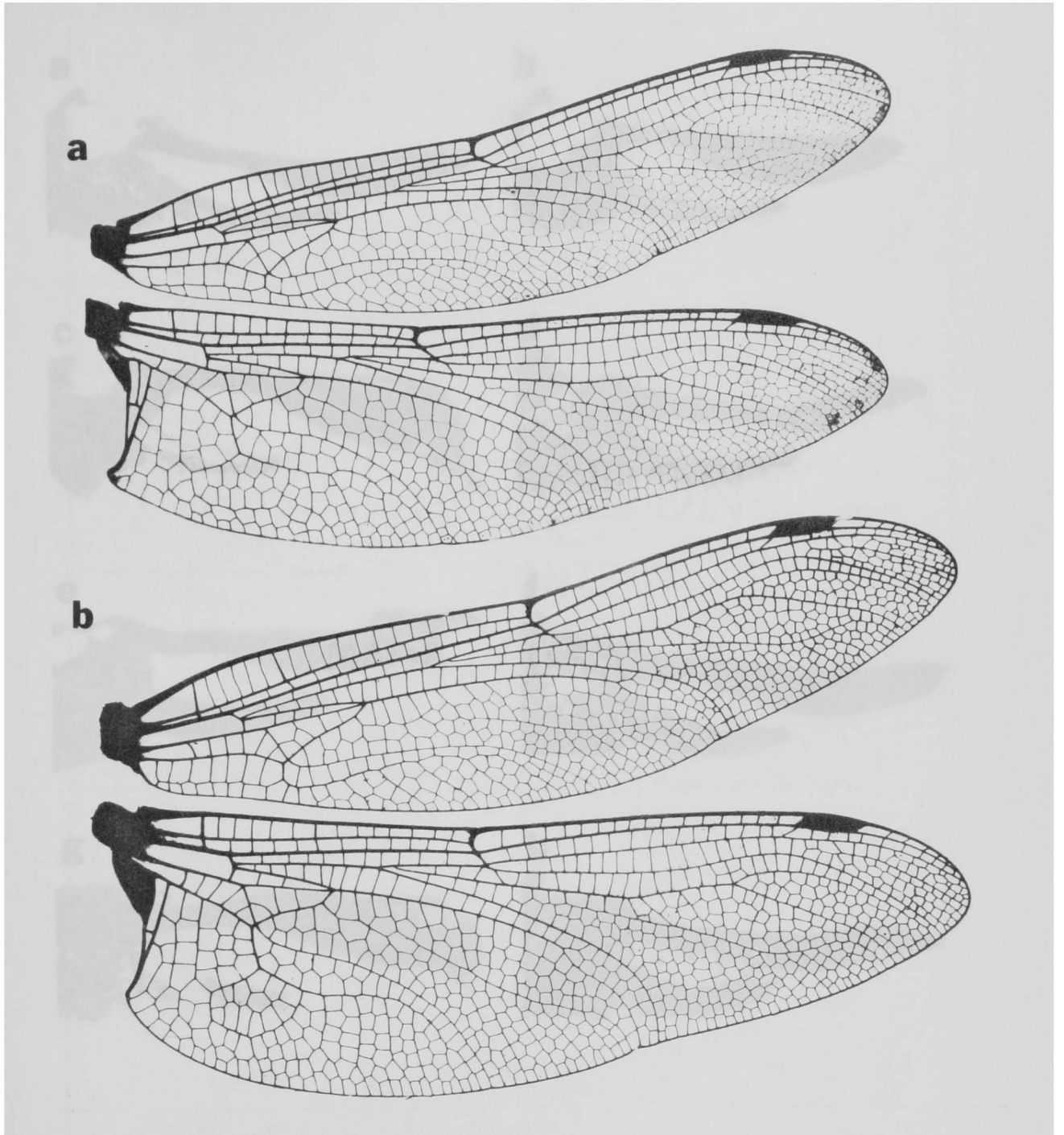


Figure 74. Wings of *Aeshna* x3: (a) *A. umbrosa*; (b) *A. verticalis*.

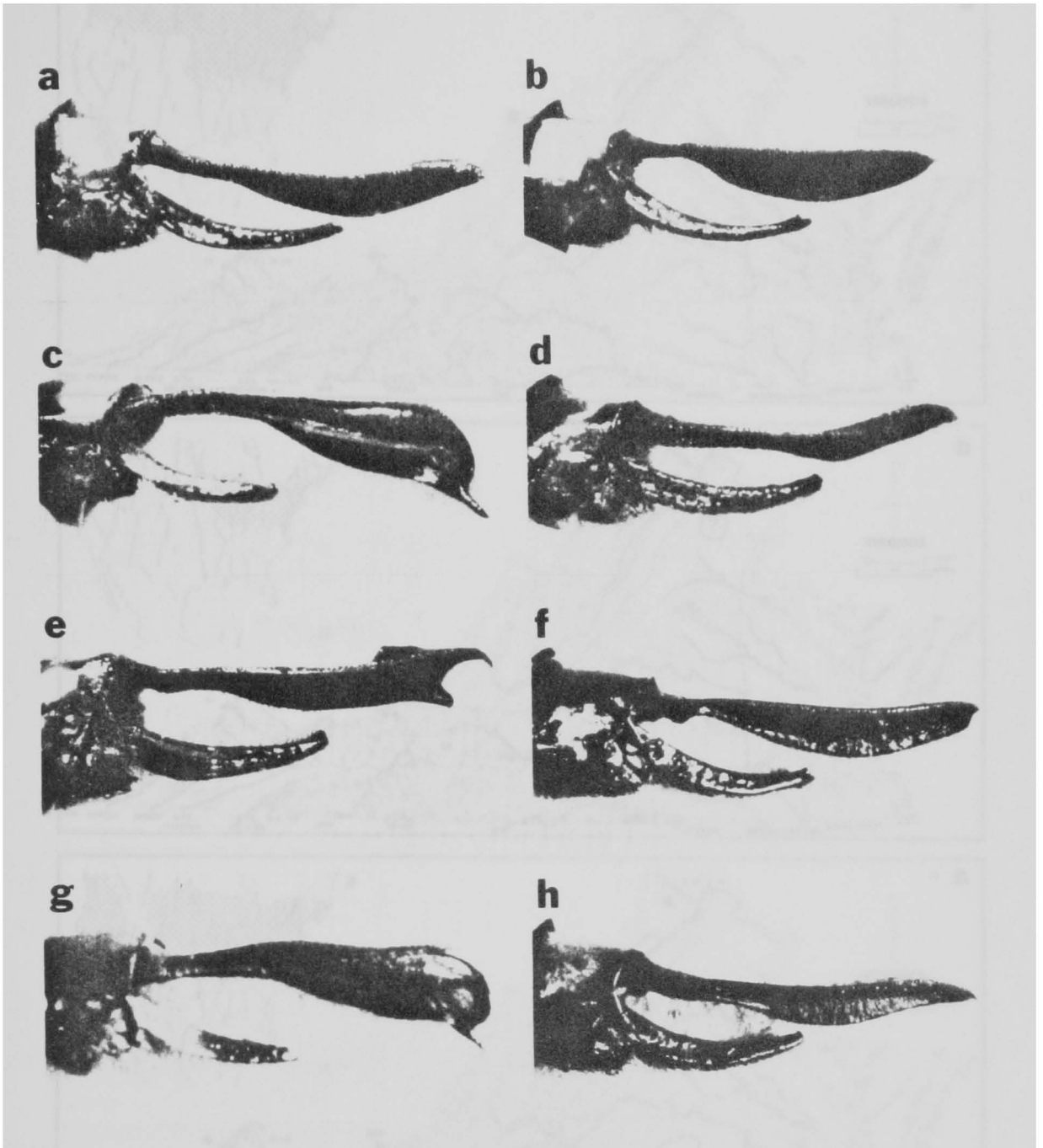


Figure 75. Male terminalia in lateral view of *Aeshna* XII:
 (a) *A. canadensis*; (b) *A. elepsydra*; (c) *A. constricta*;
 (d) *A. interrupta*; (e) *A. mutata*; (f) *A. tuberculifera*;
 (g) *A. umbrosa*; (h) *A. verticalis*.

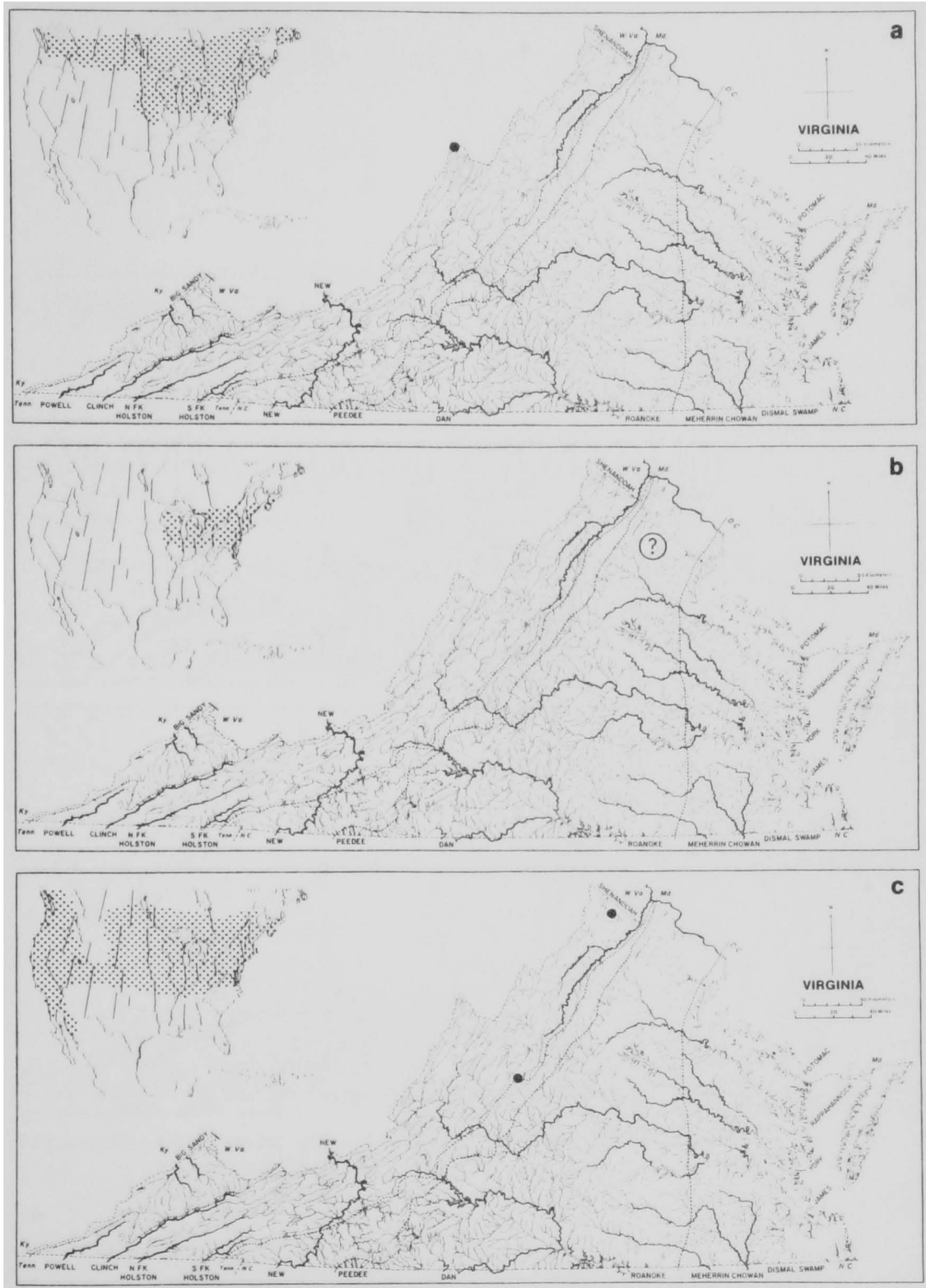


Figure 76. Geographic distribution of *Aeshna*: (a) *A. canadensis*; (b) *A. clepsydra*; (c) *A. constricta*.

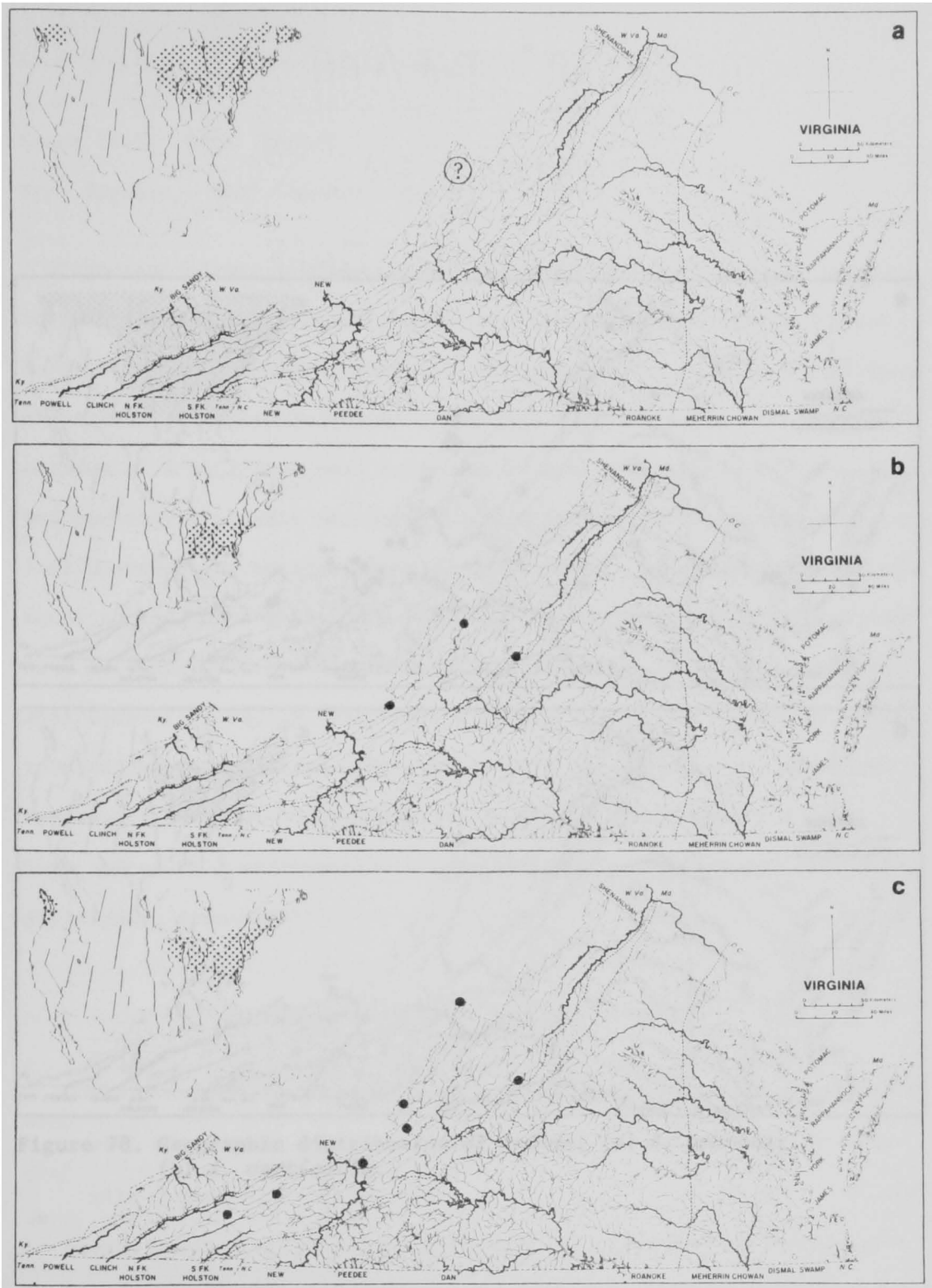


Figure 77. Geographic distribution of *Aeshna*: (a) *A. interrupta*; (b) *A. mutata*; (c) *A. tuberculifera*.

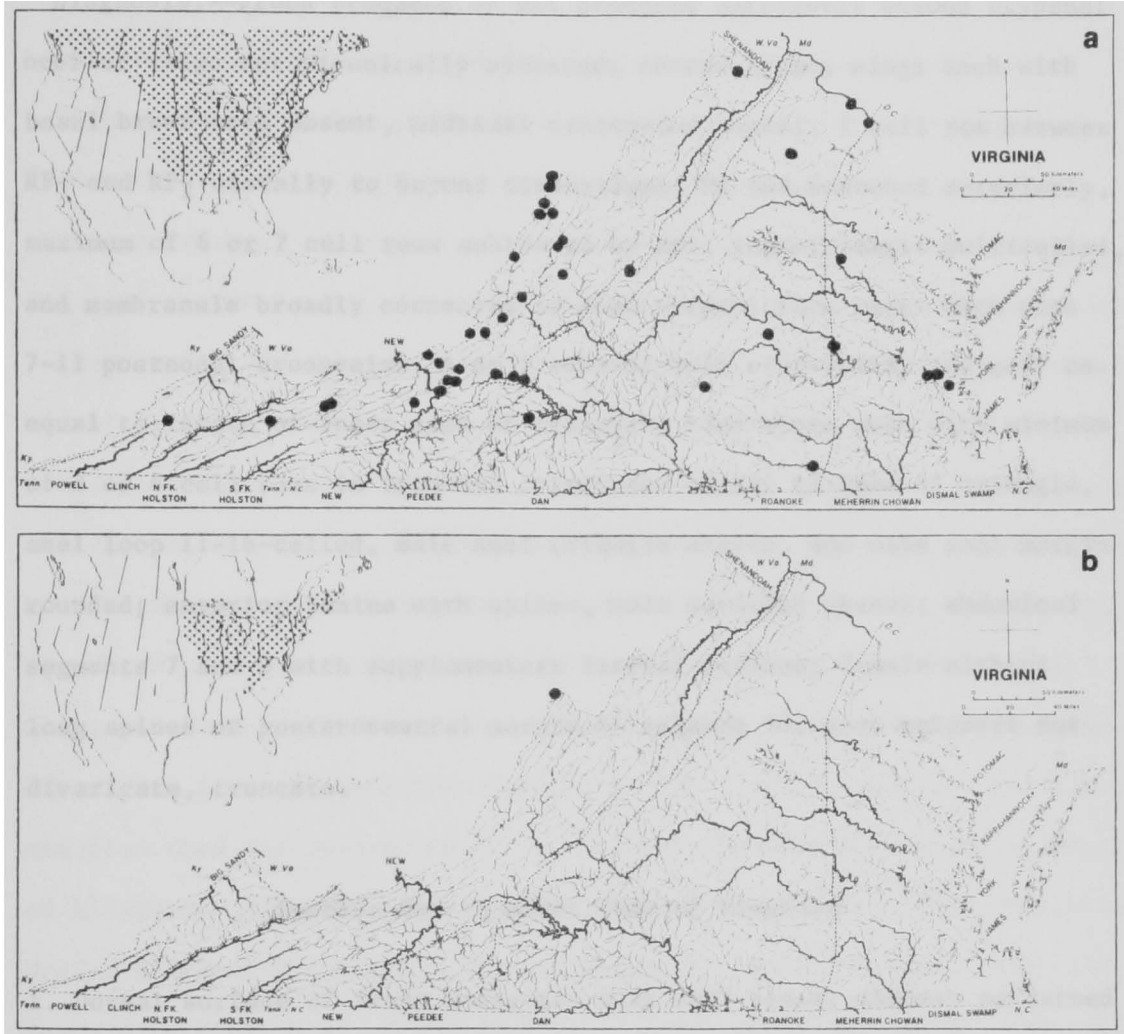


Figure 78. Geographic distribution of *Aeshna*: (a) *A. umbrosa*;
(b) *A. verticalis*.

Genus *Anax* Leach 1815

Leach 1815. Edin. Encycl., p. 137.

Type Species.--*Anax imperator* Leach.

Diagnosis.--Frons produced or not produced anteriorly beyond clypeus; ocellar ridge not biconically elevated; thorax green; wings each with basal brown area absent, midbasal crossveins absent, 1 cell row between RP_1 and RP_2 distally to beyond pterostigma, MA not branched anteriorly, maximum of 6 or 7 cell rows subtended by Mpl , supratriangle multicelled, and membranule broadly connected to anal margin; fore wings each with 7-11 postnodal crossveins, 4 or 5 cubital-anal crossveins, and gaff ca. equal to length of inner side of triangle; hind wings each with minimum of 3 or 4 cell rows in trigonal interspace distal to apex of triangle, anal loop 11-16-celled, male anal triangle absent, and male anal margin rounded; anterior lamina with spines, male auricles absent; abdominal segments 7 and 8 with supplementary lateral carinae; female without long spines on posteroventral margin of segment 10; male epiproct not divaricate, truncate.

Species Key to Adult *Anax* of Virginia

1. Dorsal surface of frons patterned with dark brown; abdomen patterned with blue; male cerci each widest in distal half; female occiput with 2 posterior projections *A. junius* p. 450
- Dorsal surface of frons not patterned with dark brown; abdomen patterned with red; male cerci each widest in proximal half; female occiput without 2 posterior projections *A. longipes* p. 456

Anax junius (Drury)Syn.: *spiniferus* Rambur

(Figures 79,81a)

Drury 1770. Ill. Exot. Ins. 1:112 (in *Libellula*).

Length 66-84 mm; abdomen 47-58 mm; hind wings 45-56 mm.

Diagnosis.--Frons not produced anteriorly beyond clypeus, dorsal surface with dark brown markings; occiput yellow, female occiput with paired posteriorly directed apical projections; thorax green, middle and hind femora brown; width of hind wings at arculus more than distance between nodus and pterostigmata; abdomen patterned with blue; male cerci widest in distal half.

Distribution.--Known from the states of AL, AK, AZ, AR, CA, CO, CT, DE, DC, FL, GA, HI, ID, IL, IN, IA, KS, KY, LA, ME, MA, MI, MN, MS, MO, MT, NB, NV, NH, NJ, NY, NC, OH, OK, OR, PA, RI, SC, SD, TN, TX, UT, VT, VA, WA, WV, WI, and WY, and the provinces of B.C., Man., N.S., Ont., P.E.I., Que., and Sask.; and from Mexico-- Baja CA, Chihuahua, Coahuila, and Tamaulipas; and from the Antilles-- Cuba, Dom. Rep., Haiti, Jamaica, and P.R.; and also from the western coast of Asia. Known from the Virginia counties of Alleghany, Augusta, Bath, Bedford, Botetourt, Charles City, Charlotte, Craig, Fairfax, Frederick, Giles, Gloucester, Greene, Henrico, Highland, James City, Lee, Loudoun, Montgomery, Nelson, New Kent, Orange, Pittsylvania, Prince William, Roanoke, Rockbridge, Russell, Southampton, Tazewell, Washington, Westmoreland, Wythe, and York, and the cities of Hampton, Norfolk, Portsmouth, Suffolk, and Virginia Beach. Known distribution among the counties of neighboring states include: Kentucky-- Allen,

Barren, Bath, Bell, Bullitt, Edmonson, Fayette, Fulton, Green, Hart, Hopkins, Jefferson, Jessamine, Madison, Marion, Menifee, Oldham, Richmond, Rockcastle, Scott, Taylor, Trigg, and Warren; North Carolina- Caldwell, Carteret, Dare, Macon, McDowell, New Hanover, and Wake; Pennsylvania- Adams, Allegheny, Beaver, Berks, Blair, Bradford, Bucks, Butler, Cambria, Centre, Chester, Clarion, Clearfield, Clinton, Columbia, Crawford, Cumberland, Dauphin, Delaware, Elk, Erie, Fayette, Forest, Franklin, Fulton, Huntingdon, Indiana, Juniata, Lackawanna, Lancaster, Lebanon, Luzerne, Lycoming, Mercer, Monroe, Montgomery, Northampton, Perry, Philadelphia, Pike, Schuylkill, Somerset, Sullivan, Union, Venango, Warren, Washington, Wayne, Westmoreland, and York; Tennessee- Blount, Cumberland, Davidson, Greene, Johnson, Knox, Montgomery, Obion, Overton, Sullivan, Sumner, Unicoi, Williamson, and Wilson; West Virginia- Mercer, Pendleton, Preston, Raleigh, Randolph, Ritchie, and Taylor.

Virginia Records.--Alleghany Co.; Pond Flat marsh off Rt. 600, 10 Sept. 1978, 1 female, FLC. Augusta Co.; Shenandoah Pd., 13 June 1980, 3 nymphal exuviae, FLC; Shenandoah Pd., 17 July 1980, 2 males, 1 female, BCK. Bath Co.; Coursey Springs Fish Hatchery, 30 May 1977, 1 male (observation), FLC; Coursey Springs Fish Hatchery, 8 June 1974, 1 male, FLC; Beaver pond along Rt. 600, 18 June 1978, 1 male, FLC; Blowing Springs Campground nr. Back Cr. at Rt. 39, 10 Sept. 1979, JRV and BCK, 1 female, VPI&SU; Pond along Rt. 678 nr. Rt. 627, 2 Oct. 1977, 1 male, FLC. Bedford Co.; Preston Pd. at Rt. 627, 1 Apr. 1978, 1 female, J. Bragg, VPI&SU; Preston Pd. at Rt. 627, 17 May 1978, 1 male, J. Bragg, VPI&SU; locality unknown, 15 June 1968, 1 female, Stephenson, VPI&SU. Botetourt Co.; Craig Cr. at Rt. 707 nr. Oriskany, 28 May 1977, 1 female,

FLC. Charles City Co.; Marl pit on Rt. 5, 19 Apr. 1938, 1 male, MED and DTR, VPI&SU; Harrison Lake nr. Roxbury, 12 June 1938, 1 male, 1 female, R. Hess, (Det. A. Hess, MDR notes), A. D. Hess Collection; Harrison Lake nr. Roxbury, 21 July 1938, 1 male, R. Hess, (Det. A. D. Hess, MDR notes), A. D. Hess Collection; Berkeley Mills, 1 Aug. 1937, 1 male, V. M. D., VPI&SU; Berkeley Mills, 5 Sept. 1937, 2 males, MED, VPI&SU.

Charlotte Co.; Keysville, 24 Aug. 1938, 1 female, J. T. Baldwin, VPI&SU.

Craig Co.; Pond along Rt. 635 2 miles SW of Paint Bank, 9 Aug. 1978, 1 male, FLC; Johns Cr. at Rt. 311, 14 Aug. 1974, 1 male, FLC.

Fairfax Co.; Great Falls, 30 Apr. 1915, 1 male, RPC, USNM; Great Falls, 9 May 1916, 1 male, RPC, USNM; Great Falls, 10 July 1914, 2 males, RPC, USNM.

Frederick Co.; Winchester Fruit Research Lab., 8 Aug. 1978, 1 male, G. Anderson, VPI&SU.

Giles Co.; Farrier Farm at Newport, 7 May 1938, 1 male (observation), MED, (Det. MED, MDR notes); Farrier Pond at Rt. 460. 16 May 1977, 1 male, C. Sheppard, VPI&SU; Pembroke, 6 Aug. 1948, 1 male, C. F. Byers, (Det. C. F. Byers, Byers 1951); Eggleston, 6 Aug. 1965, 1 male, M. Dow, VPI&SU; Bailey Gap Pd. at Rt. 714, 25 Sept. 1977, 1 female nymphal exuviae, FLC.

Gloucester Co.; Gloucester, 7 May 1937, 1 male, collector unknown, (Det. MED, MDR notes).

Greene Co.; Dyke, 28 May 1915, 1 female, L. O. Jackson, USNM.

Henrico Co.; Maymont Park in Richmond, 8 Aug. 1973, 1 female, Passalacqua, VCU.

Highland Co.; Buck Run beaver ponds, 12 June 1980, 1 male, 1 nymphal exuviae, FLC; Buck Run beaver ponds, 18 June 1978, 1 male, FLC; Buck Run beaver ponds, 3,4 July 1971, 3 males, OSF, USNM; Buck Run beaver ponds, 8 Aug. 1978, 1 male, FLC; Pond off Rt. 220, 8 Aug. 1978, 1 male, BCK.

James City Co.; Jamestown Island, 13 Apr. 1938, 1 female, MED, VPI&SU; Williamsburg, 4 May

1938, 1 female (reared), MED and McCahill, (Det. MED, MDR notes); Lake Matoaka, 5 May 1938 (emerged 17 May 1938), 1 female, MED, (Det. MED, MDR notes); Williamsburg, 18 May 1937, 1 female, MED, VPI&SU; Jamestown Road, 3 Aug. 1938, 1 male, 1 female, MED, VPI&SU; Williamsburg, 2 Oct. 1936, 1 female, MED, VPI&SU. Lee Co.; Keokee Lake, 3 July 1977, 1 female, FLC; Marsh at Rt. 606, 3 July 1977, 1 male, FLC. Loudoun Co.; locality unknown, 12 Aug. 1971, 1 female, T. Muir, VPI&SU. Montgomery Co.; Temporary pond along Rt. 685, 16 May 1978 (emerged 30 May 1978), 1 female nymph, J. Henderson, VPI&SU; Blacksburg, 13 Apr. 1938, 1 female, collector unknown, VPI&SU; Blacksburg, 14 Apr. 1938, 1 female, collector unknown, VPI&SU; locality unknown, 14 Apr. 1974, 2 males, T. Bailey, VPI&SU; Stroubles Cr. at Rt. 460, 14 Apr. 1974, 1 male, SWB, FLC Collection; VPI&SU campus, 15 Apr. 1948, 1 male, 1 female, E. C. Cockrell, (Det. LKG, Gloyd 1951); Brush Mt. at Rt. 701, 16 Apr. 1977, 1 male, BCK; McCoy pond on Rt. 3, 21 Apr. 1979, 1 female, S. Hiner, VPI&SU; Blacksburg, 5 May 1958, 1 male, L. Gallais, VPI&SU; VPI&SU Airport pond, 10 May 1977, 1 male, M. Hudy, VPI&SU; locality unknown, 10 May 1976, 1 male, W. Matthews, VPI&SU; VPI&SU Dairy Farm sewage pond, 15 May 1977, 1 male, C. Sheppard, VPI&SU; VPI&SU Dairy Farm sewage pond, 16 May 1977, 1 male, R. Southwick, VPI&SU; Pond along Rt. 685, 16 May 1978 (emerged 28 May 1978), 2 female nymphs, D. E. Minnick, VPI&SU; Craig Cr. beaver pond at Rt. 621, 17 May 1977, 1 male, J. Schmidt, VPI&SU; Temporary pond along Rt. 685, 18 May 1978, 1 male, T. L. Scalabrin, VPI&SU; VPI&SU campus, 20 May 1948, 1 male, E. M. Boush, VPI&SU; Toms Cr. marsh 0.5 miles downstream from Rt. 655, 24 May 1973, 2 males, 1 female, FLC; Pond along Rt. 685, 24 May 1978, 1 male, K. Loyd, VPI&SU; Blacksburg,

26 May 1958, 1 male, D. L. Farris, VPI&SU; Heath Pd. nr. Blacksburg,
 1 June 1978, 1 female (in emergence) with exuviae, BCK; Blacksburg, 9
 June 1958, 1 male, L. Gallais, VPI&SU; Rt. 624, 15 June 1975, 1 male,
 SWB, VPI&SU; Toms Cr. marsh 0.5 mile downstream from Rt. 655, 5 July
 1973, 2 males, FLC; Toms Cr. marsh 0.5 mile downstream from Rt. 655,
 9 July 1973, 1 male, FLC; Pandapas Pd., 10 July 1973, 3 males, 2 females,
 FLC; Toms Cr. marsh 0.5 miles downstream from Rt. 655, 15 July 1973, 1
 male, 1 nymphal exuviae, FLC; Blacksburg, 20 July 1964, 1 male, 1 female,
 (in tandem), M. Kosztarab, VPI&SU; Toms Cr. marsh 0.5 mile downstream
 from Rt. 655, 20 July 1973, 1 female, FLC; Toms Cr. marsh 0.5 mile down-
 stream from Rt. 655, 23 July 1977, 1 nymphal exuviae, FLC; Pandapas Pd.,
 23 July 1977, 2 males, FLC; Price Hall parking lot, 28 July 1977, 1
 female, BCK; Toms Cr. marsh 0.5 miles downstream from Rt. 655, 29 July
 1973, 1 female, FLC; Craig Cr. beaver pd. at Rt. 621, 25 Sept. 1977,
 1 male (observation), FLC; locality unknown, 4 Oct. 1978, 1 male, D.
 Rowe, VPI&SU; 0.1 mile below VPI&SU duck pd., 11 Oct. 1977, 1 male
 (observation), FLC; locality unknown, 13 Oct. 1973, 1 male, R. Banks,
 VPI&SU. Nelson Co.; Campground on Rt. 56 nr. Montebello, 19 July 1978,
 1 male, JRV and TJV, VPI&SU; Tye R. 0.25 mile above Rts. 56 and 151, 20
 July 1978, 2 males, JRV and TJV, VPI&SU; Pond off Rt. 56 nr. Montebello,
 20 July 1978, 1 male, JRV and TJV, VPI&SU. New Kent Co.; Plum Point,
 30 Apr. 1970, (observation), C. Shiffer; New Kent, 22 Dec. 1973, 1 male,
 S. VanHorn, VPI&SU. Orange Co.; Pond at Rt. 605 nr. Mine Run, 6 May
 1978, 1 male, W. Reynolds, VPI&SU. Pittsylvania Co.; Marshy area along
 Rt. 880, 21 May 1978, 1 male, FLC. Prince William Co.; Bull Run at
 Manassas Battlefield Park, 19 Aug. 1978, 1 male, FLC. Roanoke Co.;

Salem, 17 June 1973, 1 male, SWB, VPI&SU. Rockbridge Co.; Pond at Wilsons Point nr. Fairfield, 10 July 1899, 1 male, J. E. Benedict, Jr., USNM. Russell Co.; Laurel Bed Lake, 4 July 1977, 4 males, 1 female, FLC; Laurel Bed Lake, 26 Sept. 1977, 1 male (teneral), 10 nymphal exuviae, FLC; Laurel Bed Lake at Laurel Bed Cr., 26 Sept. 1977, 1 female, BCK. Southampton Co.; Nottoway R. at Rt. 653, 16 Apr. 1978, 1 male, 1 female, FLC. Tazewell Co.; Rt. 666 at Goses Mill, 10 June 1978, 1 male, FLC. Washington Co.; Pond along Rt. 663, 15 June 1980, 1 male, FLC; Lodi, 30 Aug. 1954, 1 male, R. L. Hoffman, (Det. R. H. Gibbs). Westmoreland Co.; nr. Cole Point, June 1917, 1 male, 1 female, J. E. Benedict, Jr., USNM. Wythe Co.; Wytheville, 28 June 1935, 2 males, 1 female, CA, (Det. MED, MDR notes). York Co.; Penniman, 25 July 1937, 1 female, collector unknown, VPI&SU. City of Hampton; Hampton, 16 Sept. 1973, 1 female, D. Simonet, VPI&SU. City of Norfolk; Norfolk, 13 June 1975, 1 female, FLC; Norfolk, 3 Sept. 1973, 1 female, P. W. Larkins, VPI&SU. City of Portsmouth; Portsmouth, 13 July 1973, 1 male, JFM, ODU. City of Suffolk; Williamson Ditch at Dismal Swamp Wildlife Refuge, 17 April 1978, 3 males, FLC and SWB, FLC Collection; Dismal Swamp, 17 Aug. 1974, 1 male, 1 female, J. Hancock, ODU; Dismal Swamp, 19 Aug. 1974, 1 male, J. Hancock, ODU; Cypress Chapel nr. Nansemond, 14 Sept. 1934, 1 female, LKG and H. K. Gloyd, (Det. LKG, Gloyd 1951). City of Virginia Beach; Back Bay Wildlife Refuge, 8 June 1975, 1 male, J. O'Hop, ODU; Seashore State Park at Cape Henry, 26 June 1971, 1 male, R. H. Perry, VPI&SU; Cape Henry, Aug. 1916, 4 males, M. Carmondy, USNM; Ocean View, 22 Sept. 1915, 1 male, V. A. Roberts, USNM.

Flight Season.--Year-round (FL); in Virginia Apr. 1 to Dec. 22. Known

season in neighboring states are: Kentucky- Apr. 12 to Oct.; North Carolina- Mar. to Oct.; Pennsylvania- Mar. 24 to Oct. 23; Tennessee- May 2 to Sept. 24; West Virginia- May 28 to Sept. 19.

Biology.--Nymphs inhabit marshy borders of ponds and lakes. Males are commonly observed patrolling pond margins at from 0.5-1.5 m. Migrants from the south are among the earliest dragonflies to appear in the spring. Females oviposit in tandem with males or singly. Oviposition occurs in submerged vegetation, the female typically alights upon a stem and slides down into the water to begin oviposition.

Remarks.--This species is the most commonly collected of Virginia Aeshnidae. It is a wide-ranging species, having been reported from Bermuda, Panama, Alaska, Tahiti, and China.

Anax longipes Hagen

(Figures 80,81b)

Hagen 1861. Syn. Neur. N. Amer., p. 118.

Length 75-87 mm; abdomen 50-60 mm; hind wings 47-56 mm.

Diagnosis.--Frons produced anteriorly beyond clypeus, dorsal surface without dark brown markings; occiput black, female occiput without paired posteriorly directed apical projections; thorax green, middle and hind femora red; width of hind wings at arculus less than distance between nodus and pterostigmata; abdomen patterned with red; male cerci widest in proximal half.

Distribution.--Known from the states of AL, AZ(?), DC, FL, GA, IN,

KY, MD, MA, MS, NJ, NY, NC, OH, OK, PA, SC, TN, TX, VA, and WV, and the province of Ont. Known from the Virginia counties of Augusta, Charles City, and Lee. Known distribution among the counties of neighboring states include: Kentucky- Green; Maryland- Prince Georges; North Carolina- Bertie, Hoke, Macon, Transylvania, Wake, and Wilson; Pennsylvania- Allegheny, Centre, Delaware, Huntingdon, Luzerne, Wayne, Westmoreland, and York; Tennessee- Blount, Cocke, Knox, and Sullivan; West Virginia- Taylor.

Virginia Records.--Augusta Co.; Shenandoah Pd., 17 July 1980, 3 males (observation), BCK. Charles City Co.; 9 miles W of Barretts Ferry Crossing, 23 May 1938, 1 male, MED, (Det. MED, Ries and Cruden 1966); 9 miles W of Barretts Ferry Crossing, 18 June 1938, 1 female, MED, (Det. MED, Ries and Cruden 1966). Lee Co.; Keokee Lake, 3 July 1977, 1 male (observation), FLC.

Flight Season.--Feb. (FL) to Nov. 28 (FL); in Virginia May 23 to July 17. Known season in neighboring states are: District of Columbia- June 13; Kentucky- June to Aug.; Maryland- June 3; North Carolina- May to July 26; Pennsylvania- May 23 to July 31; Tennessee- June 24 to Aug. 14; West Virginia- June 14.

Biology.--*Anax longipes* inhabits ponds and lakes. This species seems to prefer ponds with significant annual water fluctuations which set back the succession of aquatic vegetation. Males most often observed patrolling along the shore line at 0.5-2.0 m. Females oviposit unattended by the male in emergent vegetation.

Remarks.--The bright red abdomen of this large Aeshnid makes it one

of the easiest dragonflies to identify in flight. However, its habit of quickly moving on makes it difficult to capture. The tropical *A. concolor*, although similar to *A. longipes*, is apparently not conspecific with it as evidenced by the lack of intergrades.

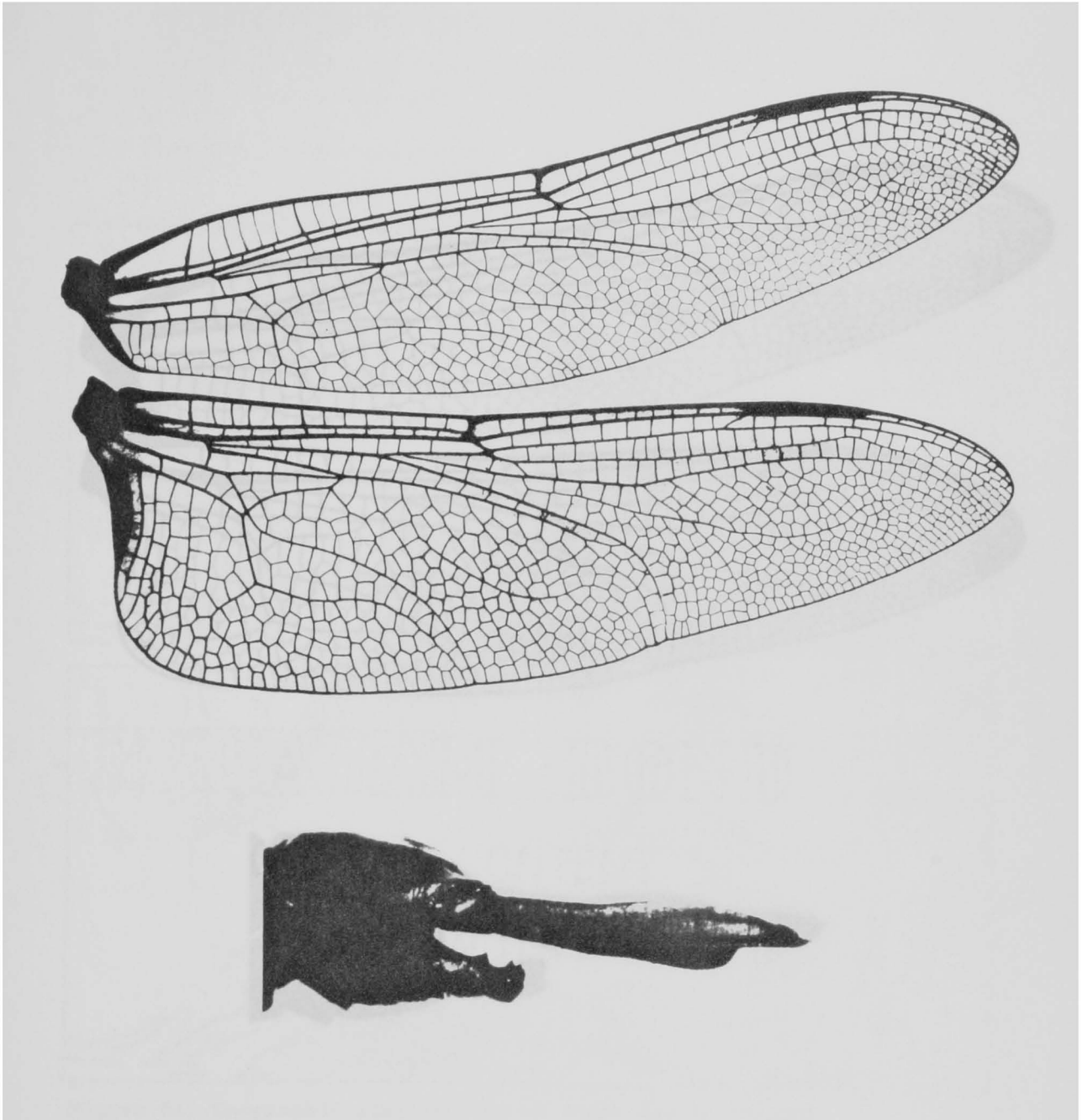


Figure 79. Wings x3 and male terminalia in lateral view x11 of *Anax junius*.

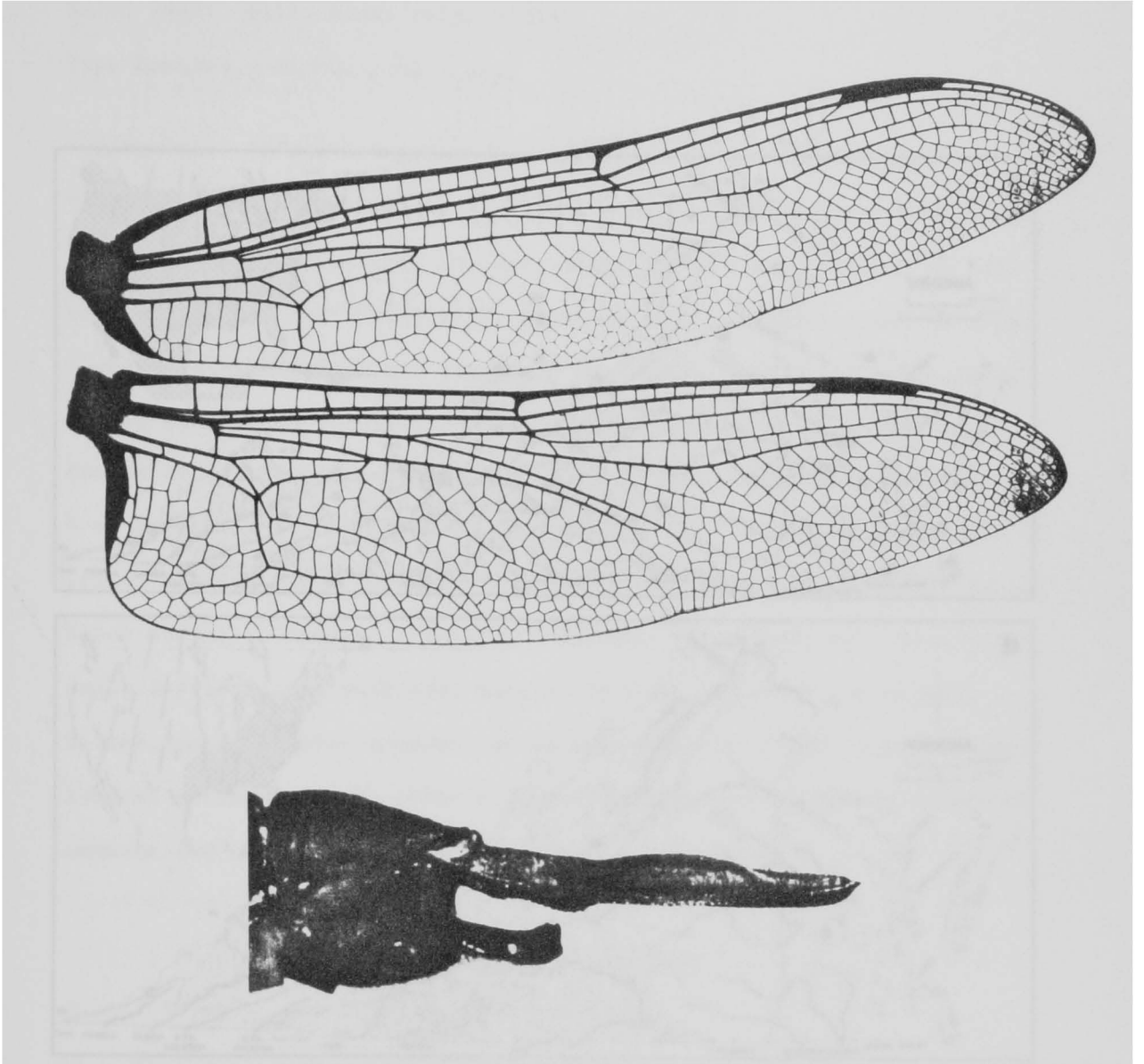


Figure 80. Wings x3 and male terminalia in lateral view x11 of
Anax longipes.

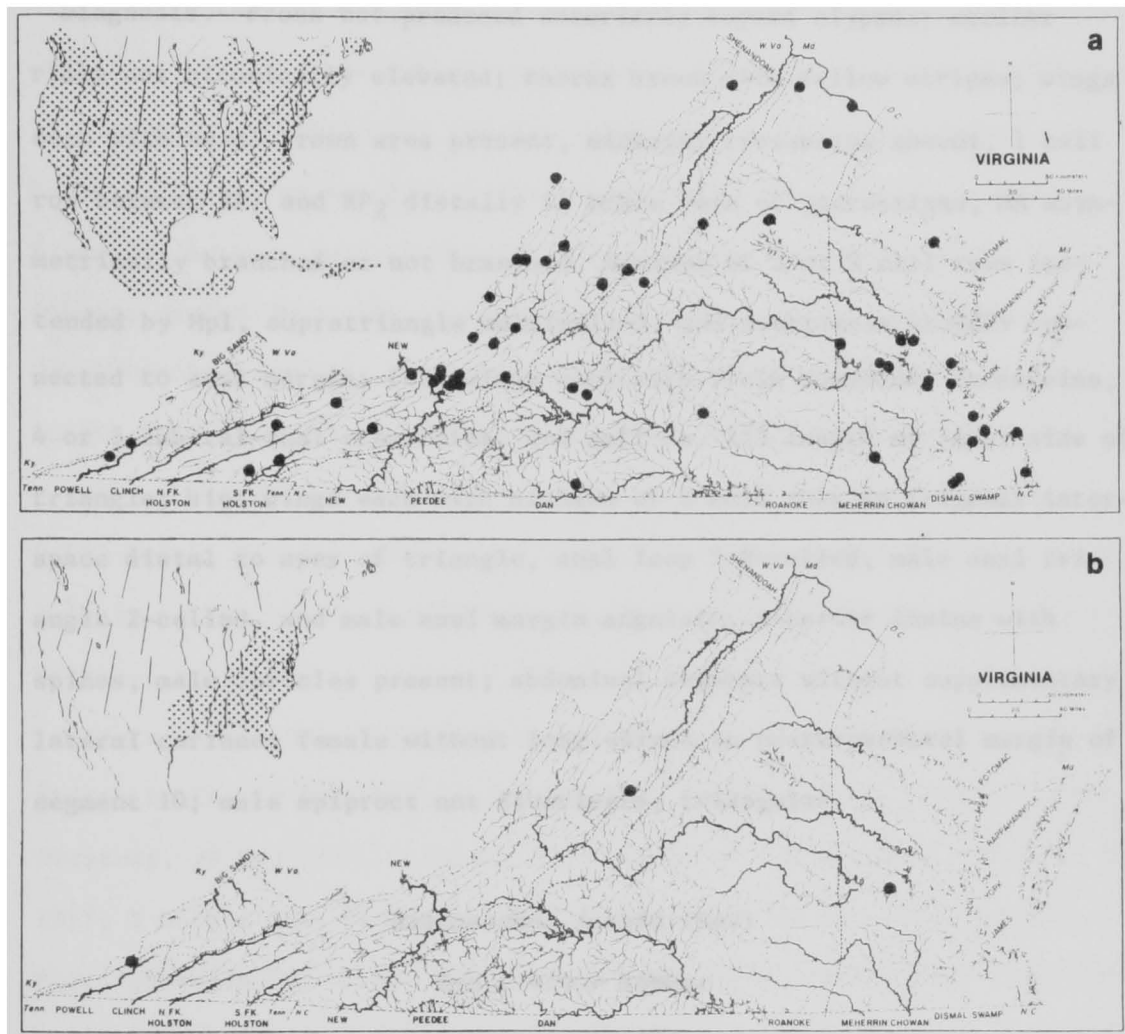


Figure 81. Geographic distribution of *Anax*: (a) *A. junius*;
(b) *A. longipes*.

Genus *Basiaeschna* Selys 1883

Selys 1883. Bull. Acad. Belg. 5:735.

Type Species.--*Aeshna janata* Say.

Diagnosis.--Frons not produced anteriorly beyond clypeus; ocellar ridge not biconically elevated; thorax brown with yellow stripes; wings each with basal brown area present, midbasal crossveins absent, 1 cell row between RP_1 and RP_2 distally to brace vein of pterostigma, MA asymmetrically branched or not branched, maximum of 2 or 3 cell rows subtended by Mpl , supratriangle multicelled, and membranule broadly connected to anal margin; fore wings each with 11-16 postnodal crossveins, 4 or 5 cubital-anal crossveins, and gaff ca. $1/3$ length of inner side of triangle; hind wings each with minimum of 2 cell rows in trigonal interspace distal to apex of triangle, anal loop 5-8-celled, male anal triangle 2-celled, and male anal margin angulate; anterior lamina with spines, male auricles present; abdominal segments without supplementary lateral carinae; female without long spines on posteroventral margin of segment 10; male epiproct not divaricate, triangular.

Basiaeschna janata (Say)

Syn.: *minor* Rambur

(Figures 82,83)

Say 1839. J. Acad. Phila., p. 13 (in *Aeshna*).

Length 50-67 mm; abdomen 38-51 mm; hind wings 32-42 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AL, AR, CT, FL, GA, IL, IN, IA, KS, KY, LA, ME, MD, MA, MI, MS, MO, NH, NJ, NY, NC, OH, OK, PA, SC, TN, TX, VT, VA, WV, and WI, and the provinces of N.B., N.S., Ont., and Que. Known from the Virginia counties of Alleghany, Botetourt, Brunswick, Charlotte, Craig, Cumberland, Fairfax, Giles, Grayson, Hanover, Highland, Louisa, Mecklenburg, Montgomery, New Kent, Roanoke, Rockbridge, Scott, Smyth, Southampton, and Spotsylvania, and the city of Suffolk. Known distribution among the counties of neighboring states include: Kentucky- Barren, Bell, Bullitt, Butler, Casey, Edmonson, Green, Jefferson, Marion, Metcalfe, Robertson, Rockcastle, Trigg, and Warren; North Carolina- Moore, Robeson, and Wake; Pennsylvania- Adams, Berks, Bucks, Centre, Chester, Columbia, Dauphin, Delaware, Fayette, Forest, Franklin, Fulton, Huntingdon, Juniata, Lycoming, Montgomery, Perry, Pike, Union, Venango, Wayne, and York; Tennessee- Cocke, Fentress, Overton, Scott, Sullivan, and Williamson; West Virginia- Pendleton, Raleigh, Ritchie, and Upshur.

Virginia Records.--Alleghany Co.; Falling Springs on Jackson R. at Indian Draft, 29 May 1977, 1 female, FLC. Botetourt Co.; Craig Cr. nr. Oriskany, 28 May 1977, 5 males, FLC; Craig Cr. nr. Oriskany, 28 May 1977, 5 males, BCK; Craig Cr. at Patterson Cr., 29 May 1977, 1 male. FLC; Patterson Cr. at Rt. 685 ford, 29 May 1977, 1 male, FLC; Craig Cr. nr. Oriskany at Rt. 706, 29 May 1977, 1 female, FLC; Craig Cr. nr. Oriskany at Rt. 706, 17 June 1978, 1 male, FLC. Brunswick Co.; Wilmington, 19 March 1977, 1 male, C. Sheppard, VPI&SU; Waqua Cr. at Rt. 1, 15 Apr. 1978, 1 male, FLC; Waqua Cr. at Rt. 1, 15 Apr. 1978, 2 males, SWB, FLC Collection. Charlotte Co.; Spring Cr. at Rt. 654, 18 May 1978, 1 male,

FLC; Spring Cr. at Rt. 654, 18 May 1978, 2 males, BCK; Twittys Cr. at Rt. 642, 23 May 1977, 2 males, FLC; Twittys Cr. at Rt. 642, 23 May 1977, 1 male, SWB, FLC Collection. Craig. Co.; Johns Cr. at Rt. 311, 28 May 1977, 2 males, FLC; Potts Cr. at Paint Bank, 7 June 1974, 1 male, FLC; Craig Cr. at Rts. 621 and 651, 17 June 1978, 4 males, FLC. Cumberland Co.; Bear Cr. Lk., 23 May 1977, 1 female, FLC. Fairfax Co.; Great Falls, 28 Apr. 1938, 1 female (in emergence), A. B. Gurney, USNM; Great Falls, 30 Apr. 1915, 5 males, RPC, USNM; Great Falls, "Apr. 30 - May 15" (Donnelly 1961); Dunn Loring, May 1913, 1 male, B. A. Reynolds, USNM; Great Falls, 9 May 1916, 2 males, RPC, USNM; Great Falls, 14 May 1915, 2 males, RPC, USNM; Great Falls, 15 May 1914, 1 female, RPC, USNM; Great Falls, 21 May 1914, 2 males, RPC, USNM. Giles Co.; Mt. Lake, 14 June 1974, 1 male, FLC. Grayson Co.; New River at Rt. 810 nr. Galax, 19 June 1977, 1 male, BCK. Hanover Co.; S. Anna R. at Rt. 657, 21 May 1978, 1 male, BCK; S. Anna R. falls at Rt. 657, 12 June 1978, 1 male, OSF, USNM. Highland Co.; Bullpasture R. at head of gorge, 30 May 1977, 1 male, FLC; Back Cr. at Rt. 250, 4 June 1977, 1 male, 1 female, FLC; Bullpasture R., 7 June 1975, 1 male, FLC, VPI&SU; Bullpasture R. at head of gorge, 8 June 1974, 2 males, FLC. Louisa Co.; S. Anna R. at Rt. 522, 3 June 1977, 1 male, BCK. N. Anna R. at Rt. 601, 12 June 1978, 1 male, BCK. Mecklenburg Co.; Allens Cr. at Rt. 678, 14 Apr. 1978, 1 male (teneral), 1 female, FLC. Montgomery Co.; Blacksburg, 23 May 1955, 1 male, R. E. Martin, VPI&SU; Pandapas Pd., 24 May 1973, 1 male, FLC; Poverty Cr. at Rt. 621, 27 May 1962, 2 males, D. Innes, VPI&SU; Pandapas Pd., 14 June 1974, 2 males, FLC; VPI&SU campus, date unknown, 1 male, collector unknown, (Det. LKG, Gloyd 1951). New Kent Co.; Plum Point, 30 Apr. 1970,

(observation), C. Shiffer. Roanoke Co.; N. Fork of Roanoke R. oxbow, 15 May 1977, 3 males, Hammond; Rts. 311 and 611, 28 June 1975, 1 male, SWB, VPI&SU. Rockbridge Co.; Brattons Run 1/2 mile N. of California, 4 June 1977, 1 female, FLC; Goshen Pass, 23 June 1978, 1 male, FLC. Scott Co.; Clinch R. at Speers Ferry, date unknown, nymph, collector unknown, (Roback and Westfall, 1967). Smyth Co.; N. Fork Holston R. nr. Saltville, date unknown, nymph, collector unknown, (Roback and Westfall, 1967). Southampton Co.; Nottoway R. at Rt. 653, 16 Apr. 1978, 1 male, 2 females, FLC. Spotsylvania Co.; Tributary of Matta R. at Rt. 617, 29 May 1978, 1 female, FLC. City of Suffolk; Williamson Ditch in Dismal Swamp Wildlife Refuge, 17 Apr. 1978, 1 female, FLC; Washington Ditch in Dismal Swamp Wildlife Refuge, 16 May 1976, 1 male, J. O'Hop, ODU.

Flight Season.--Mar. 19 (VA) to Aug. 9 (N.S.); in Virginia Mar. 19 to June 28. Known season in neighboring states are: Kentucky May 10; North Carolina- Mar. 25 to May; Pennsylvania- Apr. 24 to June 31; Tennessee- May 6 to June 1 (Trogdon (1961) lists Aug. 2 to Sept. 5, however this range of dates is not within the expected range for Tennessee and therefore may be in error.); West Virginia- May 13 to June 14.

Biology.--*Basiaeschna janata* inhabits streams with moderate gradient. Adult males patrol streams at from 20-60 cm. Oviposition is generally in emergent vegetation above and below the water line.

Remarks.--Unlike most species of Aeshnidae this species appears early in the spring.

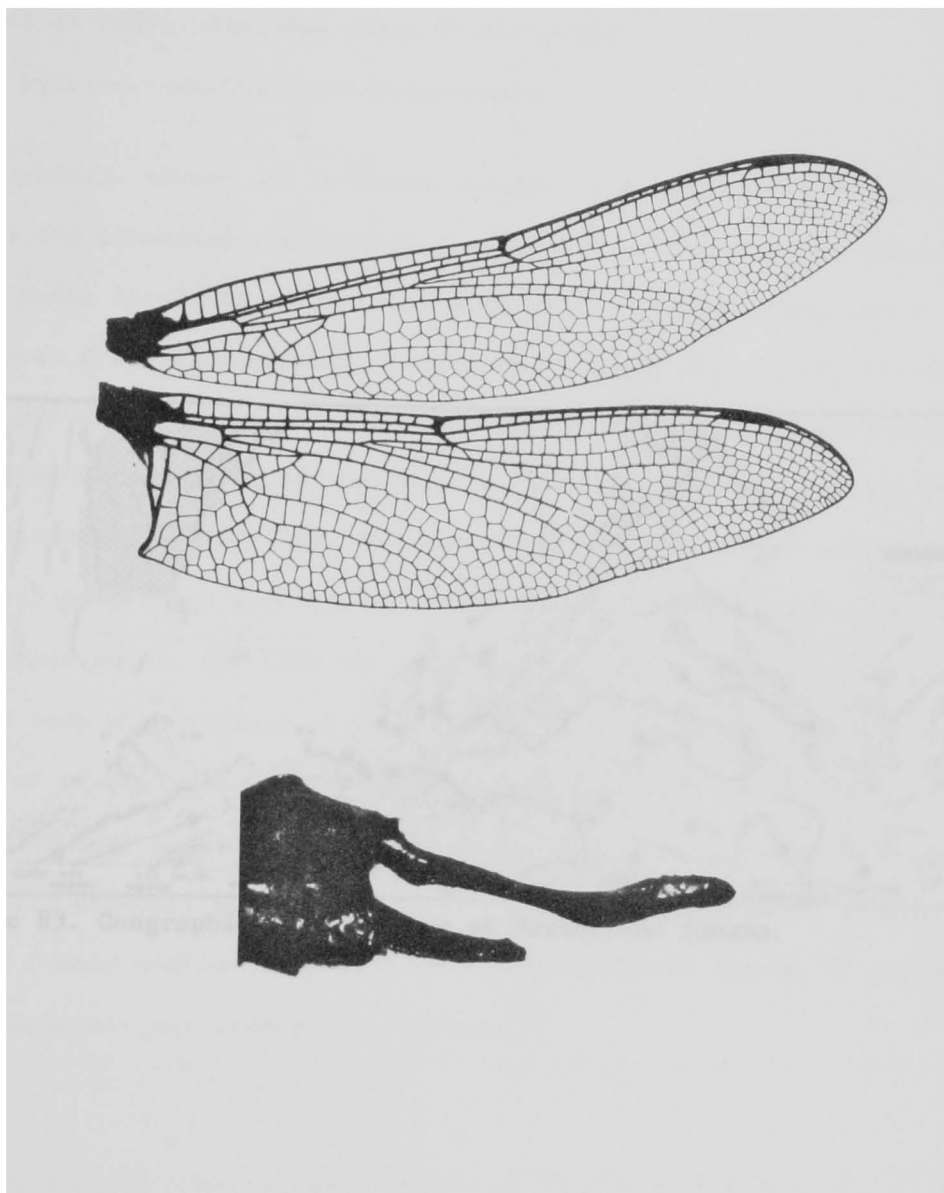


Figure 82. Wings X3 and male terminalia in lateral view x11 of *Basiaeschna junata*.

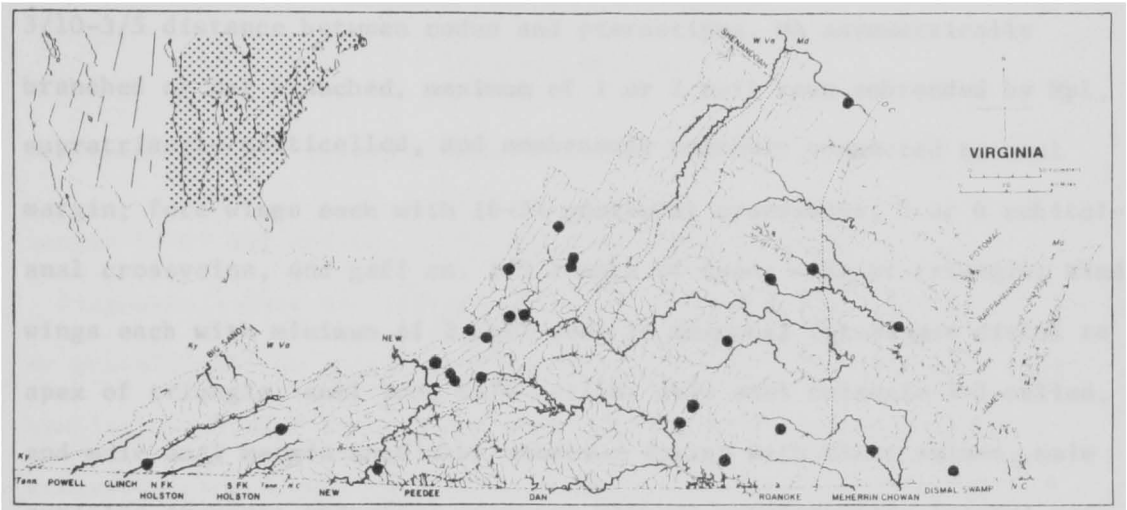


Figure 83. Geographic distribution of *Basiaechma jarrovi*.

Genus *Boyeria* McLachlan 1896

Syn.: *fonscolumbea* Selys

McLachlan 1896. Ann. Mag. Nat. Hist. 17:424.

Type Species.--*Aeshna irene* Fonscolumbe.

Diagnosis.--Frons not produced anteriorly beyond clypeus; ocellar ridge not biconically elevated; thorax brown with yellow or greenish-blue spots laterally; wings each with basal brown area present or absent, midbasal crossveins present, 1 cell row between RP_1 and RP_2 distally to $3/10-3/5$ distance between nodus and pterostigma, MA asymmetrically branched or not branched, maximum of 1 or 2 cell rows subtended by Mpl , supratriangle multicelled, and membranule narrowly connected to anal margin; fore wings each with 16-24 postnodal crossveins, 5 or 6 cubital-anal crossveins, and gaff ca. $1/3$ length of inner side of triangle; hind wings each with minimum of 2 cell rows in trigonal interspace distal to apex of triangle, anal loop 6-14-celled, male anal triangle 3-5-celled, and male anal margin angulate; anterior lamina with blunt spines, male auricles present; abdominal segments without supplementary lateral carinae; female without long spines on posteroventral margin of segment 10; male epiproct not divaricate, triangular.

Species Key to Adult *Boyeria* of North America

1. Body grayish-brown; wings each with basal brown spot not extended to first antenodal crossvein, and 4 or 5 cell rows between RP₂ and MA below proximal end of pterostigma *B. grufiana* p. 469
- Body reddish-brown; wings each with basal brown spot extended to first antenodal crossvein, and 3 cell rows between RP₂ and MA below proximal end of pterostigma *B. vinosa* p. 471

Boyeria grufiana Williamson

(Figures 84,86a)

Williamson 1907. Entomol. News 18:1.

Length 60-67 mm; abdomen 41-51 mm; hind wings 38-44mm.

Diagnosis.--Face blueish-grey; thorax greyish-brown with lateral dull or greenish-yellow spots, metanepimera with spot subtriangular; wings hyaline, each with basal brown area not extended to first antenodal crossvein, and 3 cell rows between RP₂ and MA below proximal end of pterostigma; each hind wing with 1-3 crossveins between costal braces; abdomen greyish-brown, with blueish-green middorsal triangles; dorsum of abdominal segment 10 in male blueish-green; female cerci 1-1.5 times length of abdominal segment 10.

Distribution.--Known from the states of GA, KY, ME, MA, MI, MN, MS, NH, NY, NC, OH, PA, SC, TN, VT, VA, WV, and WI, and the provinces of N.B., N.S. Ont., and Que. Known from the Virginia counties of Alleghany, Augusta, Bath, Craig, Giles, Hanover, Highland, Louisa, Montgomery, Pulaski,

Rockbridge, Tazewell, and Wise. Known distribution among the counties of neighboring states include: North Carolina- Macon, Moore, and Swain; Pennsylvania- Cambria, Cameron, Centre, Clearfield, Fayette, Fulton, Huntingdon, Lycoming, Perry, and Potter; Tennessee- Blount, Fentress, and Sevier; West Virginia- Logan, Pendleton, Raleigh, Randolph, and Webster.

Virginia Records.--Alleghany Co.; Longdale Furnace on Simpson Cr., 18 Sept. 1934, 1 male, LKG and H. K. G., (Det. LKG, Gloyd 1951), MZUM. Augusta Co.; Fridley Branch 3 miles E. of Deerfield, 4 Sept. 1977, 1 male, OSF, USNM. Bath Co.; Back Cr. at Blowing Springs campground at Rt. 39, 10 Sept. 1979, 1 male, BCK. Craig Co.; Craig Cr. at Rt. 621, 5 Aug. 1973, 1 female, FLC; Craig Cr. at Rt. 621, 9 Aug. 1973, 1 male, FLC; Potts Cr. at Steel Bridge campground 4 miles N. of Paint Bank, 29 Sept. 1977, 1 male, OSF, USNM. Giles Co.; Sinking Cr. nr. covered bridge, 9 Sept. 1947, 1 male, J. S. Rogers, (Det. LKG, MDR notes). Hanover Co.; N. Anna Falls, 6 July 1977, 1 male, 1 female, BCK. Highland Co.; Laurel Fork, 30 Aug. 1980, 5 males, BCK; Locust Springs, 18 Sept. 1976, 2 males, JFM, ODU. Louisa Co.; S. Anna R. at Rt. 522, 30 July 1977, 1 female (slightly teneral), BCK. Montgomery Co.; Mill Cr. at Rt. 785, 29 Mar. 1977, 1 female nymph with exuviae, BCK; Poverty Cr. below Pandapas Pd., 10 July 1977, 1 male, BCK; Craig Cr. at Rt. 621, 10 Aug. 1973, 3 females, FLC; Craig Cr. at Rt. 621, 15 Aug. 1973, 1 male, FLC; Poverty Hollow, 13 Sept. 1976, 1 male, Hammond; Poverty Cr. Hollow, 23 Sept. 1977, 1 female, BCK. Pulaski Co.; locality unknown, 20 June 1975, 1 male (teneral), C. Hopkins, VPI&SU. Rockbridge Co.; Guys Run, 30 Aug. 1977, 1 male, M. Meschter; Tazewell Co.; Station Spring Cr. at

Rt. 666, 16 Aug. 1977, 2 males, FLC; Spring-fed stream on Moore Bros. ranch, 1 Sept. 1979, 1 male, BCK. Wise Co.; locality unknown, 5 July 1974, 1 female, J. Simonet, VPI&SU.

Flight Season.--June 2 (WV) to Oct. 8 (TN); in Virginia June 20 (ten-eral) to Sept. 29. Known season in neighboring states are: Kentucky-Aug.; North Carolina- June 29 to Sept.; Pennsylvania- Aug. 1 to Oct. 7; Tennessee- Aug. 19 to Oct. 8; West Virginia- June 2 to Sept. 1.

Biology.--*Boyeria grafiana* inhabits rocky streams and rivers. Males are most commonly observed patrolling at 25-60 cm above small streams of moderate gradient. Oviposition occurs in wet leaves and moss accumulated on rocks and logs along the stream.

Remarks.--Primarily a northern species *B. grafiana* will doubtfully be collected east of the mountains in Virginia, its distribution being far more restricted than that of *B. vinosa*.

Boyeria vinosa (Say)

(Figures 85, 86b)

Say 1839. J. Acad. Phila. 8:13 (in *Aeshna*).

Length 60-71 mm; abdomen 45-56 mm; hind wings 39-46 mm.

Diagnosis.--Face brown; thorax reddish-brown with lateral bright yellow spots, metanepimera with spot subcircular; wings flavescent, each with basal brown area extended to first antenodal crossvein, and 4 or 5 cell rows between RP_2 and MA below proximal end of pterostigma; each hind wing with 3 or 4 crossveins between costal braces; abdomen reddish-brown, with obscure yellow middorsal triangles; dorsum of abdominal

segment 10 in male yellowish-brown; female cerci 3-5 times length of abdominal segment 10.

Distribution.--Known from the states of AL, AR, CT, DC, FL, GA, IL, IN, IA, KY, LA, ME, MD, MA, MI, MS, MO, NH, NJ, NY, NC, OH, OK, PA, SC, TN, TX, VT, VA, WV, and WI, and the provinces of N.S., Ont., and Que. Known from the Virginia counties of Albemarle, Alleghany, Bath, Botsourt, Carroll, Chesterfield, Clarke, Craig, Culpeper, Fairfax, Fluvana, Franklin, Giles, Grayson, Hanover, Highland, James City, Louisa, Madison, Montgomery, Nelson, Page, Russell, Southampton, Spotsylvania, Tazewell, and Washington, and the cities of Norfolk and Suffolk. Known distribution among the counties of neighboring states include: Kentucky- Allen, Bell, Breckinridge, Bullitt, Butler, Cumberland, Edmonson, Green, Harrison, Hart, Marion, Rockcastle, Russell, Taylor, Washington, and Wayne; North Carolina- Buncombe, Halifax, Moore, Swain, Wake, and Watauga; Pennsylvania- Adams, Beaver, Berks, Bradford, Bucks, Cambria, Centre, Chester, Clarion, Clearfield, Columbia, Cumberland, Delaware, Fayette, Forest, Fulton, Huntingdon, Jefferson, Lancaster, Lawrence, Lebanon, Lycoming, Mercer, Monroe, Perry, Philadelphia, Pike, Potter, Somerset, Susquehanna, Wayne, Westmoreland, and York; Tennessee- Anderson, Campbell, Clay, Fentress, Grainger, Greene, Henry, Jefferson, Johnson, McNairy, Monroe, Morgan, Overton, Pickett, and Putnam; West Virginia- Hampshire, Pendleton, Pocahontas, Raleigh, and Ritchie.

Virginia Records.--Albemarle Co.; Carroll Cr. at Keswick, 16 Aug. 1974, 2 males, FLC. Alleghany Co.; Dunlap Cr., 10 Aug. 1973, 1 female, FLC, VPI&SU; Simpson Cr. at Longdale Furnace, 18 Sept. 1934, 1 male, 1 female, R. L. Hoffman, (Det. LKG, Gloyd 1951); Cowpasture R. at Griffith,

1 Oct. 1953, 1 male, R. L. Hoffman, (Det. R. H. Gibbs), USNM. Bath Co.; Back Cr. at Rt. 600, 10 Aug. 1973, 1 male, FLC; Back Cr. at Rt. 600, 22 Aug. 1973, 1 male, FLC; Blowing Springs campground on Back Cr. at Rt. 39, 10 Sept. 1979, 1 female, BCK; Blowing Springs campground on Back Cr. at Rt. 39, 10 Sept. 1979, JRV, VPI&SU; Richardson Gorge on Jackson R. at Rt. 603, 11 Sept. 1979, 1 male, JRV, VPI&SU. Botetourt Co.; Patterson Cr. at Craig Cr., 5 Aug. 1973, 1 male, FLC; small stream, 18 Aug. 1974, 1 male, Hopkins, VPI&SU. Carroll Co.; New R. at bridge nr. Fries, 23 Aug. 1976, 1 male, C. R. Parker, VPI&SU. Chesterfield Co.; Falling Cr., 12 Sept. 1934, 3 males (observation), (Det. LKG, Gloyd 1951). Clarke Co.; Shenandoah R. at Rt. 621, 16 July 1980, 1 male, BCK. Craig Co.; Craig Cr. at Rt. 621, 1 Aug. 1973, 1 female, FLC; Craig Cr. at Rt. 621, 10 Aug. 1973, 2 males, FLC. Culpeper Co.; Rapidan R. 1.5 miles S. of Rt. 681, 15 July 1980, 1 male, BCK. Fairfax Co.; Great Falls, "June 15-Sept. 9" (Donnelly 1961); Great Falls, 9 July 1905, 1 female, D. H. Clemens, USNM; Great Falls, 24 July 1900, 1 female, G. N. Collins, USNM; Great Falls, 24 Aug. 1915, 1 male, BPC, USNM. Fluvanna Co.; Judy Cr. off Rt. 651 nr. Fork Union, 2 Jan. 1977, 1 nymph, FLC. Franklin Co.; Maggoodee Cr. nr. county line, 26 Aug. 1953, 1 male, R. H. Gibbs, Jr., USNM; Maggoodee Cr. nr. county line, 29 Aug. 1953, 1 male, R. H. Gibbs, USNM. Giles Co.; Sinking Cr., 10 Aug. 1949, 1 male, R. E. Bellamy, (Det. C. F. Byers, MDR notes); Little Stony Cr. below Kelly Flats, 21 Aug. 1978, 1 male, FLC; Big Walker Cr. at Rt. 622, 29 Sept. 1977, 1 male, JRV, VPI&SU; Big Walker Cr. at Rt. 622, 29 Sept. 1977, 2 males, OSF, USNM. Grayson Co.; Elk R. and New R. W. of Galax, 28 Aug. 1952, 2 males, 1 female, R. L. Hoffman, (Det. R. H. Gibbs). Hanover Co.; N.

Anna R. at Falls, 6 July 1977, 4 males, BCK; S. Anna R. at Rt. 657, 2 Aug. 1978, 1 male, BCK; S. Anna R. at Falls at Rt. 657, 22 Oct. 1977, 1 male, BCK. Highland Co.; Buck Run beaver ponds, 12 June 1980, 3 nymphal exuviae, FLC; Buck Run beaver ponds, 8 Aug. 1978, 1 nymphal exuviae, FLC; Jackson R. at Rts. 606 and 220, 8 Aug. 1978, 1 male, BCK, VPI&SU. James City Co.; Williamsburg, Oct. 1936, 1 male, collector unknown, (Det. MED), W&M; Williamsburg, 5 Oct. 1936, 1 female, MED, (Det. MED, MDR notes); Swamp nr. school building in Williamsburg, 13 Oct. 1938, 1 male, M. Ripperton, (Det. MED, MDR notes). Louisa Co.; S. Anna R. at Rt. 657, 3 June 1977, 1 female, BCK; S. Anna R. at Rt. 522, 20 June 1977, 1 male, 1 female, BCK; locality unknown, 23 June 1970 (emerged 7 July 1970), 1 nymph, D. Droppleman, FLC Collection; Tributary of Contrary Cr., 23 June 1970, 1 male, D. Droppleman, VPI&SU; Contrary Cr. at Rt. 652, 24 June 1969 (emerged 7 July 1969), 1 female nymph, J. Marsh, VPI&SU; N. Anna R. at Rt. 658, 3 July 1969, 1 male, J. Coe, VPI&SU; S. Anna R. at Rt. 522, 5 July 1977, 2 male, 1 female, BCK; S. Anna R. at Rt. 657, 6 July 1977, 1 male, BCK; Tributary of Contrary Cr., 7 July 1970, 1 male, D. Droppleman, VPI&SU; S. Anna R. at Rt. 522, 12 Sept. 1978, 3 males, BCK; N. Anna R. at Rt. 669, 4 Oct. 1968, 2 males, Simmons, VPI&SU; S. Anna R. at Rt. 522, 21 Oct. 1978, 1 female, BCK; S. Anna R. at Rt. 522, 22 Oct. 1977, 1 male, 1 female, BCK. Madison Co.; Tributary of Robinson R., 10 July 1980, 1 female, Col. E. Smith, (Det. BCK), BCK Collection. Montgomery Co.; Toms Cr., 9 Apr. 1977 (emerged 24 May 1977), 1 female with nymphal exuviae, BCK; Toms Cr. at Rt. 655, 2 May 1978 (emerged 31 May 1978), 1 female, J. Bragg, VPI&SU; Blacksburg, 14 July 1951, 1 female, D. G. Cochran, VPI&SU; Toms Cr. at Rt. 651, 15 July 1973, 1 female (slightly

teneral), FLC; Toms Cr. at Rt. 655, 20 July 1977, 9 males, FLC; Toms Cr. at Rt. 651, 1 Aug. 1973, 1 male, FLC; Toms Cr. at Rt. 651, 5 Aug. 1973, 2 males, FLC; Toms Cr. below Rt. 655 bridge, 5 Aug. 1975, 1 female, FLC; Toms Cr. at Rt. 651, 8 Aug. 1973, 1 male, FLC; Toms Cr. at Rt. 651, 10 Aug. 1973, 2 males, 1 female, FLC; Toms Cr. at Rt. 651, 11 Aug. 1978, 1 male, FLC; Toms Cr. at Rt. 651, 15 Aug. 1973, 1 female, FLC; Blacksburg, 17 Aug. 1951, 1 male, D. G. Cochran, VPI&SU; Toms Cr., 6 Sept. 1976, 1 male, 1 female, T. Bailey, VPI&SU; locality unknown, 10 Sept. 1976, 1 male, J. McCaffrey, VPI&SU; Toms Cr. at Rt. 655, 11 Sept. 1977, 1 male, FLC. Nelson Co.; locality unknown, 8 July 1928, 1 male, W. Robinson, USNM. Page Co.; Shenandoah R. SW. of Bentonville, 1 July 1973, 1 male, S. W. Dunkel. Russell Co.; Laurel Bed Lake, 4 July 1977, 1 nymphal exuviae, FLC. Southampton Co.; locality unknown, 7 Sept. 1973, 1 female, Bunch, ODU. Spotsylvania Co.; N. Anna R. at Rt. 208, 25 June 1979 (emerged 10 July 1979), 1 male, A. Winfield, VPI&SU; N. Anna R. at Rt. 208, 25 June 1970 (emerged 3 July 1970), 1 male, D. Droppleman, VPI&SU. Tazewell Co.; Maiden Mtn. Bog, 16 Aug. 1977, 3 nymphal exuviae, FLC. Washington Co.; Holston R., date unknown, 1 nymph, collector unknown, (Det. E. B. Williamson, Williamson 1903). City of Norfolk; Norfolk, 12 Sept. 1975, 1 male, Rhodes, ODU. City of Suffolk; Dismal Swamp Wildlife Refuge, 15 Sept. 1974, 1 male, 1 female, JFM, ODU.

Flight Season.--May 9 (New England) to Dec. 3 (FL); in Virginia June 3 to Oct. 22. Known season in neighboring states are: District of Columbia- July 26; Kentucky- July to Oct.; North Carolina- June 28 to Oct.; Pennsylvania- June 16 to Oct. 15; Tennessee- Sept. 3 to 29; West Virginia- June 3 to Aug. 22.

Biology.--*Boyeria vinosa* inhabits streams and small rivers with slight gradient. Adults hang in the shade for much of the day but are active on shaded streams throughout the day. Towards dusk the species becomes very active feeding both away from and at streamside. Oviposition occurs in wet or decayed wood.

Remarks.--This species is the most common aeshnine in Virginia.

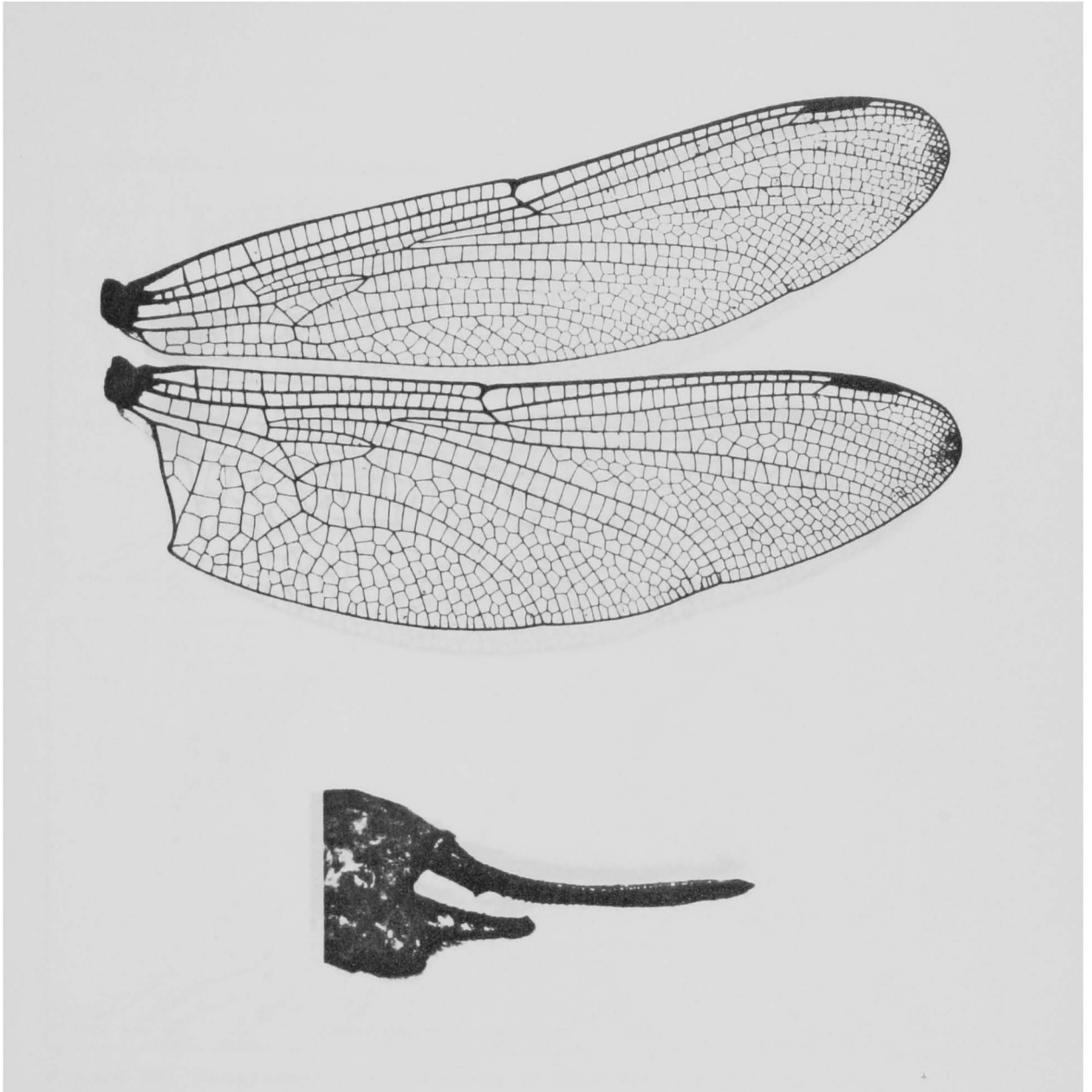


Figure 84. Wings x3 and male terminalia in lateral view x11 of *Boyeria graflana*.

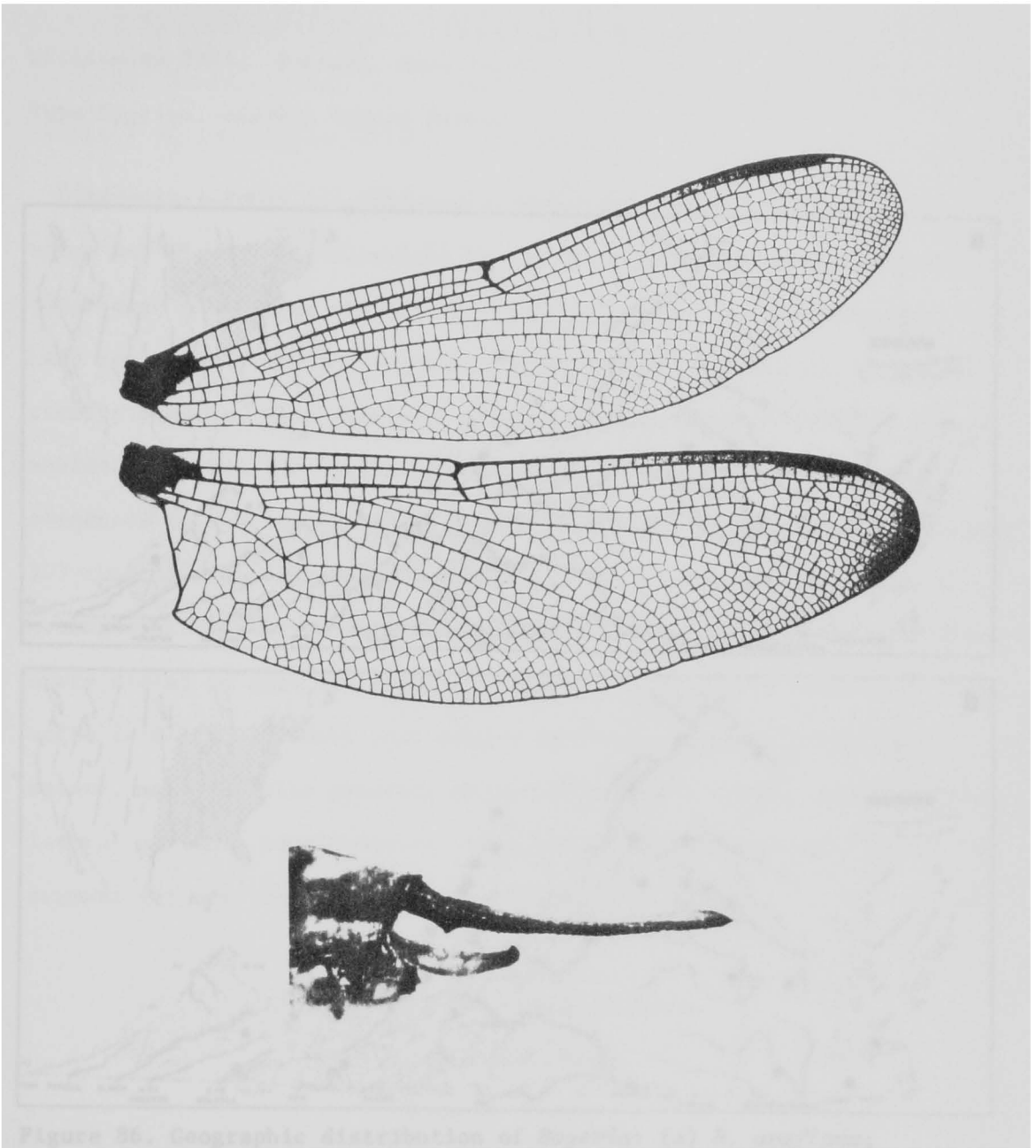


Figure 85. Wings x3 and male terminalia in lateral view x11 of *Boerhaavia vinosa*.

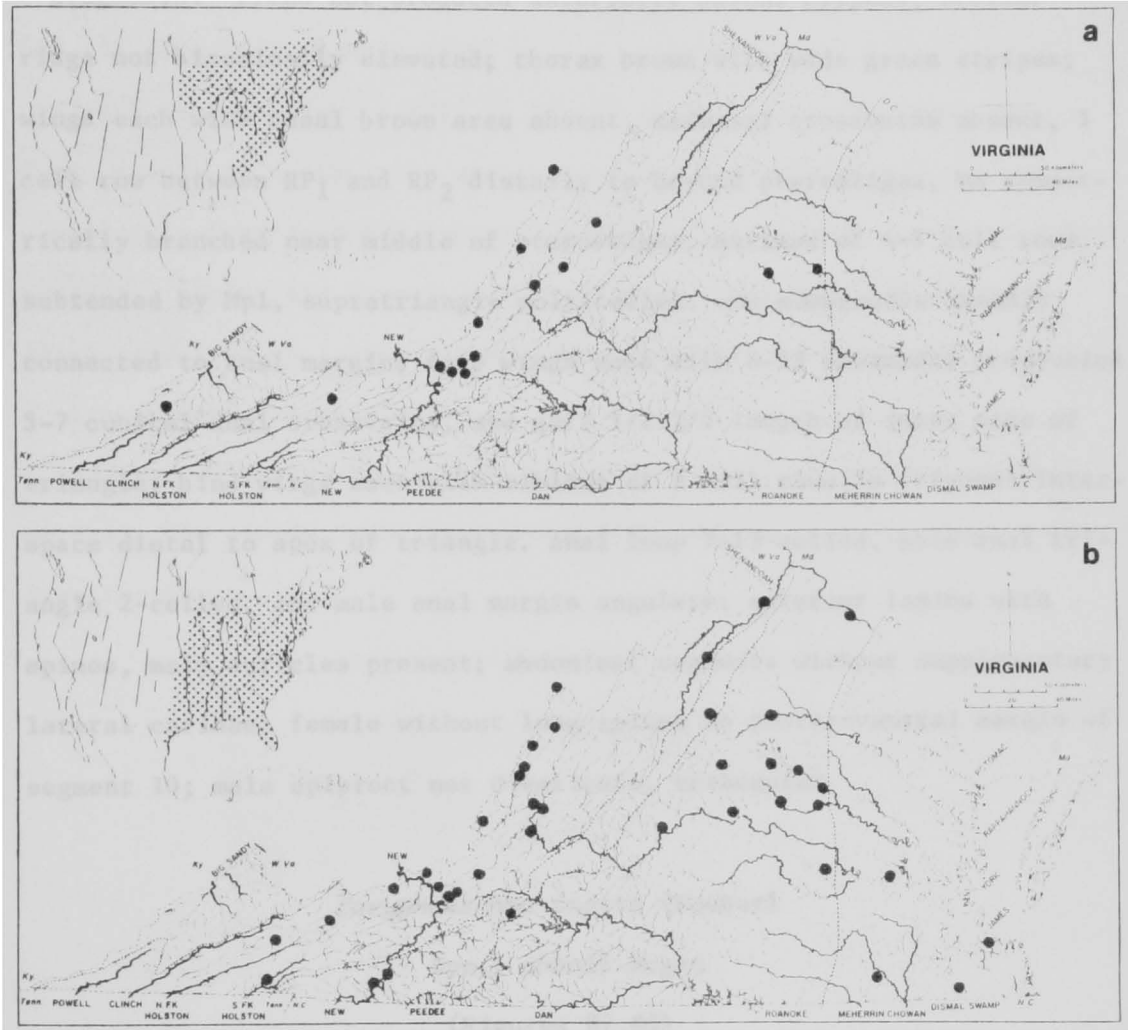


Figure 86. Geographic distribution of *Boyeria*: (a) *B. grujiana*; (b) *B. vinosa*.

Genus *Coryphaeschna* Williamson 1903

Williamson 1903. Entomol. News 14:2.

Type Species.--*Aeshna ingens* Rambur.

Diagnosis.--Frons not produced anteriorly beyond clypeus; ocellar ridge not biconically elevated; thorax brown with wide green stripes; wings each with basal brown area absent, midbasal crossveins absent, 1 cell row between RP_1 and RP_2 distally to beyond pterostigma, MA symmetrically branched near middle of pterostigma, maximum of 4-6 cell rows subtended by Mpl , supratriangle multicelled, and membranule broadly connected to anal margin; fore wings each with 8-13 postnodal crossveins, 5-7 cubital-anal crossveins, and gaff $1/2-3/5$ length of inner side of triangle; hind wings each with minimum of 2 cell rows in trigonal interspace distal to apex of triangle, anal loop 7-13-celled, male anal triangle 2-celled, and male anal margin angulate; anterior lamina with spines, male auricles present; abdominal segments without supplementary lateral carinae; female without long spines on posteroventral margin of segment 10; male epiproct not divaricate, triangular.

Coryphaeschna ingens (Rambur)

Syn.: *abboti* Hagen

(Figures 87,88)

Rambur 1842. Ins. Neur., p. 192 (in *Aeshna*).

Length 85-100 mm; abdomen 64-79 mm; hind wings 53-60 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AL, FL, GA, LA, MS, NC, SC, TX, and VA, and the Antilles- Cuba, and also south to Panama. Known from the Virginia county of Southampton. Known distribution among the counties of neighboring states include: North Carolina- Craven and Martin.

Virginia Record.--Southampton Co.; Logging road between Rts. 258 and 684, 11 June 1975, 1 male, FLC.

Flight Season.--Feb. 6 (FL) to Oct. 3 (FL); in Virginia June 11. Known season in neighboring states are: North Carolina- May to June.

Biology.--*Coryphaeschna ingens* inhabits weedy ditches, ponds, and lake margins. Adults fly from 1-30 m high along roads and seem to prefer large prey such as tabanids and wasps. Oviposition (observed once) occurs in emergent vegetation.

Remarks.--This species is the largest dragonfly of Eastern North America. The single individual known from Virginia may have been a stray from further south.

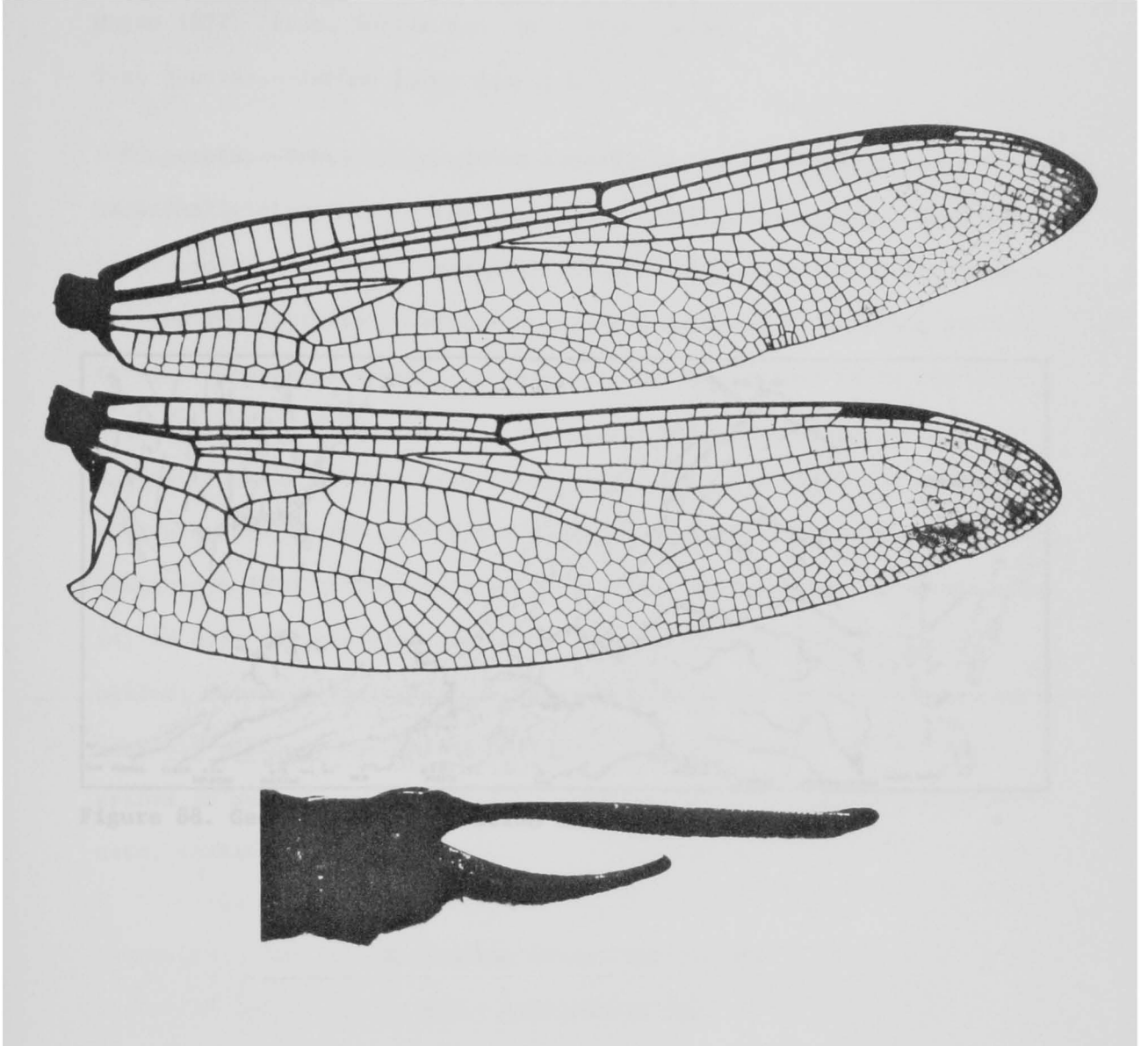


Figure 87. Wings X3 and male terminalia in lateral view X11 of *Comptosia ingens*.

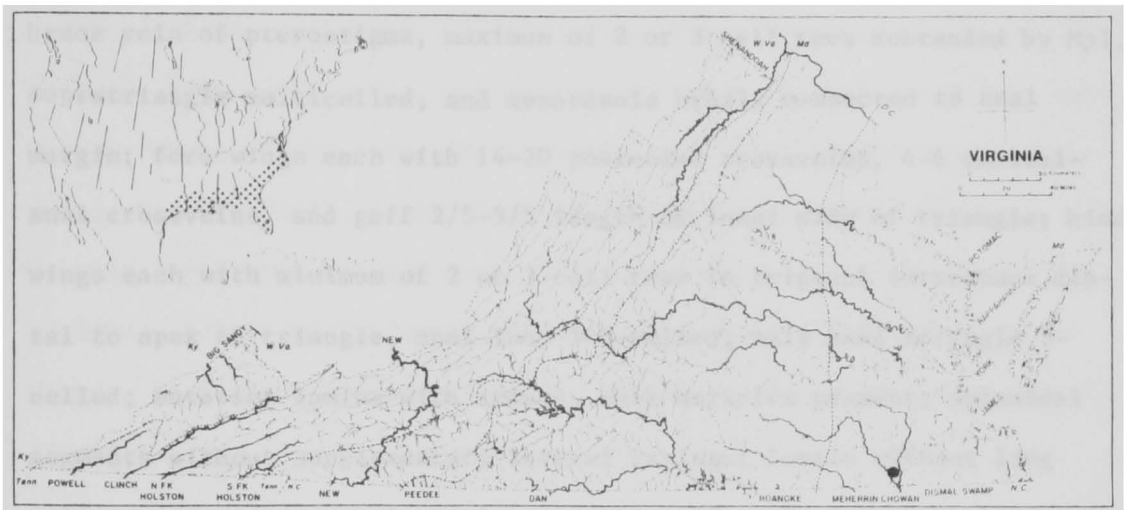


Figure 88. Geographic distribution of *Coryphaeschna ingens*.

Genus *Epiaeschna* Hagen 1877

Hagen 1877. Proc. Boston Soc. Nat. Hist. 18:86.

Type Species.--*Aeshna heros* Fabricius.

Diagnosis.--Frons not produced anteriorly beyond clypeus; ocellar ridge biconically elevated; thorax brown with green stripes; wings each with basal brown area absent, midbasal crossveins absent, 1 cell row between RP_1 and RP_2 distally to pterostigma, MA symmetrically branched before brace vein of pterostigma, maximum of 2 or 3 cell rows subtended by Mpl , supratriangle multicelled, and membranule broadly connected to anal margin; fore wings each with 14-20 postnodal crossveins, 4-6 cubital-anal crossveins, and gaff $2/5-3/5$ length of inner side of triangle; hind wings each with minimum of 2 or 3 cell rows in trigonal interspace distal to apex of triangle, anal loop 5-8-celled, male anal triangle 3-celled; anterior lamina with spines, male auricles present; abdominal segments without supplementary lateral carinae; female without long spines on posteroventral margin of segment 10; male epiproct nondivaricate, rectangular.

Epiaeschna heros (Fabricius)

Syn.: *multicincta* Say

(Figures 89,90)

Fabricius 1798. Entomol. Syst., Suppl., p. 285 (in *Aeshna*).

Length 78-94 mm; abdomen 61-72 mm; hind wings 48-62 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AL, AR, DC, DE, FL, GA, IL, IN, KS, KY, LA, ME, MD, MA, MI, MS, MO, NH, NJ, NY, NC, OH, OK, PA, RI, SC, TN, TX, VA, WV, and WI, and the provinces of Ont. and Que., and Mexico. Known from the Virginia counties of Charlotte, Fairfax, Halifax, Isle of Wight, James City, Montgomery, New Kent, Pittsylvania, Roanoke, Spotsylvania, and Westmoreland, and the cities of Chesapeake, Suffolk, and Virginia Beach. Known distribution among the counties of neighboring states include: Kentucky- Breathitt, Bullitt, Edmonson, Fayette, Green, Jackson, Jefferson, Metcalfe, and Trigg; Maryland- Baltimore, Fairfax, Talbot, Wicomico, and Worcester; North Carolina- Chatham, Dare, Durham, Moore, Pasquotank, Transylvania, and Wake; Pennsylvania- Allegheny, Beaver, Berks, Bucks, Cambria, Centre, Clearfield, Clinton, Dauphin, Delaware, Fulton, Huntingdon, Lancaster, Lawrence, Perry, Philadelphia, Pike, and Westmoreland; Tennessee- Coffee, Davidson, Greene, Grundy, Knox, Obion, and Shelby; West Virginia- Hampshire, Mason, and Ritchie.

Virginia Records.--Charlotte Co.; Spring Cr. at Rt. 654, 10 June 1975, 1 male, 1 female, FLC. Fairfax Co.; Great Falls, 22 May 1906, 1 female, D. H. Clemens, USNM. Halifax Co.; Rt. 306, 8 June 1978, 1 female (observation), BCK. Isle of Wight Co.; locality unknown, 1 June 1975, 1 male, JFM and Hancock, ODU. James City Co.; Jamestown Rd., 3 Aug. 1938, 1 female, MED, VPI&SU. Montgomery Co.; Poverty Hollow, 3 May 1977, 1 male, Hammond; Blacksburg, 13 May 1948, 1 male, Walker, VPI&SU; Blacksburg, 25 May 1948, 1 male, Cockran, VPI&SU; Blacksburg, 25 May 1980, 1 female, BCK; locality unknown, 21 Oct. 1901, 1 female, collector unknown, USNM. New Kent Co.; 3 miles SE. of Plum Point, 29 Apr. 1970,

(observation), C. Shiffer. Pittsylvania Co.; Rt. 862 nr. Rt. 863, 21 May 1978, 1 female, FLC. Roanoke Co.; Tributary of N. Fork Roanoke R. oxbow, 15 May 1977, 1 female, Hammond. Spotsylvania Co.; Tributary of Matta R. at Rt. 617, 29 May 1978, 1 female, FLC; Fredericksburg, June 1889, 1 male, W. D. Richardson, (Det. P. P. Calvert, Calvert 1890), ANSP; swamp along Rt. 617, 7 July 1978, 1 female, FLC. Westmoreland Co.; Colonial Beach, July 1916, 1 male, V. Busck, USNM. City of Chesapeake; Lake Drummond in Dismal Swamp nr. Nansemond, 9,10 June 1974, 2 males, 2 females, MED and D. Davis, USNM. City of Suffolk, Dismal Swamp Wildlife Refuge, 10 May 1970, 1 male, Fearington, ODU; Dismal Swamp Wildlife Refuge, 10 May 1970, 1 female, F. Causey, ODU; Dismal Swamp Wildlife Refuge, 11 May 1970, 1 male, J. C. Steere, ODU; Lake Drummond in Dismal Swamp Wildlife Refuge, 16 May 1970, 1 male, JFM, ODU; Jericho Lane in Dismal Swamp Wildlife Refuge, 21 May 1977, 3 males, 3 females, FLC; Washington Ditch in Dismal Swamp Wildlife Refuge, 21 May 1977, 2 males, FLC; Washington Ditch in Dismal Swamp Wildlife Refuge, 27 May 1970, 2 males, JFM, ODU; Lake Drummond in Dismal Swamp Wildlife Refuge, 14 June 1973, 1 male, C. R. Parker, VPI&SU; Dismal Swamp Wildlife Refuge, 18 June 1970, 1 female, P. Jones, ODU; Jericho Lane in Dismal Swamp Wildlife Refuge, 22 June 1975, 1 male, 8 females, FLC; Dismal Swamp Wildlife Refuge, 5 Aug. 1974, 3 males, J. Hancock, ODU; Dismal Swamp Wildlife Refuge, 12 Aug. 1974, 2 females, J. Hancock, ODU; Jericho Lane in Dismal Swamp Wildlife Refuge, 29 Aug. 1975, 1 female, SWB, FLC Collection. City of Virginia Beach, White Lake Seaside State Park, 22 May 1977, 1 male, 1 female, FLC; Cape Henry, Aug. 1916, 1 female, M. Carmondy, USNM.

Flight Season.--Feb. 27 (FL) to Oct. 21 (Va); in Virginia Apr. 29 to Oct. 21. Known season in neighboring states are: District of Columbia- May 19 to Sept. 3; Kentucky- Apr. 21 to Sept.; Maryland- June 26 to Aug. 22; North Carolina- Apr. to Sept. 5; Pennsylvania- Apr. 24 to Sept. 23; Tennessee- Apr. 23 to Aug. 2; West Virginia- June 4 to July 7.

Biology.--*Epiaeschna heros* inhabits swamps and shaded borders of ponds and ditches. Adults are most frequently observed flying at 1-20 m in road cuts or other open areas near swamps fed by seepage waters. Oviposition occurs in decayed wet wood above the water surface.

Remarks.--This species is a very large dragonfly exceeded in length by only one other Eastern North American dragonfly, *Coryphaeschna ingens*. *Epiaeschna heros* is particularly abundant in the Dismal Swamp Wildlife Refuge where toward dusk thousands may be observed along a short section of road.

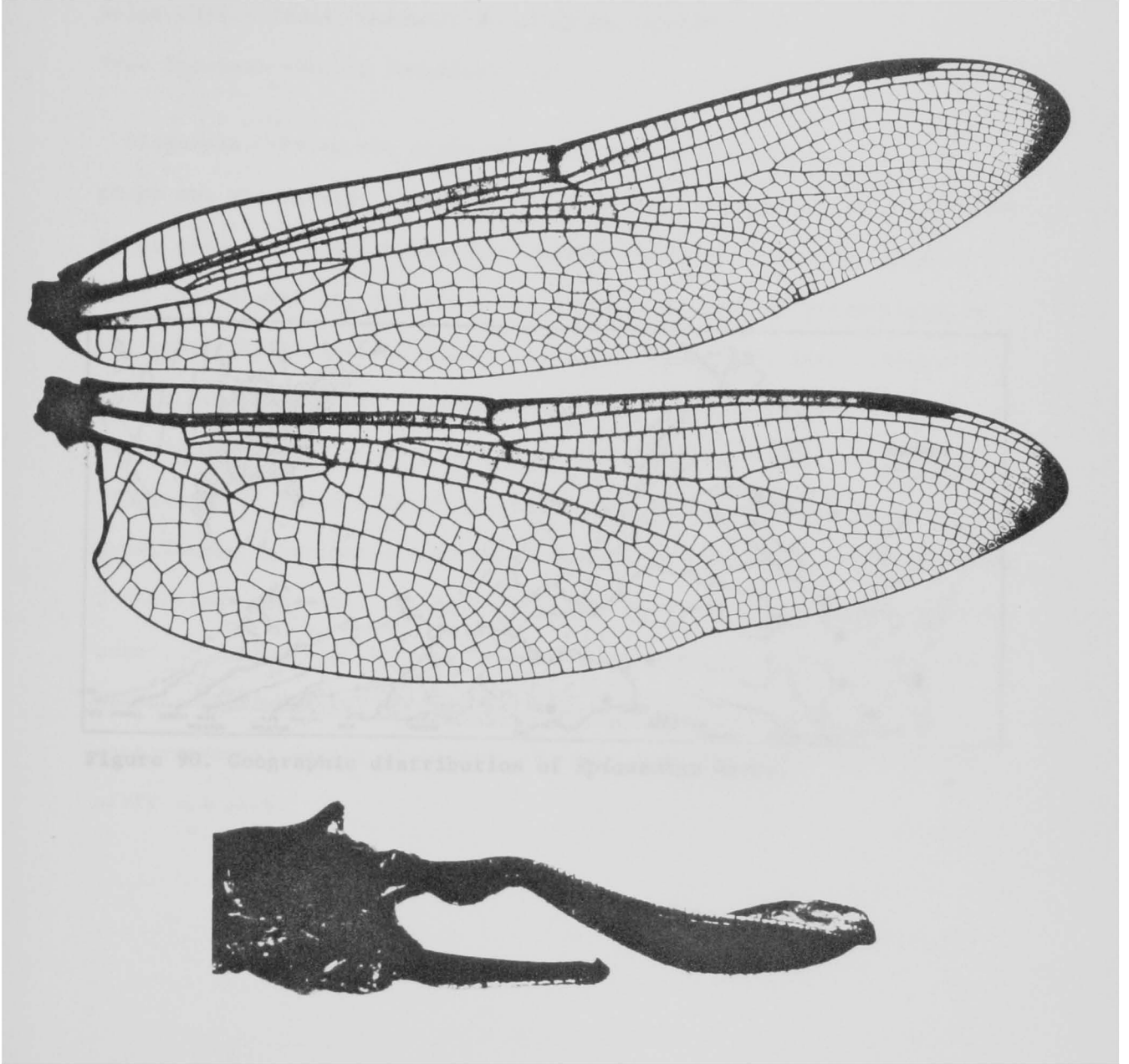


Figure 89. Wings x3 and male terminalia in lateral view x11 of *Epiplatys heros*.

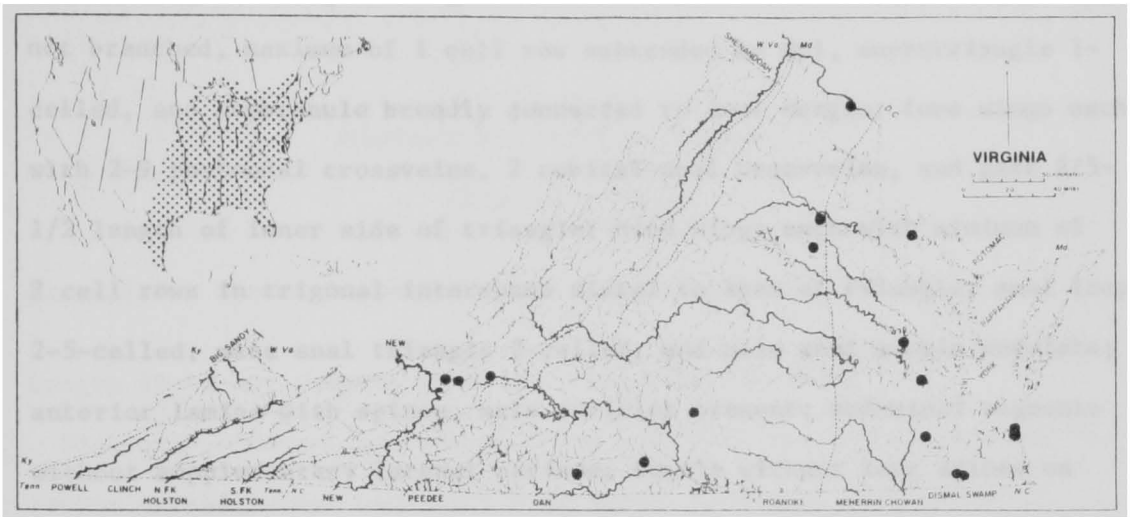


Figure 90. Geographic distribution of *Epiplatys heros*.

Genus *Gomphaeschna* Selys 1871

Selys 1871. Trans. Entomol. Soc. London, p. 413.

Type Species.--*Aeshna furcillata* Say.

Diagnosis.--Frons not produced anteriorly beyond clypeus; ocellar ridge not biconically elevated; thorax brown with diffuse pale markings; wings each with basal brown area absent, midbasal crossveins absent, 1 cell row between RP_1 and RP_2 distally to brace vein of pterostigma, MA not branched, maximum of 1 cell row subtended by Mpl , supratriangle 1-celled, and membranule broadly connected to anal margin; fore wings each with 2-9 postnodal crossveins, 2 cubital-anal crossveins, and gaff $2/5-1/2$ length of inner side of triangle; hind wings each with minimum of 2 cell rows in trigonal interspace distal to apex of triangle, anal loop 2-5-celled, male anal triangle 2-celled, and male anal margin angulate; anterior lamina with spines, male auricles present; abdominal segments without supplementary lateral carinae; female without long spines on posteroventral margin of segment 10; male epiproct divaricate, deeply cleft apically.

Species Key to Adult *Gomphaeschna*

- 1. Wings each with 1 cell row between RP_2 and MA below proximal end of pterostigma, and 1 antenodal crossvein between costal braces; male cerci separated by ca. width of cercus . . . *G. antilope* p. 491
- Wings each with 2 cell rows between RP_2 and MA below proximal end of pterostigma, and 2 antenodal crossveins between costal braces; male cerci separated by twice width of cercus
 *G. furcillata* p. 493

Gomphaeschna antilope (Hagen)

(Figures 91,93a)

Hagen 1874. Proc. Boston Soc. Nat. Hist. 16:354 (in *Aeshna*).

Length 49-61 mm; abdomen 36-47 mm; hind wings 30-36 mm.

Diagnosis.--Dorsal surface of frons with dark area extended along anterior carina; wings each with 1 antenodal crossvein between costal braces, and 1 cell row between RP_1 and MA below pterostigma; fore wings each with dark area in female centered proximal to nodus, and 2-5 (occasionally 6) postnodal crossveins; width of hind wings at nodus more than distance between nodus and pterostigma in fore wings; posterior hamuli clublike apically; male cerci straight, basally separated by ca. width of cercus; apical width of male epiproct slightly greater than basal width.

Distribution.--Known from the states of AL, DC, DE, FL, GA, LA, MD, MS, NJ, NC, OH, PA, SC, TN, and VA. Known from the Virginia counties

of Albemarle, Fairfax, Giles, Middlesex, and Nelson, and the cities of Norfolk, Suffolk, and Virginia Beach. Known distribution among the counties of neighboring states include: Maryland- Anne Arundel and Calvert; North Carolina- Moore, Robeson, and Wake; Pennsylvania- Allegheny, Delaware, Philadelphia, and Venango.

Virginia Records.--Albemarle Co.; Charlottesville, 13 June 1975, 1 male, M. Zimmerman, VCU. Fairfax Co.; Park Fairfax in Alexandria, 26 June 1972, 1 female, OSF, USNM. Giles Co.; locality unknown, 20 Apr. 1972, 1 female, B. Rumbach, VPI&SU. Middlesex Co.; Stingaree Point, 30 June 1937, 1 female, CC, (Det. MDR, MDR notes). Nelson Co.; locality unknown, 25 June 1928, 1 female, WR, USNM. City of Norfolk; locality unknown, 16 Apr. 1976, 1 female, L. O'Hop, ODU; Norfolk, 19 Apr. 1974, 1 female, W. I. Prist, ODU; Norfolk, 4 June 1973, 1 female, D. Simonet, VPI&SU; Norfolk, 5 June 1941, 1 male, 1 female, B. McBane, FSCA; Norfolk, 18 June 1973, 1 male, D. Simonet, VPI&SU. City of Suffolk; Dismal Swamp Wildlife Refuge, 10 May 1970, 1 female, Fearington, ODU; Washington Ditch in Dismal Swamp Wildlife Refuge, 16 May 1970, 1 female, JFM, ODU; Lake Drummond in Dismal Swamp Wildlife Refuge, 9 June 1905, 1 male, H. S. Barber, USNM; Jericho Lane in Dismal Swamp Wildlife Refuge, 22 June 1975, 1 male, FLC. City of Virginia Beach, locality unknown, 27 Apr. 1970, 1 male, Schmidt, ODU.

Flight Season.--Mar. 3 (FL) to July 15 (PA); in Virginia Apr. 16 to June 30. Known season in neighboring states are: District of Columbia- May 23 to June 25; Maryland- June 18 to 20; North Carolina- Apr. 15 to June 5; Pennsylvania- May 16 to July 15.

Biology.--*Gomphaeschna antilope* inhabits sphagnum borders of bog ponds.

Adults are commonly observed flying back and forth over roads and other open areas near the nymphal habitats. Adults commonly rest vertically on tree trunks. Oviposition occurs in decayed wet wood above the water surface.

Remarks.--This species is easily distinguished from *G. furcillata* with which it is often confused by the more open wing venation. *Gomphaeschna antilope* appears to be relatively common in eastern Virginia.

Gomphaeschna furcillata (Say)

Syn.: *quadrifida* Rambur

(Figures 92,93b)

Say 1839. J. Acad. Phila. 8:14 (in *Aeshna*).

Length 44-60 mm; abdomen 31-45 mm; hind wings 28-36 mm.

Diagnosis.--Dorsal surface of frons with dark area not extended along anterior carina; wings each with 2 antenodal crossveins between costal braces, and 2 cell rows between RP_1 and MA below pterostigma; fore wings each with dark area in female centered distal to nodus, and 6-9 (occasionally 5) postnodal crossveins; width of hind wings at nodus less than distance between nodus and pterostigma in fore wings; posterior hamuli bootlike apically; male cerci curved, basally separated by ca. twice width of cercus; apical width of male epiproct distinctly greater than basal width.

Distribution.--Known from the states of AL, AR, CT, DC, DE, FL, GA, KY, ME, MD, MA, MI, MS, NH, NJ, NY, NC, PA, SC, TN, VT, and VA, and the province of N.S. Known from the Virginia counties of Alleghany, Henrico,

James City, Lee, Montgomery, and New Kent, and the cities of Chesapeake, Norfolk, and Virginia Beach. Known distribution among the counties of neighboring states include: Kentucky-- Green and McCreary; Maryland-- Worcester; North Carolina-- Beaufort, Birdie, Columbus, Gates, Moore, New Hanover, Orange, Pitt, and Wake; Pennsylvania-- Allegheny, Centre, Clinton, Crawford, Delaware, Luzerne, Mercer, Sullivan, and Warren.

Virginia Records.--Alleghany Co.; Cowpasture R. at Griffith, 16 May 1951, 1 male, R. L. Hoffman, (Det. LKG). Henrico Co.; Curles Neck Bridge, 19 Apr. 1938, 2 males, MED, (Det. MED, MDR notes). James City Co.; Williamsburg, 8 Apr. 1938, 1 female, collector unknown, VPI&SU; Williamsburg, 1 May 1938, 1 male, collector unknown, (Det. MED), W&M; Jollys Pond, 17 May 1966, 1 male, MDR, VPI&SU. Lee Co.; locality unknown, date unknown, (Cabot 1881). Montgomery Co.; Pandapas Pond, 24 May 1973, 1 male, FLC. New Kent Co.; Plum Point, 30 Apr. 1970, 2 males, C. Shiffer. City of Chesapeake; locality unknown, 15 Apr. 1977, 1 female, J. Vanluik, ODU. City of Norfolk; locality unknown, 13 Apr. 1970, 1 male, T. D. Fearington, ODU. City of Suffolk; Blackwater R. at Rt. 189, 11 Apr. 1976, 1 female, J. O'Hop, ODU; Badger Ditch in Dismal Swamp Wildlife Refuge, 17 Apr. 1978, 1 female, FLC; Dismal Swamp Wildlife Refuge, 22 Apr. 1974, 7 males, 1 female, JFM, ODU; Dismal Swamp Wildlife Refuge, 25 Apr. 1970, 4 males, 2 females, JFM, ODU; Dismal Swamp Wildlife Refuge, 25 Apr. 1971, 1 female, Jenkins, VPI&SU; Washington Ditch in Dismal Swamp Wildlife Refuge, 6 May 1976, JFM, ODU; Nansemond, 8 May 1971, 1 male, T. D. B., ODU; Dismal Swamp Wildlife Refuge, 10 May 1970, 1 male, F. Causey, ODU; Dismal Swamp Wildlife Refuge, 10 May 1970, 1

male, T. D. Fearington, ODU; Dismal Swamp Wildlife Refuge, 10 May 1970, 1 male, Donaldson, ODU; Dismal Swamp Wildlife Refuge, 16 May 1971, 1 female, T. D. B., ODU; Dismal Swamp Wildlife Refuge, 25 May 1971, 2 males, H. F. D., ODU. City of Virginia Beach; Princess Anne, 6 May 1938, 1 female, collector unknown, (Det. MED), W&M.

Flight Season.--Jan 8 (FL) to Aug. (MI); in Virginia Apr. 8 to May 25. Known season in neighboring states are: District of Columbia- June 10; Kentucky- June 4; Maryland- May 27; North Carolina- Mar. 31 to July; Pennsylvania- Apr. 24 to July 15.

Biology.--*Gomphaeschna furcillata* inhabits sphagnum borders of bog ponds. Adults are commonly observed flying back and forth over roads and other open areas near nymphal habitats. Adults commonly rest vertically on tree trunks. Oviposition occurs in wet decaying wood above the water surface.

Remarks.--This species is easily distinguished from *G. antilope* with which it is often confused by the less open wing venation. *Gomphaeschna furcillata* is collected infrequently in Virginia but is apparently more common in eastern Virginia.

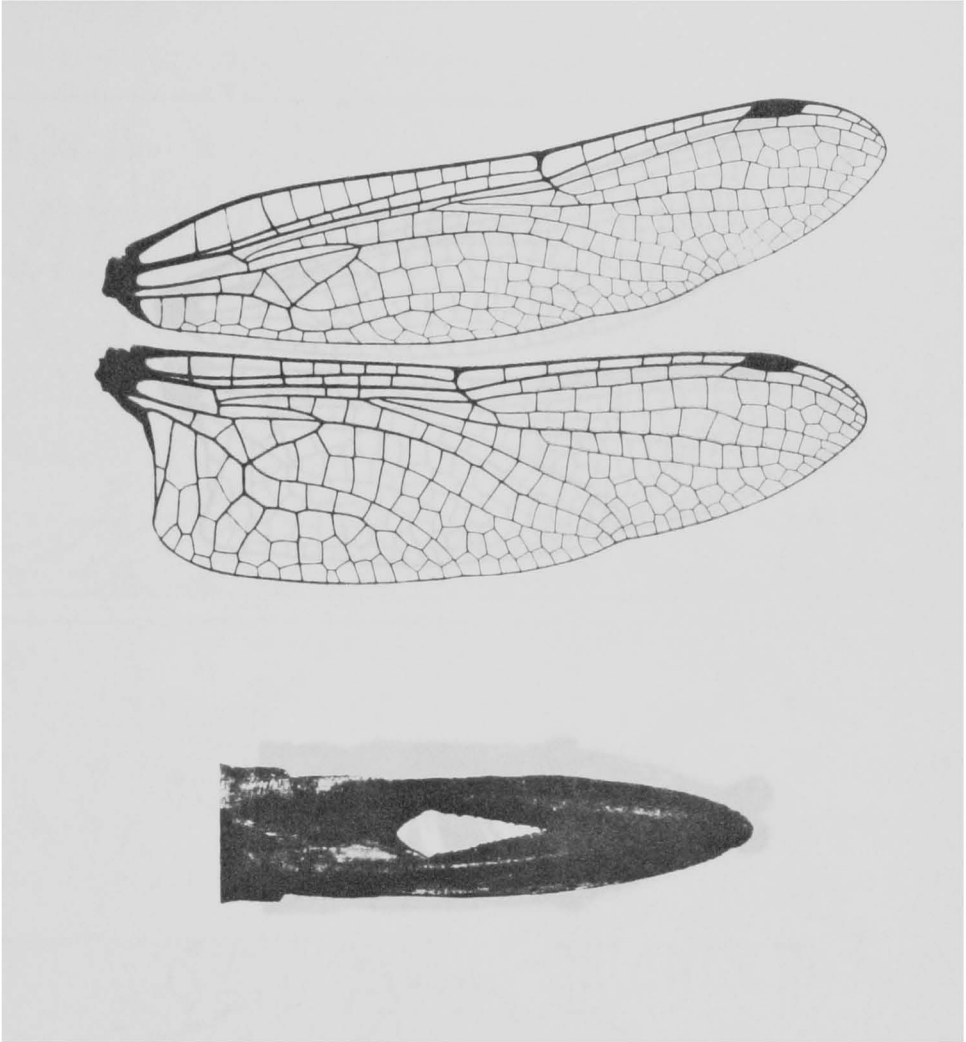


Figure 91. Wings x3 and male terminalia in dorsal view x15 of *Comptosia antilope*.

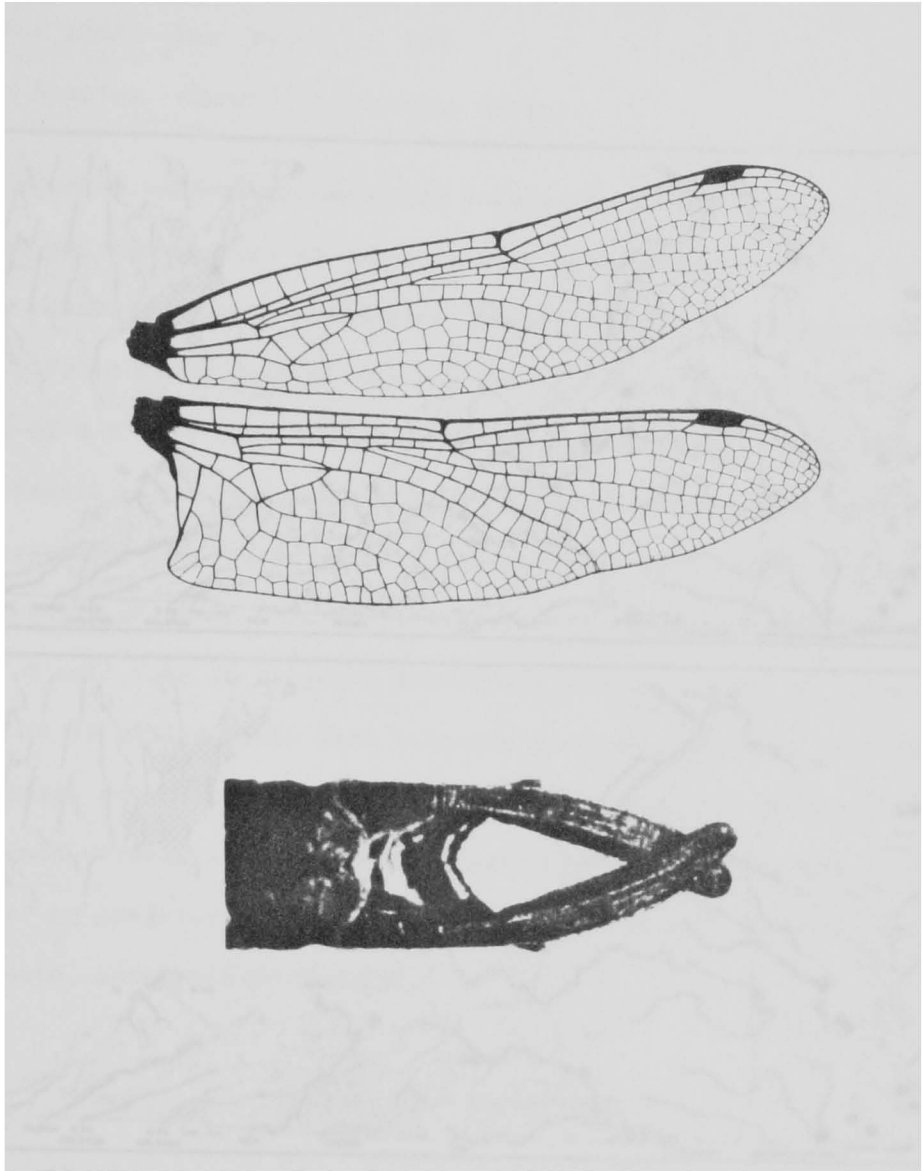


Figure 92. Wings x3 and male terminalia in dorsal view x15 of *Iomphactina furcillata*.

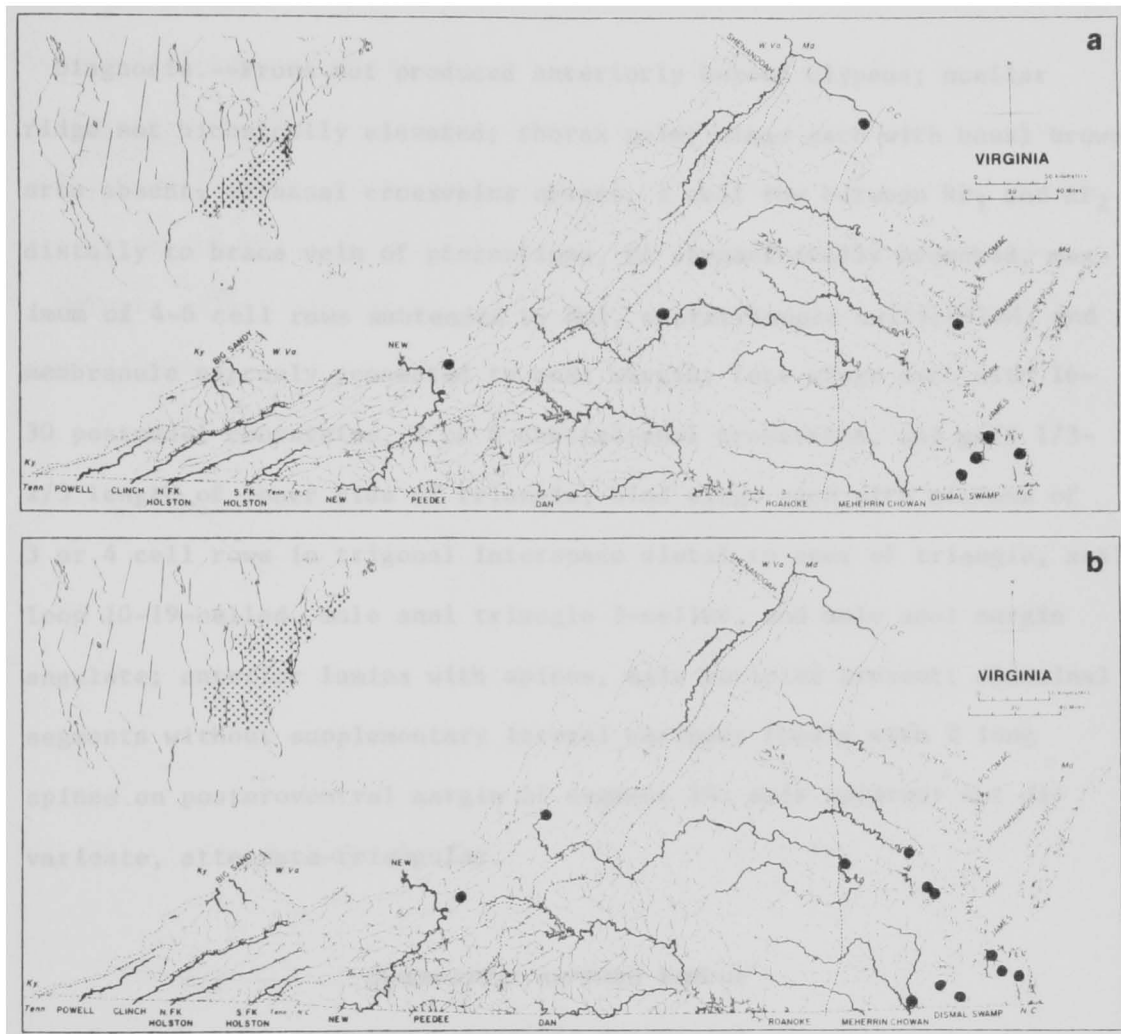


Figure 93. Geographic distribution of *Gomphaeschnia*: (a) *G. antilope*; (b) *G. furcillata*.

Genus *Gynacantha* Rambur 1842Syn.: *Acanthopyga* Kirby

Rambur 1842. Ins. Neur., p. 213.

Type Species.--*Gynacantha nervosa* Rambur.

Diagnosis.--Frons not produced anteriorly beyond clypeus; ocellar ridge not biconically elevated; thorax pale; wings each with basal brown area absent, midbasal crossveins absent, 1 cell row between RP_1 and RP_2 distally to brace vein of pterostigma, MA asymmetrically branched, maximum of 4-6 cell rows subtended by Mpl , supratriangle multicelled, and membranule narrowly connected to anal margin; fore wings each with 16-30 postnodal crossveins, 7 or 8 cubital-anal crossveins, and gaff $1/3-2/5$ length of inner side of triangle; hind wings each with minimum of 3 or 4 cell rows in trigonal interspace distal to apex of triangle, anal loop 10-19-celled, male anal triangle 3-celled, and male anal margin angulate; anterior lamina with spines, male auricles present; abdominal segments without supplementary lateral carinae; female with 2 long spines on posteroventral margin of segment 10; male epiproct not divaricate, attenuate-triangular.

Gynacantha nervosa RamburSyn.: *gracilis* Burmeister

(Figures 94,95)

Rambur 1842. Ins. Neur., p. 213.

Length 68-80 mm; abdomen 50-63 mm; hind wings 47-56 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of CA, FL, GA, OK, and SC, and the Antilles- Cuba, Dom. Rep., Haiti, Jamaica, and P.R., and also south to Bolivia and Brazil.

Flight Season.--Year-round in southern Florida and southward, limited to the fall season northward.

Biology.--*Gynacantha nervosa* inhabits slow-moving streams. Adults are primarily crepuscular although they may be observed hanging pendulously in the shade during daylight. Oviposition occurs in wet mud.

Remarks.--This species may occur in swampy streams of the Virginia coastal plain.

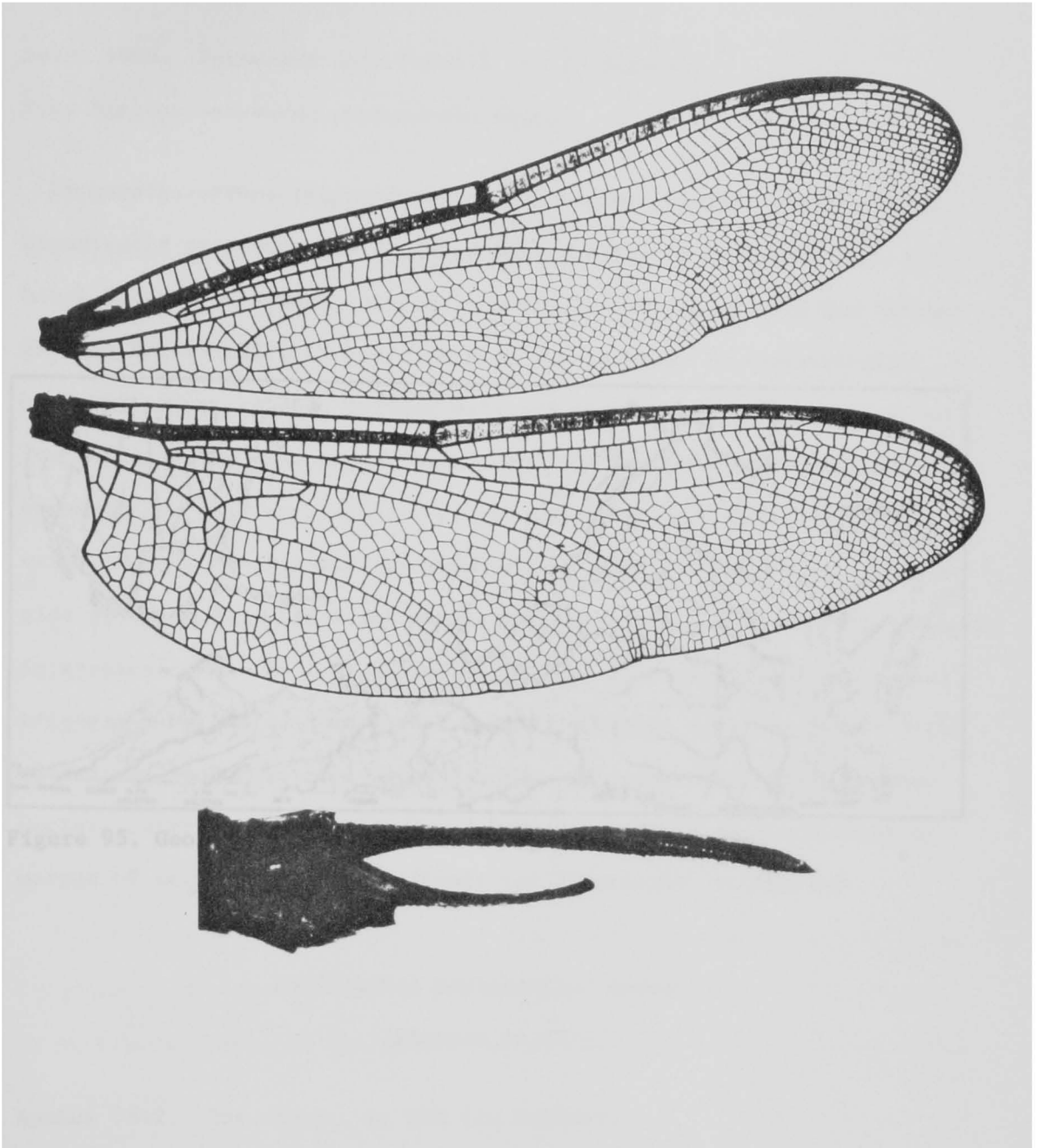


Figure 94. Wings x3 and male terminalia in lateral view x11 of *Gynacantha nervosa*.

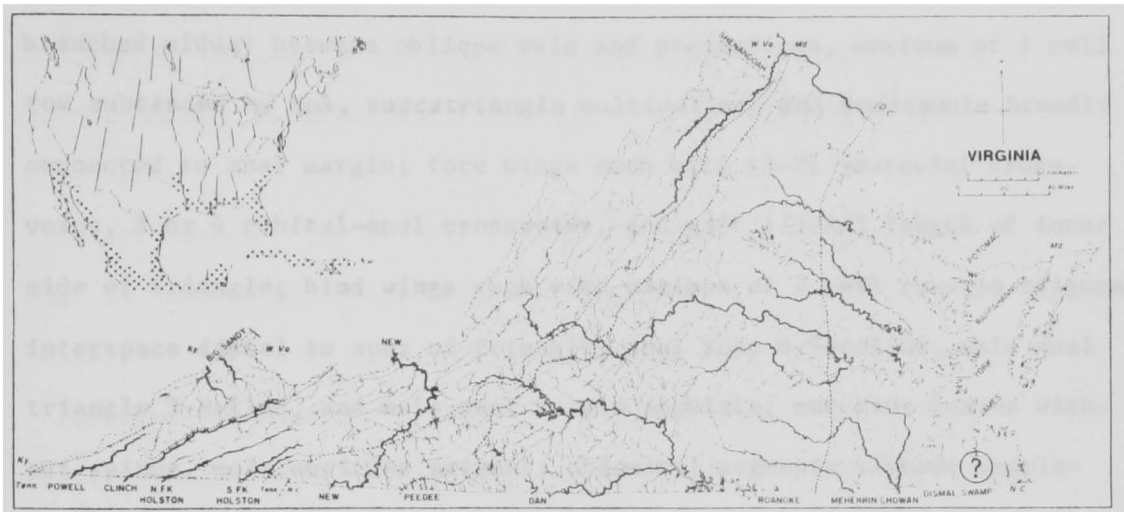


Figure 95. Geographic distribution of *Gynacantha nervosa*.

Genus *Nasiaeschna* Selys 1900

Selys 1900. Termeszetráji Füzetek V. 23 Budapest.

Type Species.--*Aeschna pentacantha* Rambur.

Diagnosis.--Frons produced anteriorly beyond clypeus; ocellar ridge biconically elevated; thorax brown with green stripes; wings each with basal brown area absent, midbasal crossveins absent, 1 cell row between RP_1 and RP_2 distally to brace vein of pterostigma, MA symmetrically branched midway between oblique vein and pterostigma, maximum of 1 cell row subtended by M_{pl} , supratriangle multicelled, and membranule broadly connected to anal margin; fore wings each with 15-21 postnodal crossveins, 3 or 4 cubital-anal crossveins, and gaff $1/3-2/5$ length of inner side of triangle; hind wings each with minimum of 2 cell rows in trigonal interspace distal to apex of triangle, anal loop 6-9-celled, male anal triangle 3-celled, and male anal margin angulate; anterior lamina without spines, male auricles present; abdominal segments without supplementary lateral carinae; female without long spines on posteroventral margin of segment 10; male epiproct not divaricate, triangular.

Nasiaeschna pentacantha (Rambur)

(Figures 96,97)

Rambur 1842. Ins. Neur., p, 208 (in *Aeshna*).

Length 62-73 mm; abdomen 46-55 mm; hind wings 43-50 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AL, AR, FL, GA, IL, IN, IA,

KS, LA, MD, MA, MI, MS, NH, NY, NC, OH, OK, PA, SC, TN, TX, VA, WV, and WI, and the provinces of Ont. and Que. Known from the Virginia counties of Charlotte and Isle of Wight, and the city of Virginia Beach. Known distribution among the counties of neighboring states include: North Carolina- Beaufort, Columbus, Martin, and Wake; Pennsylvania- Mercer; Tennessee- Grundy, Marion, and Obion; West Virginia- Mason.

Virginia Records.--Charlotte Co.; Twittys Cr. at Saxe, 8 June 1974, 1 male, FLC. Isle of Wight Co.; locality unknown, 1 June 1975, 1 female, JFM and J. Hancock, ODU. City of Virginia Beach; North Landing on County Cr. nr. Princess Anne, 14 Aug. 1948, 1 male, R. L. Hoffman, (Det. LKG).

Flight Season.--Mar. 2 (FL) to Oct. 15 (IN); in Virginia June 1 to Aug. 14. Known season in neighboring states are: North Carolina- July; Tennessee- June 2 to Aug. 2; West Virginia- July 7.

Biology.--*Nasiaeschna pentacantha* inhabits slow-moving forest streams. Adult males are most often observed patrolling 30-60 cm above shaded forest pools. Oviposition occurs in decayed wet wood above the water surface.

Remarks.--The prominent frons and evenly tapered abdomen easily distinguishes this species from other Aeshnine dragonflies. This species is much more common on the coastal plain and piedmont than in mountainous regions.

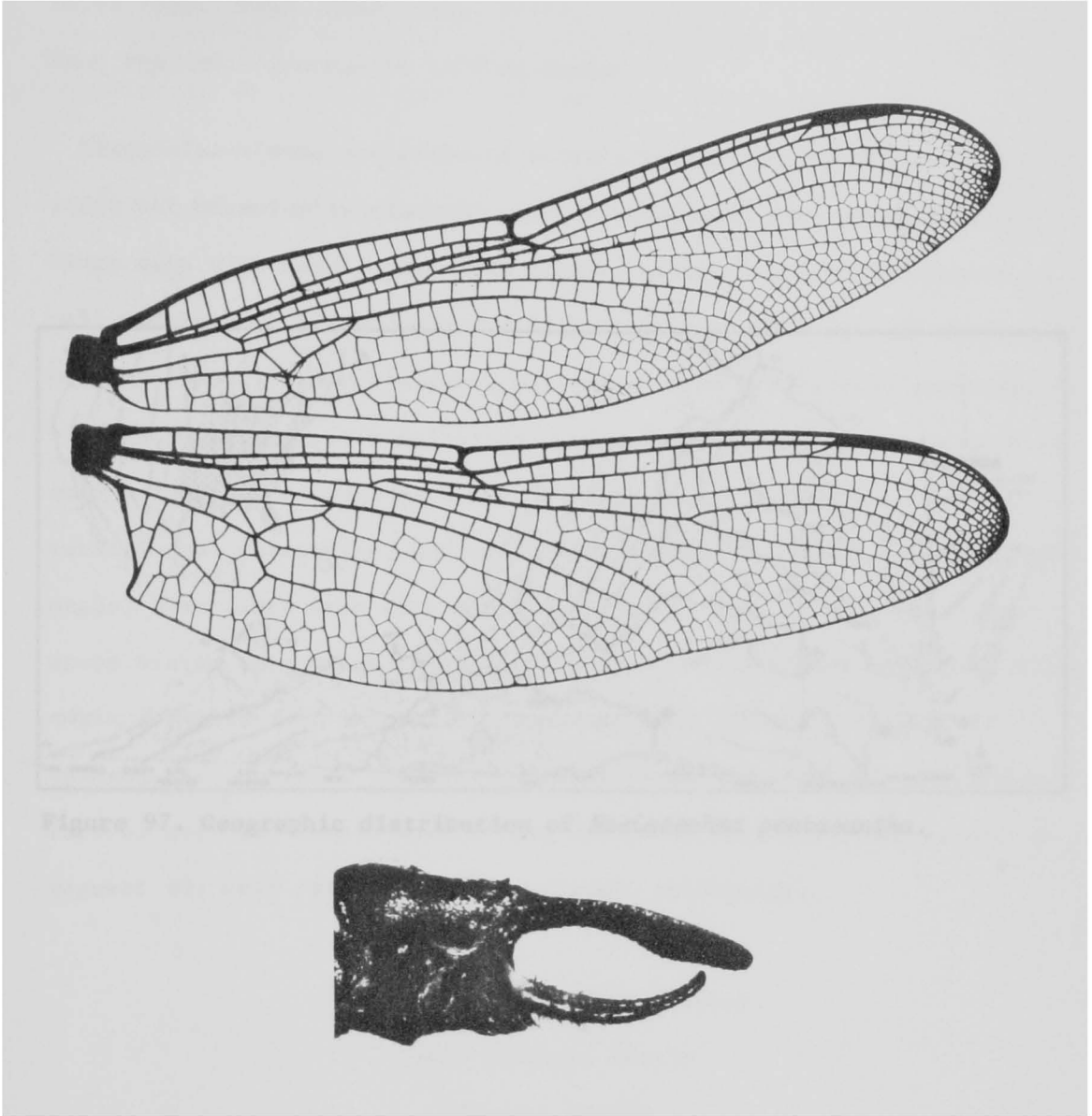


Figure 96. Wings x3 and male terminalia in lateral view x10 of *Nasiaeschna pentacantha*.

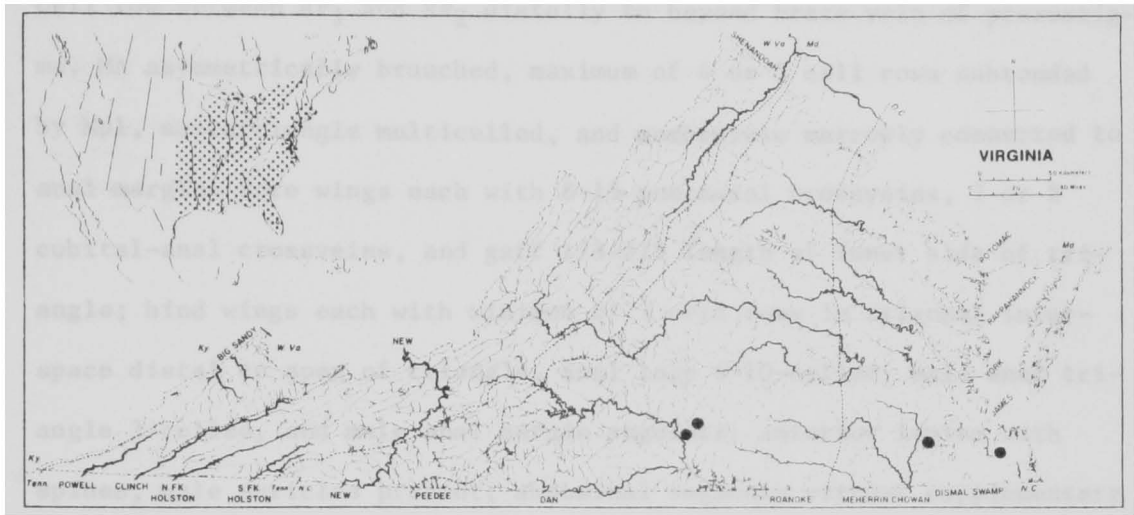


Figure 97. Geographic distribution of *Nasiaeschna pentacantha*.

Genus *Triacanthagyna* Selys 1883

Selys 1883. Bull. Acad. Belg. 5:745.

Type Species.--*Gynacantha trifida* Rambur.

Diagnosis.--Frons not produced anteriorly beyond clypeus; ocellar ridge not biconically elevated; thorax brown with wide green stripes; wings each with basal brown area absent, midbasal crossveins absent, 1 cell row between RP_1 and RP_2 distally to beyond brace vein of pterostigma, MA asymmetrically branched, maximum of 4 or 5 cell rows subtended by Mpl , supratriangle multicelled, and membranule narrowly connected to anal margin; fore wings each with 8-15 postnodal crossveins, 7 or 8 cubital-anal crossveins, and gaff $1/3-2/5$ length of inner side of triangle; hind wings each with minimum of 3 cell rows in trigonal interspace distal to apex of triangle, anal loop 6-10-celled, male anal triangle 3-celled, and male anal margin angulate; anterior lamina with spines, male auricles present; abdominal segments without supplementary lateral carinae; female with 3 long spines on posteroventral margin of segment 10; male epiproct not divaricate, triangular.

Triacanthagyna trifida (Rambur)

Syn.: *needhami* Martin

(Figures 98,99)

Rambur 1842. Ins. Neur., p. 210 (in *Gynacantha*).

Length 59-71 mm; abdomen 40-56 mm; hind wings 34-47 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of CA, FL, GA, and NC, and the Antilles- Cuba, Dom. Rep., Haiti, Jamaica, and P.R., and also from the Bahamas and south to Bolivia. Known distribution among the counties of neighboring states include: North Carolina- Craven.

Flight Season.--May 27 (Cuba) to Jan. 8 (FL). Known season in neighboring states are: North Carolina- June 23.

Biology.--*Triacanthagyna trifida* inhabits slow-moving streams. Adults are primarily crepuscular although they may be observed hanging pendulously in the shade during daylight. Oviposition occurs in wet mud.

Remarks.--This species may occur in swampy streams of the Virginia coastal plain.

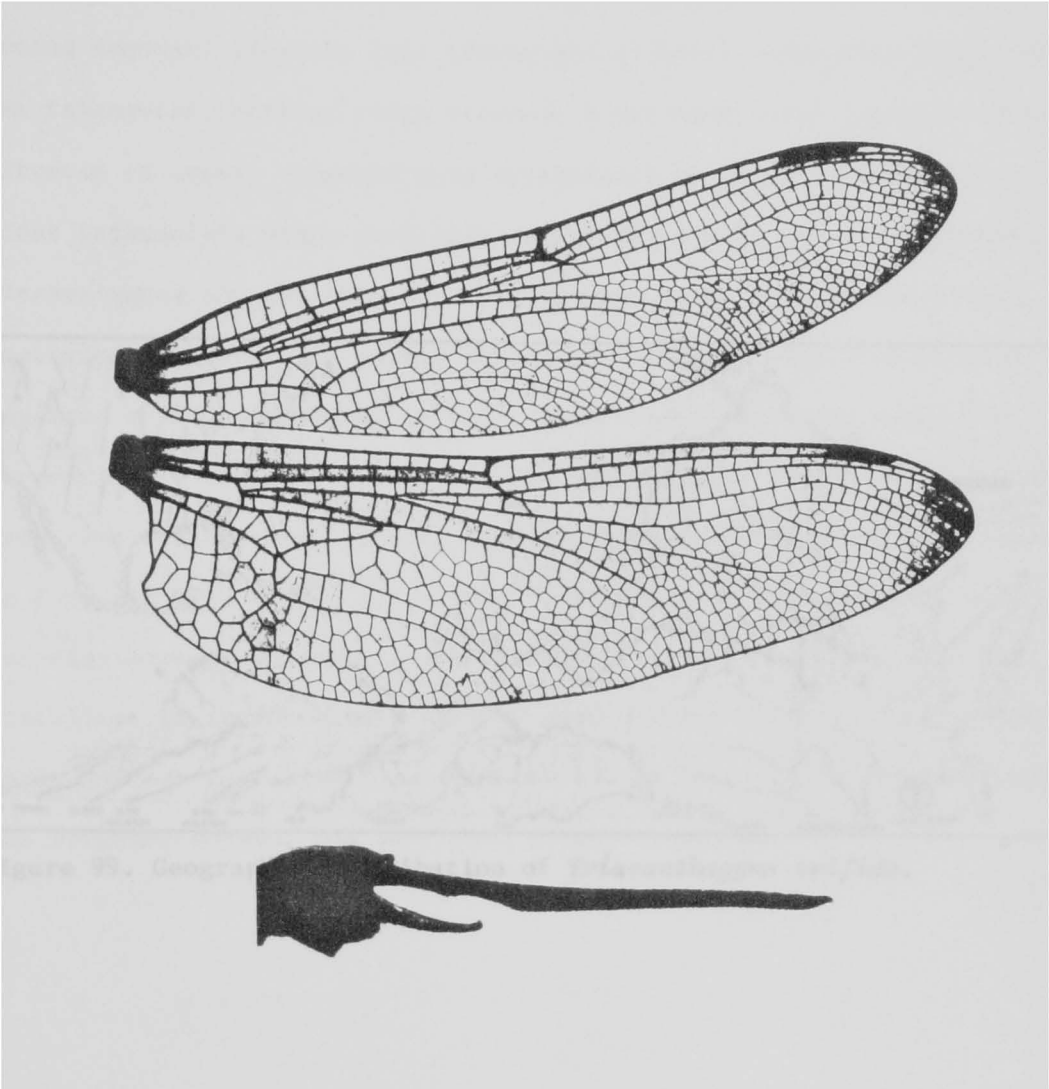


Figure 98. Wings x3 and male terminalia in lateral view x10 of *Triacanthagyna trifida*.

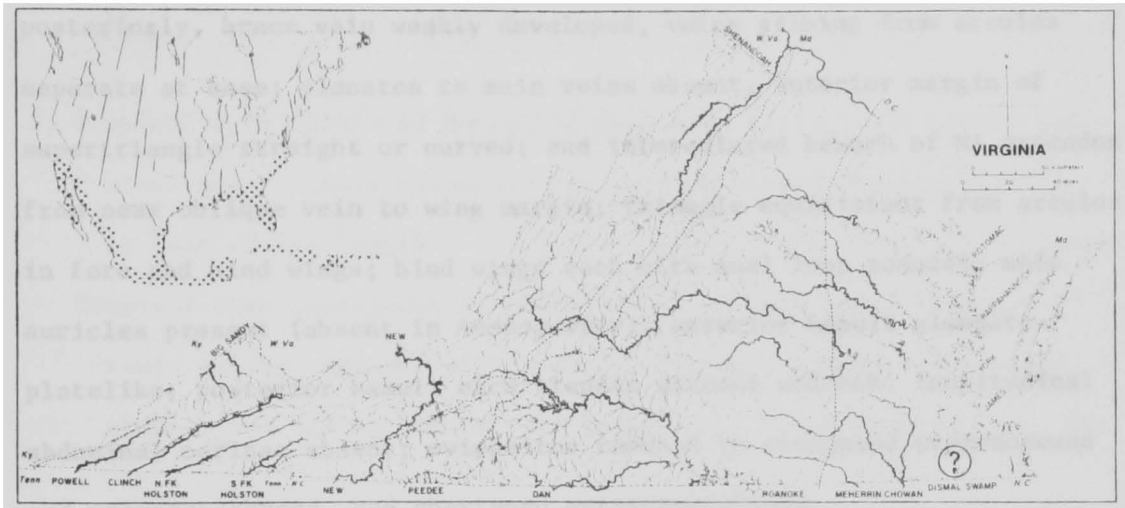


Figure 99. Geographic distribution of *Triacanthagyna trijida*.

Family CORDULEGASTRIDAE Calvert

Diagnosis.--Distal margin of labium cleft; first segments of labial palpi not approximate distally and each with incurved apical spine, second segments present; face (frons and clypeus) wider than high; vertex triangular, ocellar ridge present, transverse, with lateral ocelli situated on crest; compound eyes approximate at point middorsally; occiput triangular; wings each with antenodals mostly not in alignment, pterostigmata shorter than distance between costal braces and level posteriorly, brace vein weakly developed, veins arising from arculus separate at base; planates to main veins absent, anterior margin of supertriangle straight or curved; and intercalated branch of MA extended from near oblique vein to wing margin; triangle equidistant from arculus in fore and hind wings; hind wings each with anal loop rounded; male auricles present (absent in *Anotogaster*); anterior hamuli elongate-platelike; posterior hamuli each slender without endhook; longitudinal abdominal carinae absent; ovipositor reduced to elongated progonocoxae and progonapophyses, and shortened metagonapophyses.

Generic Key to Adult Cordulegastridae of North America

1. Occiput conically elevated; abdominal segments 3-7 with middorsal spear-shaped yellow spots; male cerci separated at base by less than basal width of cercus, each with ventral spines located near base *Taeniogaster* p. 522
- Occiput evenly convex; abdominal segments 3-7 with paired dorso-lateral yellow spots; male cerci separated at base by more than basal width of cercus, each with ventral spines not located near base 2
2. Compound eyes separated dorsally; head distinctly tumid behind compound eyes; female ovipositor projecting beyond abdomen for 1/3 or less of its length *Zoraena* p. 528
- Compound eyes contiguous at point dorsally; head not distinctly tumid behind compound eyes; female ovipositor projecting beyond abdomen for 1/2 or more of its length . . . *Cordulegaster* p. 513

Genus *Cordulegaster* Leach 1815Syn: *Theaiphora* Burmeister

Leach 1815. Edin. Encycl. 9:136.

Type Species.--*Aeshna annulata* Latreille.

Diagnosis.--Compound eyes contiguous dorsally; occiput not conically elevated; posterior surface of head not distinctly tumid, in dorsal view portion behind postocular carina 1-2 times distance from ocular margin to carina; wings each with 2 cell rows between RP_1 and RP_2 for ca. $1/4$ distance between nodus and pterostigma; abdominal terga 3-7 with paired submedian yellow spots or with yellow annulations; ovipositor extended beyond apex of abdomen for $1/2$ or more its length; male cerci separated at base by 1-2 times basal width of cercus, each with ventrolateral spine located near base, and ventromedian spine located at $1/3-1/2$ distance between laterobasal spine and apex; portion of epiproct beyond segment 10 longer than wide.

Species Key to Adult *Cordulegaster* of Eastern North America

1. Abdominal segments 3-7 with yellow annulations; anterior surface of frons and posterior surface of head predominantly black; male cerci each with laterobasal spine ca. as long as inner spine *C. erronea* p. 514
- Abdominal segments 3-7 with submedian yellow spots; anterior surface of frons and posterior surface of head not predominantly black; male cerci each with laterobasal spine ca. 5 times as long as inner spine *C. maculata* p. 515

Cordulegaster erronea Hagen

(Figures 100a, 101a, 102a)

Hagen 1878. In Selys, Bull. Acad. Belg. 46:688.

Length 65-77 mm; abdomen 50-65 mm; hind wings 42-52 mm.

Diagnosis.--Labrum yellow with black margin and median band; anteclypeus black, clypeus yellow; anterior surface of frons black, dorsal surface black with apical shelf yellow; width of frons ca. 1/2 width of head; posterior surface of head predominantly black; hind wings each generally with 3 cubital anal crossveins; abdominal segments 3-7 black with yellow annulations, male cerci with inner spine ca. as long as laterobasal spine.

Distribution.--Known from the states of CT, DC, DE, GA, KY, MD, MA, MI, MS(?), NY, NC, OH, PA, SC, TN, VA, and WV. Known from the Virginia counties of Fairfax, Fauquier, Giles, Madison, Nelson, Pulaski, Rockbridge, and Warren. Known distribution among the counties of neighboring states include: Kentucky- Green; Maryland- Frederick; North Carolina- Burke, Macon, and Transylvania; Pennsylvania- Bucks, Cameron, Centre, Dauphin, Delaware, Huntingdon, Perry, Pike, and Westmoreland; Tennessee- Fentress and Sevier; West Virginia- Raleigh.

Virginia Records.--Fairfax Co.; Difficult Run, 22 Aug. 1901, 1 male, J. E. Benedict, (Det. MDR, MDR notes), USNM. Fauquier Co.; Spring Run at Jackson Hollow, 15 July 1974, 1 male, OSF, USNM. Giles Co.; Newport, 17 July 1959, 1 male, D. Messersmith, VPI&SU. Madison Co.; Small run flowing into Robinson R., 5 July 1980, 1 male, 2 females, Col. E. Smith, (Det. BCK), BCK Collection. Nelson Co.; locality unknown, 7 July 1919, 1 male, WR, (Det. MDR, MDR notes), USNM; locality unknown, 10 July 1925,

1 female, WR, (Det. MDR, MDR notes), USNM; locality unknown, 31 July 1917, 1 male, WR, (Det. MDR, MDR notes), USNM. Pulaski Co.; Kegley Farm, 21 June 1978, 1 male, P. J. Sieburth, VPI&SU. Rockbridge Co.; Vesuvius, 3 July 1958, 1 male, E. M. Raffensperger, VPI&SU. Warren Co.; Smith Cr. at Rt. 634, 5 July 1975, 8 males, 1 female (teneral), FLC; Tributary of Lands Run at Rt. 622, 23 July 1978, 16 males, FLC; Tributary of Lands Run at Rt. 622, 23 July 1978, 1 male, FLC; Tributary of Lands Run at Rt. 622, 20 Aug. 1978, 1 female, FLC.

Flight Season.--June 8 (CT) to Sept. 3 (NC); in Virginia June 21 to Aug. 22. Known season in neighboring states are: Kentucky- Aug.; Maryland- July 18; North Carolina- June to Sept. 3; Pennsylvania- June 8 to Aug. 23; Tennessee- June 28 to Aug. 13; West Virginia- June 28.

Biology.--Inhabits small spring-fed forest streams. Males patrol the upper reaches of streams at from 10-20 cm generally in an upstream direction. Oviposition (observed only once) occurs in the vertical position. The sole female observed ovipositing flew 40-50 cm above the stream in an upstream direction; after a short hesitation she would drop in the vertical position and make 3-6 stabs in the accumulation of soft mud and sand behind a rock. The adults hang vertically while at rest.

Remarks.--Although locally abundant, this species is one of the rarer species of Cordulegasteridae.

Cordulegaster maculata Selys

(Figures 100b, 101b, 102b)

Selys 1854. Bull. Acad. Belg. 21:105.

8 Mar. 1977), 1 female, FLC; Spring Cr. at Rt. 654, 18 May 1978, 1 male, FLC; Spring Cr. at Rt. 654, 18 May 1978, 1 male, BCK. Chesterfield Co.; locality unknown, 7 Apr. 1974, 1 male, J. L. Kopsch, VCU. Craig Co.; Cold Spring Br. at Rt. 611, 28 May 1977, 1 male, FLC. Cumberland Co.; Little Bear Cr. in Cumberland State Park, 23 May 1977, 3 males, FLC. Fairfax Co.; Great Falls, "April 12 to May 5", (Donnelly 1961); Great Falls, 29 Apr. 1906, 1 female, D. H. Clemons, (Det. RPC), USNM; Great Falls, 29 Apr. 1906, 2 males, F. Knat, (Det. RPC), USNM; Great Falls, 15 May 1915, 1 female, E. W. Reynolds, USNM. Hanover Co.; Lukart's Farm, 12 May 1974, 1 male, T. Kline, VCU. Highland Co.; Shaws Fork at Rt. 250 nr. Headwaters, 30 May 1977, 1 male (observed), FLC. James City Co.; Williamsburg, 17 Apr. 1938, 1 female, collector unknown, (Det. MED), W&M; Williamsburg, 3 May 1937, 1 male, collector unknown, (Det. MED), W&M; Jamestown Road, 17 May 1938, 1 male, MED, (Det. MED, MDR notes). Louisa Co.; Reeds Cr. at bridge at Rts. 650, 652, and 701, 16 Mar. 1969, 1 male, G. M. Simmons, VPI&SU. Lunenburg Co.; Big Hounds Cr. at Rt. 652, 15 Apr. 1978 (emerged 15 May 1978), 1 male, FLC. Montgomery Co.; Smith Cr. at Rts. 674 and 675, 17 Mar. 1977 (emerged 1 Apr. 1977), 1 female, P. K. Powell, VPI&SU; Smith Cr. at Rts. 674 and 675, 17 Mar. 1977 (emerged 5 Apr. 1977), 1 female nymph, S. M. Johnson, VPI&SU; Blacksburg, 15 Apr. 1958, 1 male, G. Rock, VPI&SU; small stream nr. Toms Cr. at Rt. 655, 19 Apr. 1977 (emerged 22 Apr. 1977), 1 female nymph, M. Hudy, VPI&SU; Craig Cr., 12 May 1976, 1 male, L. Hornick, VPI&SU; Craig Cr. beaver pd. at Rt. 621, 15 May 1977, 1 male, C. Sheppard, VPI&SU; Craig Cr. at Rt. 621, 16 May 1977, 1 male, C. Sheppard, VPI&SU; small tributary of Toms Cr. 0.5 miles downstream from Rt. 655, 24 May 1973, 1

Length 63-76 mm; abdomen 47-58 mm; hind wings 35-49 mm.

Diagnosis.--Labrum yellow with brown margin and median band; anteclypeus brown, clypeus yellow; anterior surface of frons yellow, dorsal surface brown and yellow; width of frons ca. $\frac{3}{5}$ width of head; posterior surface of head predominantly brown and yellow; hind wings each generally with 2 cubital anal crossveins; abdominal segments 3-7 dark with yellow lateral spots; male cerci each with inner spine 5 times as long as laterobasal spine.

Distribution.--Known from the states of AL, CT, DC, FL, GA, IN, KY, LA, ME, MD, MA, MI, MN, MS, NH, NJ, NY, NC, OH, PA, SC, TN, TX, VT, VA, WV, and WI, and the provinces of N.B., N.S., Ont., and Que. Known from the Virginia counties of Arlington, Bedford, Charlotte, Chesterfield, Craig, Cumberland, Fairfax, Hanover, Highland, James City, Louisa, Lunenburg, Montgomery, Pittsylvania, Roanoke, Rockbridge, Tazewell, and Washington. Known distribution among the counties of neighboring states include: Kentucky- Adair, Bell, Floyd, Letcher, McCreary, and Whitley; Maryland- Montgomery and Prince Georges; North Carolina- Durham, Moore, Orange, Randolph, and Wake; Pennsylvania- Beaver, Bucks, Centre, Clarion, Clearfield, Clinton, Delaware, Forest, Huntingdon, Jefferson, Mifflin, Perry, Pike, Somerset, Sullivan, Union, Wayne, and Westmoreland; Tennessee- Cumberland, Greene, Hardin, Putnam, and Unicoi; West Virginia- Hampshire, Pendleton, Pocahontas, Raleigh, Ritchie, and Tucker.

Virginia Records.--Arlington Co.; Arlington, "Apr. 12 to May 5", (Donnelly 1961); locality unknown, 29 Apr. 1906, 1 male, H. S. Barber, (Det. RPC), USNM. Bedford Co.; Five Forks Cr. at Rt. 619, 16 May 1979, 1 male, BCK. Charlotte Co.; Spring Cr. at Rt. 654, 10 Feb. 1977, (emerged

male, FLC; Poverty Cr. at Pandapas Pd., 25 May 1978, 3 males, FLC; tributary of Toms Cr. 0.5 miles downstream from Rt. 655, 14 June 1974, 1 male, FLC; Poverty Cr. below Pandapas Pd. dam, 14 June 1974, 8 males, 1 female, FLC; Poverty Cr. 0.1 mile downstream from Pandapas Pd., 10 July 1973, 1 male, VPI&SU. Pittsylvania Co.; Rt. 863 0.1 mile E. of Norfolk and Southern railroad crossing, 21 May 1978, 1 female, C. Shiffer. Roanoke Co.; N. Fork Roanoke R. at oxbow, 8 May 1977, 3 males, Hammond. Rockbridge Co.; Brattons Run at Rt. 618, 16 June 1979, 1 male, BCK. Tazewell Co.; E. Fork of Cove Cr. at Rt. 662, 10 June 1978, 1 male, BCK; Cove Cr. at Rt. 662, 14 June 1980, 1 male, 1 female, FLC. Washington Co.; Straight Br. at Beartree campground, 12 June 1979, 1 male, JRV and TJV, VPI&SU; Spoon Gap at Rt. 670, 15 June 1980, 1 male, FLC.

Flight Season.--Feb. 21 (FL) to Oct. 5 (CT); in Virginia Mar. 16 to July 10. Known season in neighboring states are: Kentucky- May 28 to June 19; Maryland- Apr. 12 to May 5; North Carolina- Apr. 2 to May 20; Pennsylvania- May 16 to July 15; Tennessee- May; West Virginia- May 31 to July 11; District of Columbia- Apr. 12 to May 5.

Biology.--Nymphs inhabit forest streams. Males patrol the entire length of small streams at 10-15 cm. Oviposition occurs in the vertical position, generally in sandy substrates where the water depth is less than 4 cm. The adults hang vertically at rest.

Remarks.--This species is the most common Cordulegastrine dragonfly in North America.

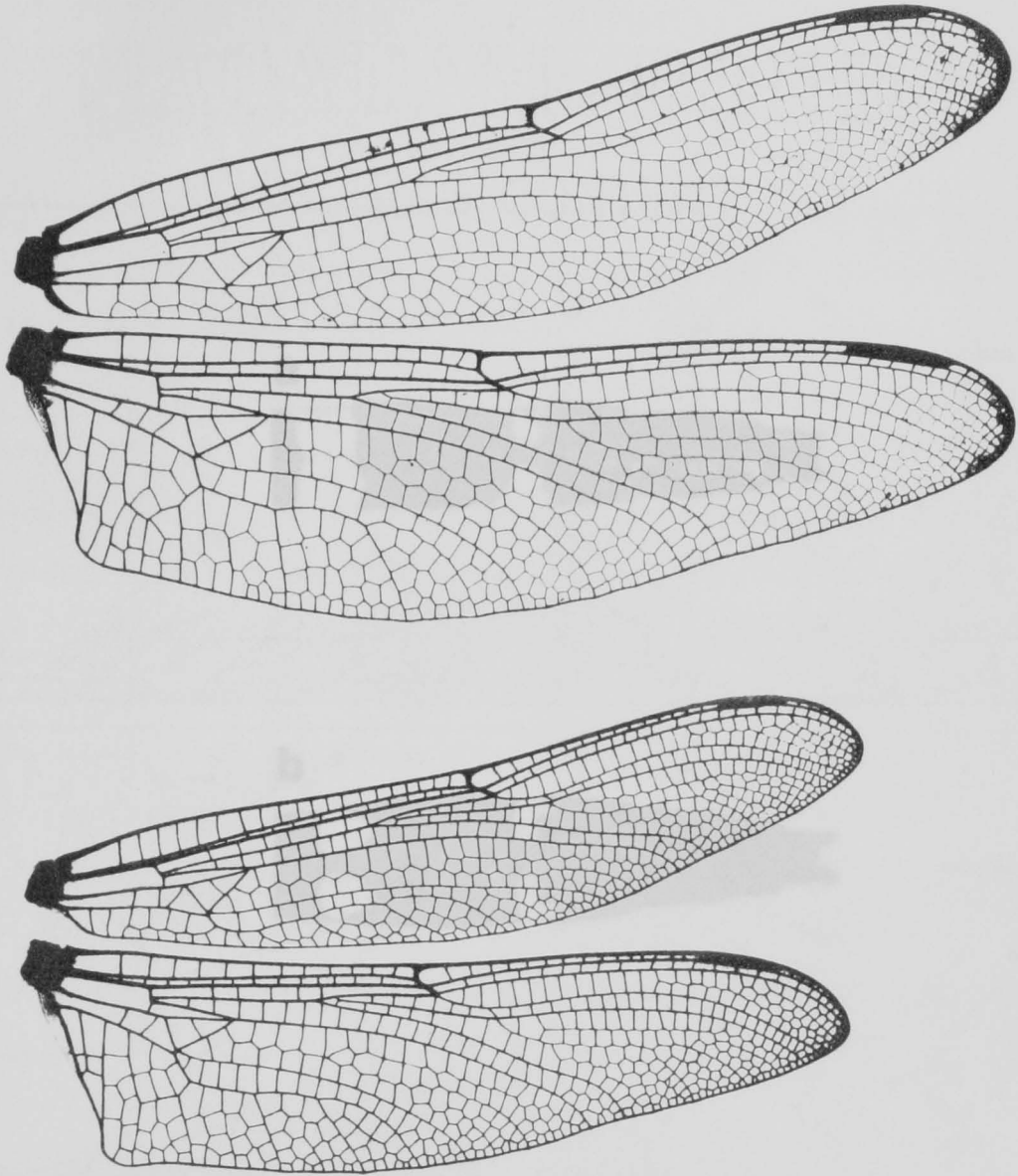


Figure 100. Wings of *Cordulegaster* x3: (a) *C. erronea*; (b) *C. maculata*.

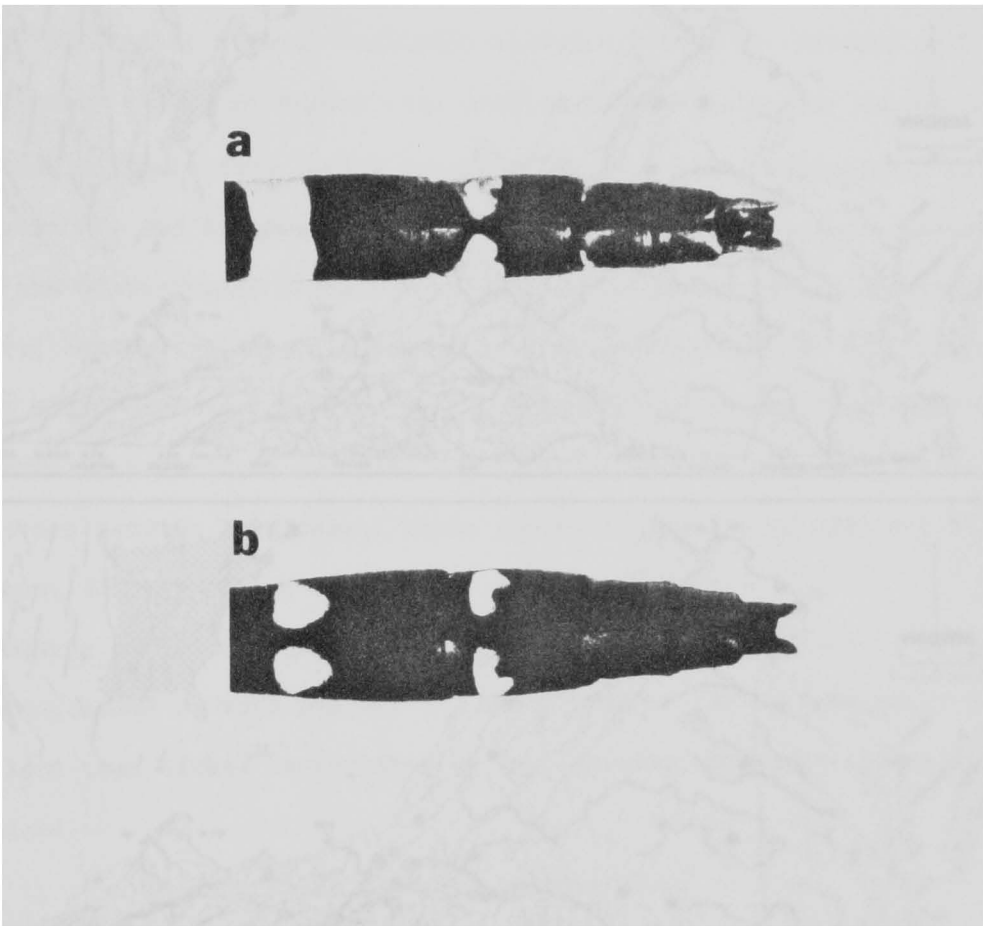


Figure 101. Abdominal apex in dorsal view of *Cordulegaster* x5:
(a) *C. erronea*; (b) *C. maculata*.

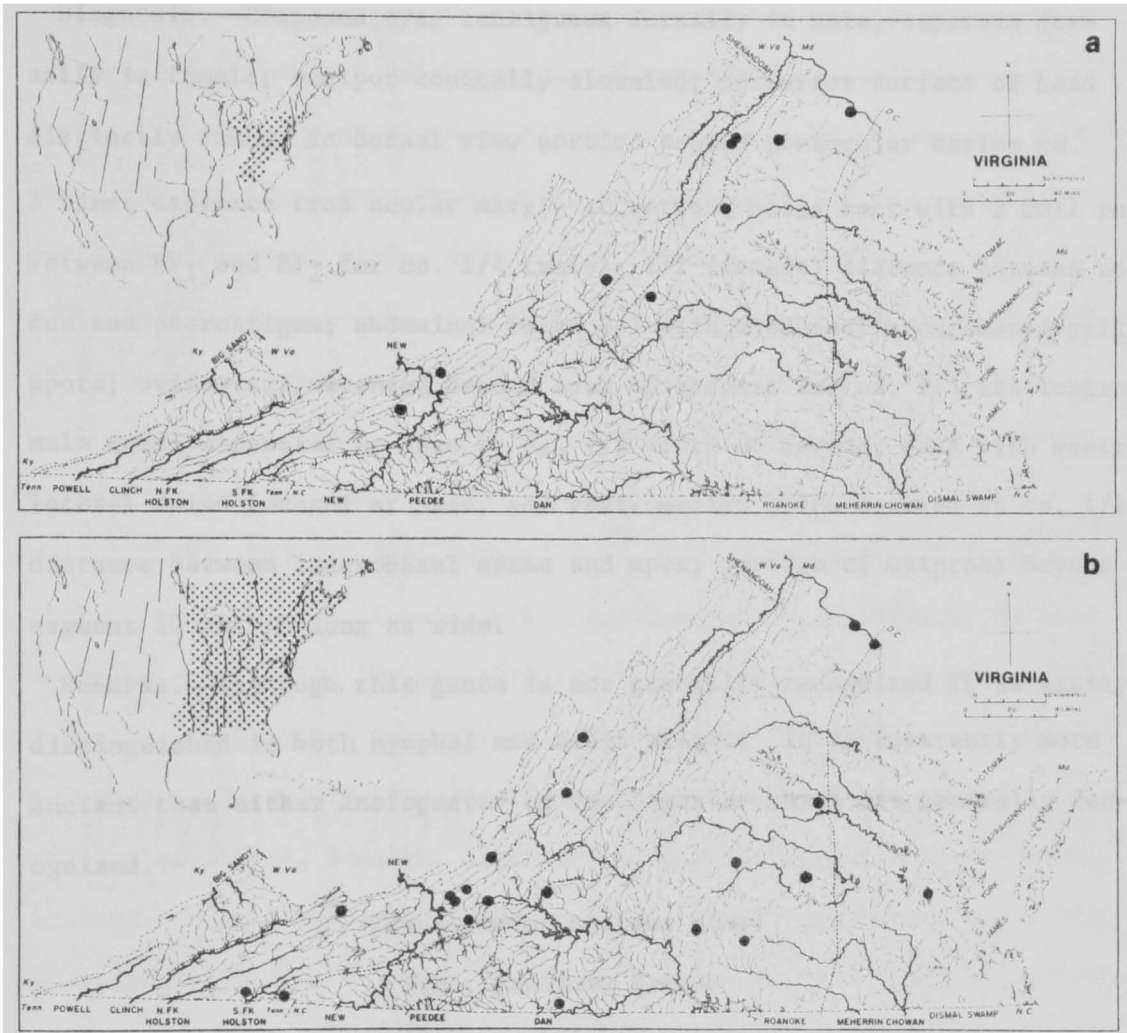


Figure 102. Geographic distribution of *Cordulegaster*: (a) *C. eminea*; (b) *C. maculata*.

Genus *Taeniogaster* Selys 1854

Selys 1854. Bull. Acad. Belg. 21:107.

Type Species.--*Aeshna obliqua* Say.

Diagnosis.--Compound eyes contiguous dorsally in male, separate dorsally in female; occiput conically elevated; posterior surface of head distinctly tumid, in dorsal view portion behind postocular carina ca. 3 times distance from ocular margin to carina; wings each with 2 cell rows between RP_1 and RP_2 for ca. $1/4$ (male), $1/2$ (female) distance between nodus and pterostigma; abdominal terga 3-7 with middorsal spearshaped yellow spots; ovipositor extended beyond apex of abdomen for ca. $2/5$ its length; male cerci separated at base by ca. $1/5$ width of cercus, each with ventrolateral spine located at base, and ventromedian spine located at ca. $1/10$ distance between laterobasal spine and apex; portion of epiproct beyond segment 10 ca. as long as wide.

Remarks.--Although this genus is not generally recognized it is easily distinguished in both nymphal and adult stages. It is apparently more ancient than either *Anotogaster* or *Neallogaster* which are generally recognized.

Taeniogaster obliqua (Say)

Syn.: *fasciata* Rambur

(Figures 103, 104, 105)

Say 1839. J. Acad. Phila. 8:15 (in *Aeshna*).

Length 68-88 mm; abdomen 48-72 mm; hind wings 41-60 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AL, AR, CT, DC, FL, GA, IL, IN, KS, KY, LA, ME, MD, MA, MI, MS, NJ, NY, NC, OH, OK, PA, SC, TN, TX, VA, WV, and WI, and the provinces of Ont. and Que. Known from the Virginia counties of Bath, Fairfax, Highland, Montgomery, Southampton, Tazewell, Warren, and city of Suffolk. Known distribution among the counties of neighboring states include: Kentucky- Harrison; North Carolina- Avery, Durham, McDowell; Pennsylvania- Allegheny, Beaver, Bucks, Centre, Fayette, Huntingdon, Perry, Washington, Westmoreland; Tennessee- Overton and Putnam; West Virginia- Raleigh.

Virginia Records.--Bath Co.; Small mud-bottomed stream along Rt. 600, 18 June 1978, 4 males, FLC. Fairfax Co.; Enola, 27 May 1915, 1 male, E. W. Reynolds, (Det. MDR, MDR notes), USNM. Highland Co.; Bullpasture R. at head of gorge, 30 May 1977, 1 male, FLC. Montgomery Co.; Pedlar Hollow at Rt. 603, 13 June 1978, 1 male, FLC; Poverty Cr. in Poverty Hollow, 10 July 1977, 1 male, BCK. Southampton Co.; Tributary of Nottoway R. at Rt. 653, 16 Apr. 1978 (emerged 19 June 1978), 1 male nymph, 1 female nymph, FLC. Tazewell Co.; Tributary of E. fork of Cove Cr. at Rt. 662, 10 June 1978, 2 males, BCK; Tributary of Cove Cr. along Rt. 662, 10 June 1978, 9 males, 1 female, FLC; Tributary of Cove Cr. along Rt. 662, 14 June 1980, 12 males, 1 female, FLC. Warren Co.; Small rill in spring bog along Rt. 634, 6 June 1977, 1 male, FLC. City of Suffolk; Washington Ditch in Dismal Swamp, 14 Feb. 1976, 1 nymph, J. O'Hop, ODU; Washington Ditch in Dismal Swamp, 21 May 1977, 10 males, 2 females, FLC.

Flight Season.--Apr. 18 (TX) to Aug. (NC); in Virginia May 21 to July 10. Known season in neighboring states are: Kentucky- May; North Carolina- May 6 to Aug.; Pennsylvania- May 24 to June 31; West Virginia-

June 29.

Biology.--Inhabits small mud-bottomed streams. Males patrol small rills at 10-30 cm; they will also often patrol the upper dry reaches of a stream. Oviposition occurs in the verticle or slightly inclined position, generally in muddy substrates where the water is less than 2 cm in depth. Adults rest slightly inclined to the verticle.

Remarks.--Two species have been recognized in this genus, the larger southern (FL, GA, LA, MS, NC, SC, TX, VA) form *T. fasciata* (length 83-88 mm) is here considered a synonym of *T. obliqua* because specimens from eastern Virginia are intermediate between the two; also characteristics indicating the development of isolating mechanisms have not been demonstrated. The considerable variation in size of this species is also found in other Cordulegastridae such as *C. maculata* and *Anotogaster sieboldii*.

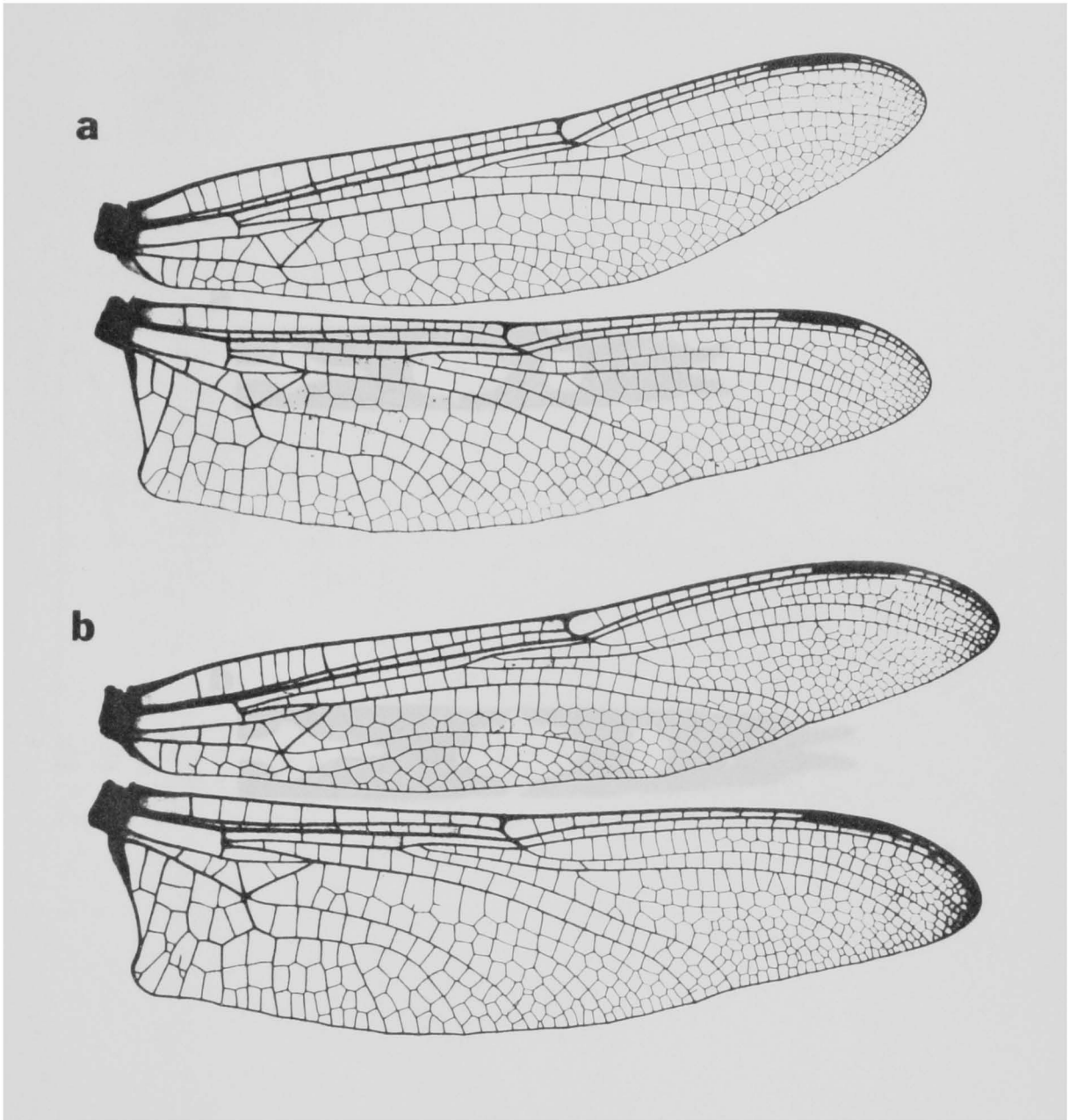


Figure 103. Wings of *Taeniogaster obliqua* x3: (a) western VA;
(b) eastern VA.

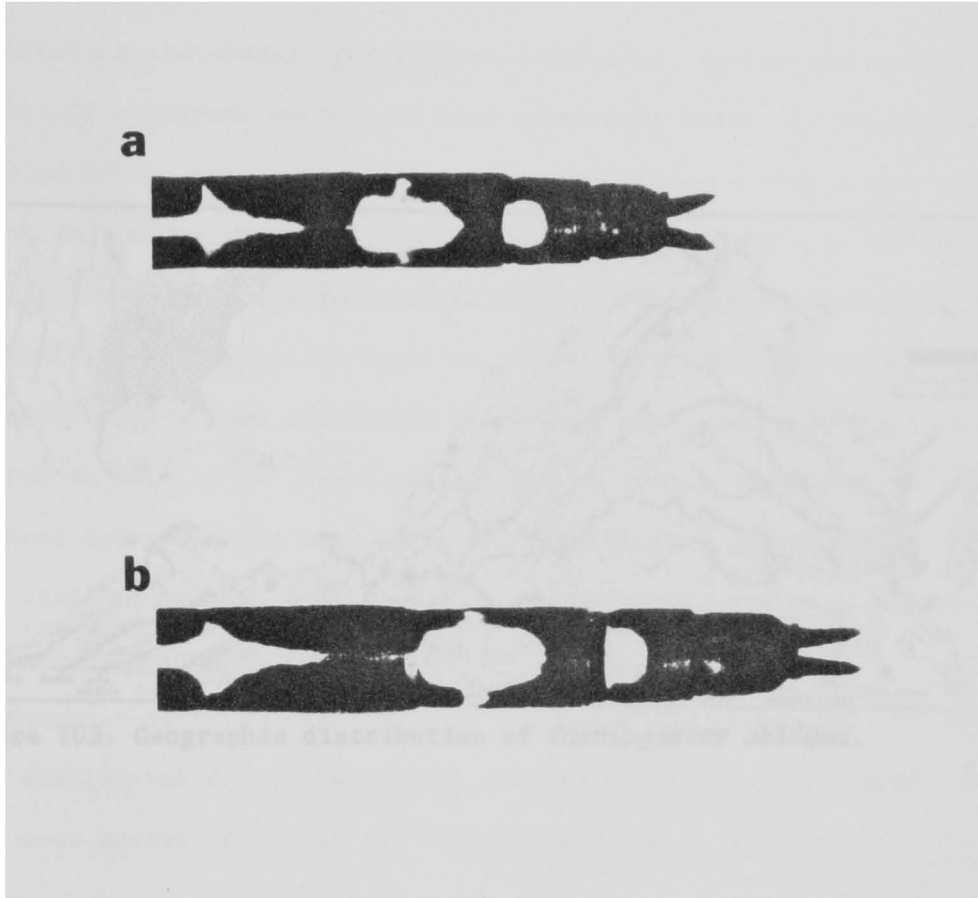


Figure 104. Abdominal apex in dorsal view of *Taenioqaster obliqua* x5:
(a) western VA; (b) eastern VA.

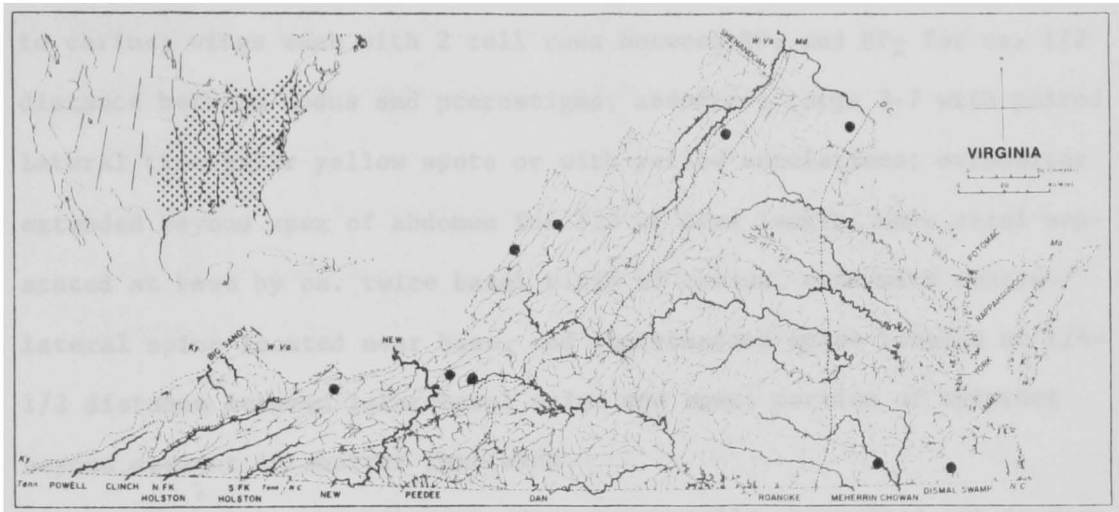


Figure 105. Geographic distribution of *Taeniogaster obliqua*.

Genus *Zoraena* Kirby 1890

Syn.: *Thecaphora* Selys

Kirby 1890. Syn. Cat. Neur., p. 79.

Type Species.—*Thecaphora diastatops* Selys.

Diagnosis.--Compound eyes separated dorsally; occiput not conically elevated; posterior surface of head distinctly tumid, in dorsal view portion behind postocular carina 4-5 times distance from ocular margin to carina; wings each with 2 cell rows between RP_1 and RP_2 for ca. $1/2$ distance between nodus and pterostigma; abdominal terga 3-7 with paired lateral triangular yellow spots or with yellow annulations; ovipositor extended beyond apex of abdomen for $1/3$ or less length; male cerci separated at base by ca. twice basal width of cercus, each with ventrolateral spine located near base, and ventromedian spine located at $1/4$ - $1/2$ distance between laterobasal spine and apex; portion of epiproct beyond segment 10 shorter than wide.

Remarks.--Although this genus is not generally recognized, it is easily distinguished in both nymphal and adult stages. It is apparently the most ancient group of the Cordulegastrinae.

Species Key to Adult *Zoraena*

1. Abdominal segments 2-8 with yellow annulations; metanepisternal stripes reddish-brown; male cerci each with inner spine at ca. $1/4$ distance between laterobasal spine and apex . . . *Z. sayi* p. 533
- Abdominal segments 2-8 without yellow annulations; metanepisternal stripes vestigial; male cerci each with inner spine at $2/5-1/2$ distance between laterobasal spine and apex 2
2. Anteclypeus light brown; metanepimeral pale stripes less than $1/2$ as wide as metanepimeran; apical width of male epiproct ca. equal to length of cerci *Z. bilineata* n. sp. p. 529
- Anteclypeus dark brown; metanepimeral pale stripes more than $1/2$ as wide as metanepimeran; apical width of male epiproct greater than length of cerci *Z. diastatops* p. 532

Zoraena bilineata n. sp.

(Figures 106a, 107a, 108a)

Length 58-69 mm; abdomen 43-50 mm; hind wings 34-43 mm.

Diagnosis.--Face pale yellow, anteclypeus light brown; compound eyes separated dorsally by 0.4-0.7 width of median ocelli; thoracic yellow stripes bordered by brown; metanepisternal pale stripes absent; metanepimeral yellow stripes less than $1/2$ width of metanepimeran; abdomen with lateral yellow triangular shaped spots, spots on segments 4-7 ca. as wide as long; male cerci each with inner spine at ca. $2/5$ distance between laterobasal spine and apex; apical width of male epiproct ca.

as long as cerci.

Distribution.--Known from the states of AL, DE, GA, IN, KY, MD, MI, MS, NC, OH, PA, SC, TN, VA, and WV. Known from the Virginia counties of Alleghany, Craig, Cumberland, Fairfax, Floyd, Giles, Highland, Madison, Montgomery, Patrick, Rockbridge, Russell, Tazewell and Warren. Known distribution among the counties of neighboring states include: Kentucky--Russell; Maryland-- Prince Georges(?); North Carolina-- Cherokee, Jackson, Macon, Mitchell, Moore, Swain, Transylvania, and Wake; Pennsylvania-- (The following records originally reported by White and Beatty (1968) for *Z. diastatops* may include records for this species) Bucks, Chester, Clarion, Clearfield, Clinton, Columbia, Delaware, Elk, Fayette, Forest, Huntingdon, Luzerne, Mercer, Monroe, Montgomery, Northampton, Perry, Somerset, Sullivan, Union, Venango, Warren, Wayne, and Westmoreland; Tennessee-- Cocke and Johnson; West Virginia-- Pocahontas and Raleigh.

Virginia Records.--Alleghany Co.; Powell Farm at Rt. 602 on Big Ridge Mtn., 10 June 1978, 1 male, P. K. Powell, FLC Collection. Botetourt Co.; spring 1 mile N. of Oriskany, 17 June 1978, 2 males, FLC. Craig Co.; Cold Spring seepage area at Rt. 611, 17 June 1978, 2 females, FLC. Fairfax Co.; Pohick Cr. at Gunston Cove, 1 May 1949, 1 female, TWD, (Det. TWD). Floyd Co.; Seep entering Camp Cr. at Rt. 615, 10 June 1978, 2 males, FLC. Giles Co.; seepage area above Riopel Pd. at Mtn. Lk. Bio. Sta., 26 June 1977, 1 male, FLC; Riopel Pd. at Mtn. Lk. Bio. Sta., 29 June 1977, 1 male, BCK; Mtn. Lk., 1 Aug. 1949, 1 female, C. F. Byers, (Byers 1951); Little Stoney Cr. at White Pine Lodge, 11 Aug. 1949, nymphs, C. F. Byers, (Byers 1951). Highland Co.; Back Cr. at Rt. 250, 4 June 1977, 3 males, FLC; Buck Run beaver pds., 10 June 1979, 1 male,

BCK; Buck Run beaver pds., 18 June 1978, 1 male, FLC; Buck Run beaver pds., 8 Aug. 1978, 1 male, FLC. Lee Co.; Pennington Gap, Aug. 1879, 1 female nymph, H. G. Hubbard, (Hagen 1885). Madison Co.; small run flowing into Robinson R., 7 July 1980, 1 female, Col. E. Smith, (Det. BCK), BCK Collection. Montgomery Co.; Blacksburg, 15 Apr. 1958, 1 male, G. Rock, VPI&SU; locality unknown, 18 May 1960, 1 male, M. G. Nichols, VPI&SU; Poverty Cr. at Rt. 708, 25 May 1978, 1 male, FLC; Pedlar Hollow at Rt. 603, 13 June 1978, 1 male, FLC. Patrick Co.; Rock Castle Cr. at Rt. 605, 21 May 1978, 1 male, 3 females (teneral), FLC; seepage area along Rock Castle Cr. at Rt. 605, 11 June 1978, 3 males, 1 female, FLC. Rockbridge Co.; Brattons Run 0.5 mile N. of California nr. Rts. 60 and 780, 4 June 1977, 2 males, FLC. Russell Co.; Laurel Bed Lk., 4 July 1977, 1 female, FLC. Tazewell Co.; small tributary of Cove Cr. at Rt. 662, 10 June 1978, 3 males, FLC; small tributary of E. fork of Cove Cr. at Rt. 662, 10 June 1978, 6 males, BCK. Warren Co.; small rill running through bog at Rt. 634, 6 June 1977, 1 male, FLC.

Flight Season.--Mar. 20 (MS) to Aug. 8 (VA). Known season in neighboring states are: Kentucky- May; North Carolina- Apr. to July 9; Pennsylvania- May 16 to July 23; Tennessee- June 1 to 30; West Virginia- June 5 to July 11.

Biology.--Inhabits spring seeps. Adult males generally found resting on upright stems at 20-40 cm above ground in open. While at rest the body is held characteristically at ca. 30° from verticle. Oviposition is accomplished by hovering at from 10-30 cm above the water while dropping obliquely to stab soft mud in about 2 cm of water.

Remarks.--Although previously confused with *Z. diastatops* it is

easily distinguished from that species by the light brown thorax with its two narrow yellow bands. Previous records of *Z. diastatops* from areas south and west of Virginia belong to this species.

Zoraena diastatops Selys

Syn.: *lateralis* Scudder

(Figures 106b, 107b, 108b)

Selys 1854. Bull. Acad. Belg. 21:101 (in *Thecaphora*).

Length 56-67 mm; abdomen 43-52 mm; hind wings 36-44 mm.

Diagnosis.—Face pale greenish-yellow, anteclypeus blackish-brown; compound eyes separated dorsally by 0.8-1.3 times width of median ocelli; thoracic yellow stripes bordered by black; metanepisternal pale stripes present, represented by narrow yellow bands; metanepimeral yellow stripes more than 1/2 width of metanepimeran; abdomen with lateral yellow spear point-shaped spots, spots on segments 4-7 longer than wide; male cerci each with inner spine at ca. 1/2 distance between latero-basal spine and apex; apical width of male epiproct 1.5 times length of cerci.

Distribution.—Known from the states of CT, ME, MI, NH, NJ, NY, PA, VT, and VA, and the provinces of N.B., N.S., Ont., and Que. Known from the Virginia county of Highland. Known distribution among the counties of neighboring states include: Pennsylvania- Centre; also reported from the following Pennsylvania counties by White and Beatty (1968): Bucks, Chester, Clarion, Clearfield, Clinton, Columbia, Delaware, Elk, Fayette, Forest, Huntingdon, Luzerne, Mercer, Monroe, Montgomery, Northampton,

Perry, Somerset, Sullivan, Union, Venango, Warren, Wayne, and Westmoreland.

Virginia Records.--Highland Co.; Buck Run Beaver Ponds, 4 June 1977, 1 male, FLC.

Flight Season.--May 28 (Ont.) to Aug. 29 (Que.); in Virginia June 4. Known season in neighboring states are: Pennsylvania- June 1 to July 23.

Biology.--Inhabits spring-fed brooks with pools. Adult males frequently observed in open areas along stream pools resting on upright stems at 20-40 cm above ground. While at rest the body is characteristically held at about 45° to the verticle. Oviposition is accomplished by hovering at from 10-30 cm above the water while dropping obliquely to stab the soft mud in less than 2 cm of water. Oviposition primarily occurs along the banks of pools.

Remarks.--This species has been previously confused with both *Z. sayi* and *Z. bilineata*. *Z. diastatops* is a northern species known as far south as the mountains of northwestern Virginia.

Zoraena sayi Selys

Syn.: *obliqua*; var. A. Say

(Figures 106c, 107c, 108c)

Selys 1854. Bull. Acad. Belg. 21:104.

Length 60-69 mm; abdomen 45-52 mm; hind wings 37-42 mm.

Diagnosis.--Face pale yellow, anteclypeus blackish brown; compound eyes separated dorsally by 0.8-1.3 times width of median ocelli; thoracic yellow stripes bordered by reddish-brown; metanepisternal pale stripes

present, reddish-brown; metanepimeral pale yellow stripes less than 1/2 width of metanepimeran; abdomen with yellow annulations; male cerci each with inner spine at ca. 1/4 distance between laterobasal spine and apex; apical width of male epiproct ca. 1.1 times length of cerci.

Distribution.--Known from the states of FL, GA, and MD(?).

Flight Season.--Feb. 27 (FL) to Apr. 14 (FL).

Biology.--Nymphs inhabit small spring-fed streams of the coastal plain. Adults frequent openings near their nymphal habitat where they are most often found resting on upright stems at from 15-30 cm above the ground. While at rest the body is characteristically held at about 45° to the vertical. Oviposition is accomplished by hovering at from 10-20 cm above the water while dropping obliquely to stab the soft mud in less than 2 cm of water.

Remarks.--Apparently a very rare species which may occur in small spring brooks of the coastal plain as far north as Virginia.

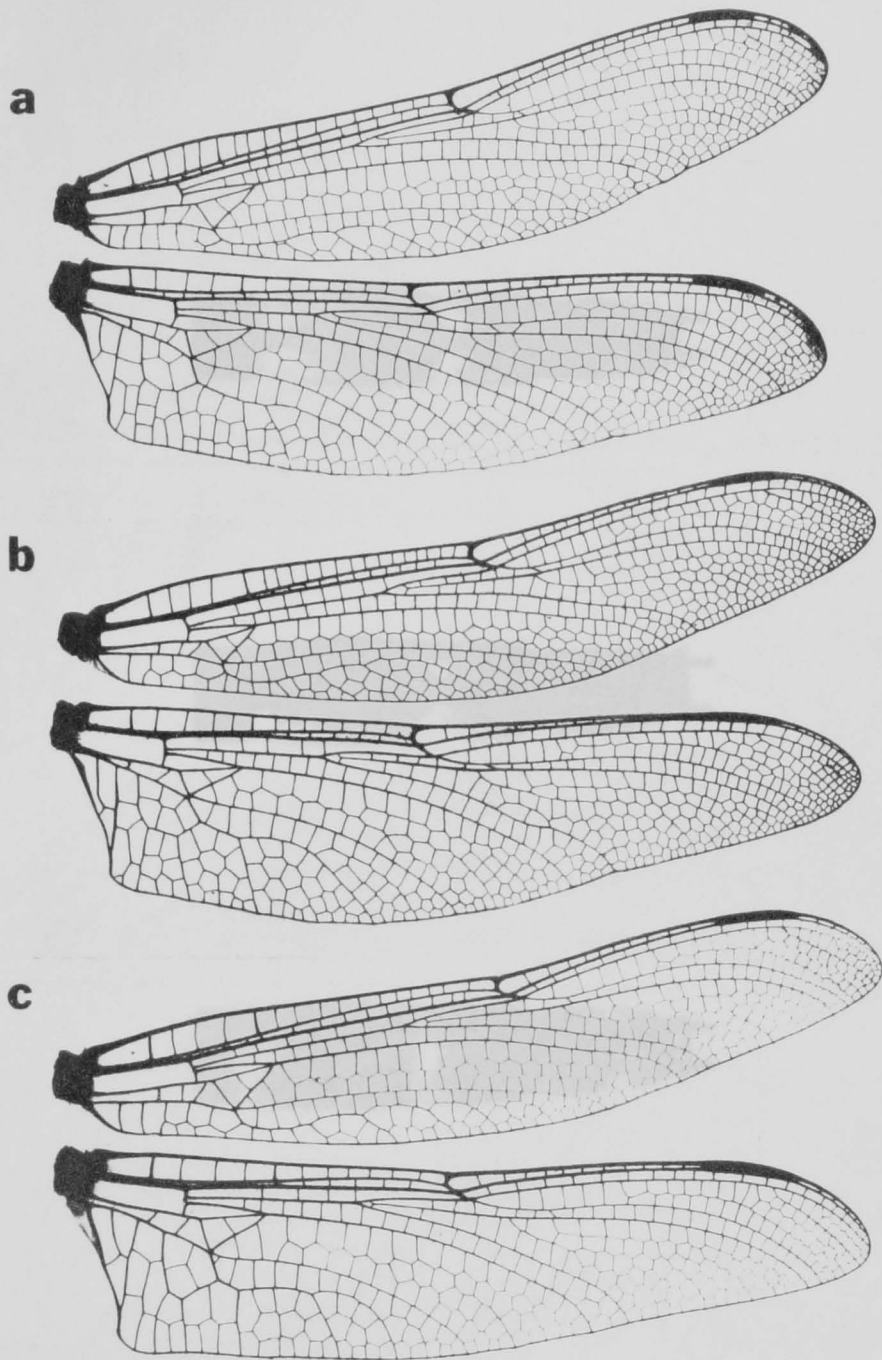


Figure 106. Wings of *Zoraena* x3: (a) *Z. bilineata*; (b) *Z. diastatops*; (c) *Z. sayi*.

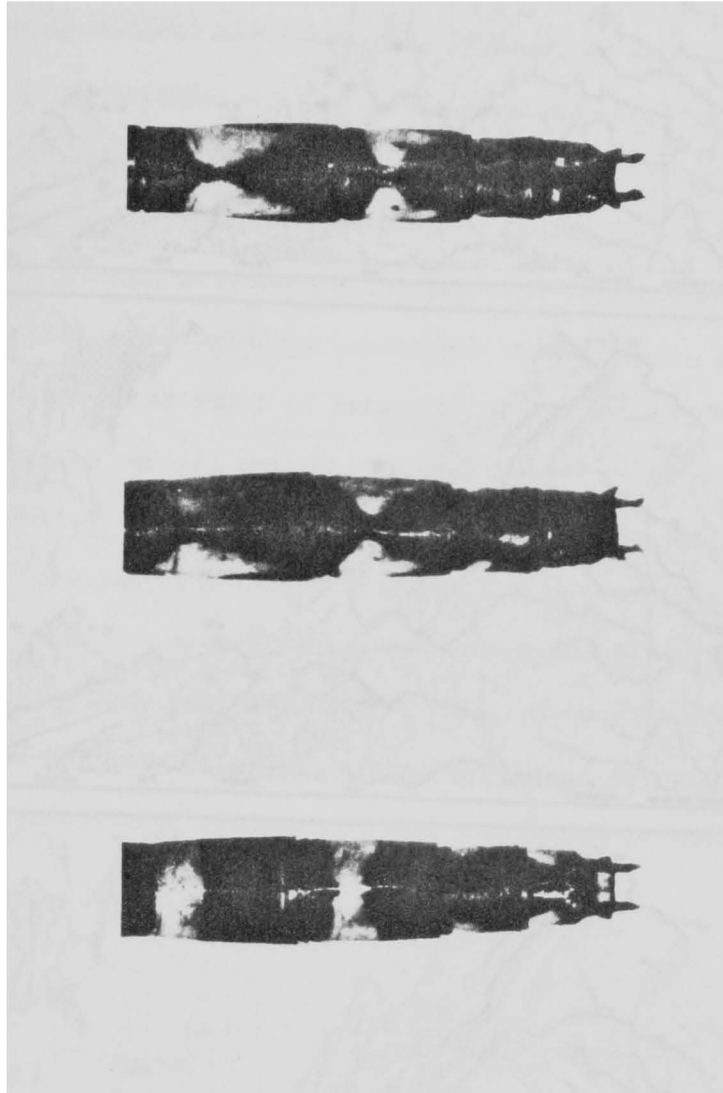


Figure 107. Abdominal apex in dorsal view of *Zonosoma* x5:
(a) *Z. bilineata*; (b) *Z. diasticta*; (c) *Z. signi*.

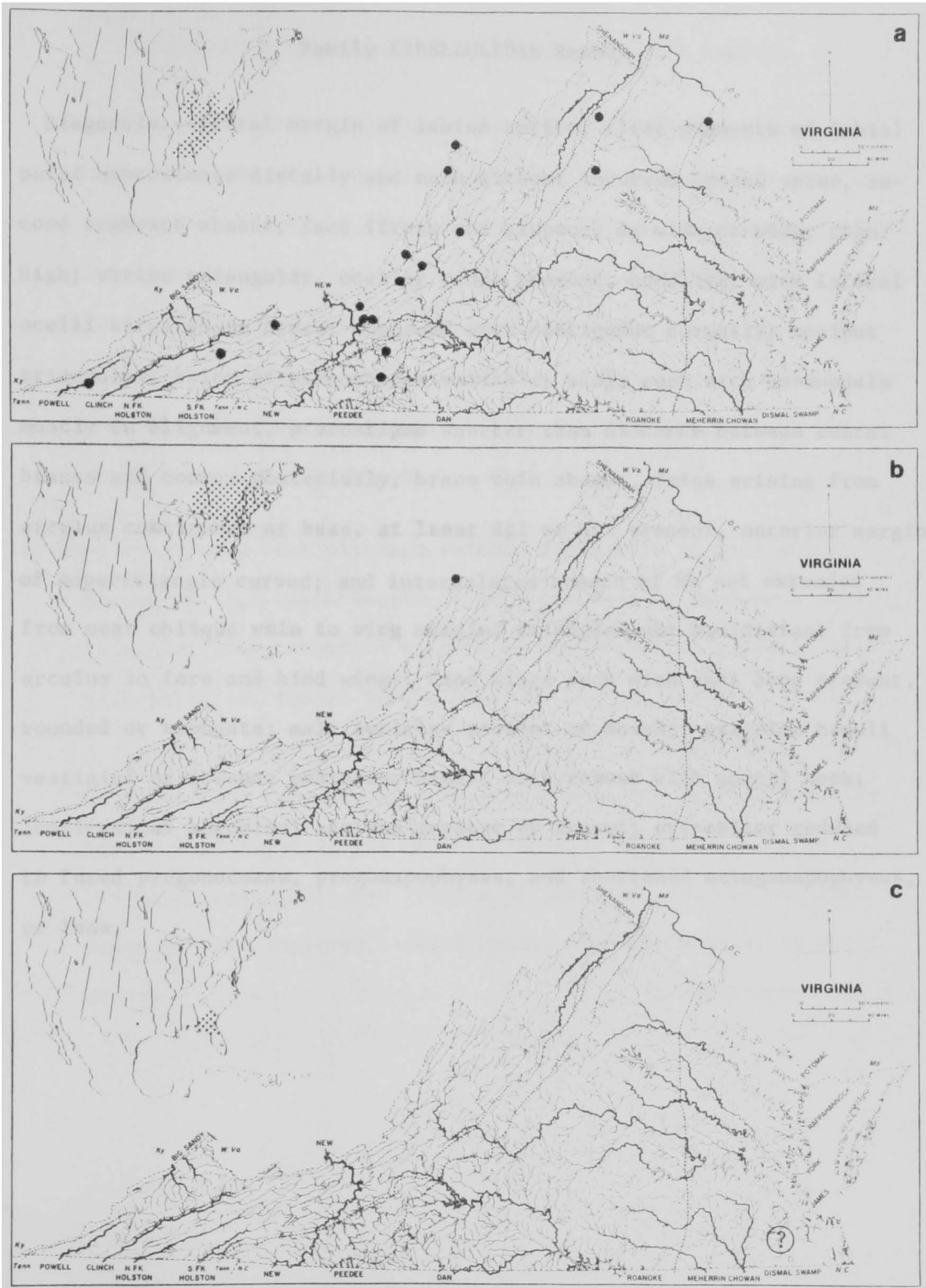


Figure 108. Geographic distribution of *Zoraena*: (a) *Z. bilineata* n. sp.; (b) *Z. diastatops*; (c) *Z. sayi*.

Family LIBELLULIDAE Rambur

Diagnosis.--Distal margin of labium entire; first segments of labial palpi approximate distally and each without incurved apical spine, second segments absent; face (frons and clypeus) as wide or wider than high; vertex triangular, ocellar ridge present, hoodlike, with lateral ocelli situated on crest; compound eyes contiguous dorsally; occiput triangular; color of pterothorax variable; wings each with antenodals mostly in alignment, pterostigma shorter than distance between costal braces and convex posteriorly, brace vein absent, veins arising from arculus contiguous at base, at least Rpl or Mpl present, anterior margin of supertriangle curved; and intercalated branch of MA not extended from near oblique vein to wing margin; triangles not equidistant from arculus in fore and hind wings; hind wings each with anal loop present, rounded or elongate; male auricles present or absent; anterior hamuli vestigial or absent; posterior hamuli each robust with apical hook; longitudinal abdominal carinae present or absent; ovipositor reduced to fused progonocoxae, progonapophyses, and shortened metagonapophyses, or less.

Subfamily Key to Adult Libellulidae of North America

1. Abdominal segments without ventrolateral carinae; hind wings each with anal loop rounded and not bisected by midvein, and with proximal side of triangle distant from arculus; tarsal claws each with dorsal and ventral hook ca. equal in size... Macromiinae p. 540
- Abdominal segments 4-8 with ventrolateral carinae; hind wings each with anal loop elongated and bisected by midvein, and with proximal side of triangle opposite arculus; tarsal claws each with ventral hook smaller than dorsal hook 2
2. Hind wings each with distance between distal end of gaff and wing margin ca. 1.5 times length of anterior side of each fore wing triangle; posterolateral margins of compound eyes sinuate; males with auricles, tibial keels, anterior hamuli, and anal braces Corduliinae p. 565
- Hind wings each with distance between distal end of gaff and wing margin 2-10 times length of anterior side of each fore wing triangle; posterolateral margins of compound eyes not sinuate; males without auricles, tibial keels, anterior hamuli, or anal braces Libellulinae p. 673

Subfamily Macromiinae Needham

Diagnosis.--Hind margin of compound eyes sinuate laterally; mesopleural sulci sinuate; males with tibial keels; hooks of tarsal claws subequal in length; wings each with supplementary costal braces well developed basally, veins arising from arculus fused basally, and Mpl and Cupl absent; hind wings each with triangle distant from arculus, anal loop rounded, without midrib, males with anal brace well developed, and male anal margin angulate; males with auricles, and with anterior hamuli present; abdominal terga 4-8 without lateral carinae.

Remarks.--Although monophyletic this group is questionably of sufficient geologic age to receive the rank of family.

Generic Key to Adult Macromiinae of North America

1. Cerci pale; vertex not biconically elevated; occiput longer than eye seam; abdomen brown marked with pale yellowish-white
 *Didymops* p. 541
- Cerci black; vertex biconically elevated; occiput as long as eye seam; abdomen black marked with bright yellow
 *Macromia* p. 547

Genus *Didymops* Rambur 1842

Rambur 1842. Ins. Neur., p. 142.

Type Species.--*Libellula transversa* Say.

Diagnosis.--General coloration brown striped with pale yellow; ocellar ridge not biconically elevated; eye seam ca. 1/4 length of occiput; posterior margin of occiput semicircular; fore wings each with 9-13 antenodals, and with nodus located at 0.52-0.54 distance between base and apex of wing; posterior hamuli each with laminate apical hook; genital lobes prolonged posteriorly; cerci pale yellow, male cerci each without sigmoid curvature and lateral spine.

Didymops transversa (Say)

Syn.: *cinnamomea* Burmeister, *servillei* Rambur

(Figures 109,110)

Say 1839. J. Acad. Phila. 8:19 (in *Libellula*).

Length 52-60 mm; abdomen 34-43 mm; hind wings 34-38 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AL, AR, CT, DC, FL, GA, IL, IN, KS, KY, LA, ME, MD, MA, MI, MN, MS, MO, NH, NJ, NY, NC, OH, OK, PA, SC, TN, TX, VT, VA, WV, and WI, and the provinces of N.B., N.S., Ont., and Que. Known from the Virginia counties of Augusta, Campbell, Charles City, Charlotte, Craig, Cumberland, Dickenson, Dinwiddie, Fairfax, Giles, Highland, Isle of Wight, Louisa, Montgomery, Patrick, Prince Edward, Stafford, Sussex, and Wythe, and the cities of Norfolk and

Suffolk. Known distribution among the counties of neighboring states include: Kentucky- Fayette, Jefferson, and Oldham; Maryland- Montgomery; North Carolina- Columbus, Guilford, Johnston, Robeson, and Wake; Pennsylvania- Beaver, Bucks, Cambria, Centre, Chester, Clinton, Columbia, Cumberland, Delaware, Fayette, Franklin, Huntingdon, Juniata, Lancaster, Lebanon, Luzerne, Monroe, Montgomery, Perry, Philadelphia, Pike, Somerset, Union, Wayne, Westmoreland, and York; Tennessee- Clay, Davidson, Jackson, Jefferson, Overton, and Sullivan; West Virginia- Pendleton, Raleigh, and Ritchie.

Virginia Records.--Augusta Co.; Calfpasture R. at Rt. 688, 4 June 1977, 1 male, FLC; Hearthstone L. and stream, 30 June 1973, 1 male, S. W. Dunkel. Campbell Co.; Pond along Rt. 646, 2 May 1980, 1 male, BCK. Charles City Co.; Harrison Lake, 28 May 1967, 1 male, MDR, VPI&SU. Craig Co.; Johns Cr. at Rt. 311, 28 May 1977, FLC. Dickenson Co.; Small lake at Breaks Interstate Park below dam, 14 June 1979, 1 male, JRV and TJV, VPI&SU. Charlotte Co.; Beaver dam on Spring Cr., 10 Feb. 1977 (emerged 15 Feb. 1977), 1 female, FLC; Twittys Cr., 23 Apr. 1976, 1 male, M. Mauney, VPI&SU; Twittys Cr. upstream from Twittys Cr. Res., 18 May 1978, 1 male, FLC; Spring Cr. at Rt. 654, 3 males, FLC; Spring Cr. at Rt. 654, 18 May 1978, 1 male, BCK, FLC Collection. Cumberland Co.; Bear Cr. Lake, 17 Apr. 1976, 3 males, SWB, VPI&SU; Bear Cr. Lake, 29 Apr. 1974, 2 males, T. Bailey, VPI&SU. Dinwiddie Co.; Buckskin Cr. at Rt. 40, 15 Apr. 1978, exuviae, SWB, FLC Collection. Fairfax Co.; Great Falls, "Apr. 30 to June 12" (Donnelly 1961); Great Falls, 9 May 1916, 1 male, RPC, USNM; Great Falls, 15 May 1914, 1 male, RPC, USNM; Great Falls, 21 May 1914, 2 males, RPC, USNM. Giles Co.; Farrier Farm

at Newport, 7 May 1938, MED, VPI&SU; Pond nr. headwaters of Johns Cr. at Rt. 632, 20 May 1979, 3 males, BCK; Mountain Lake, 25 June 1935, 4 males, CA, (Kormondy 1960), MZUM. Highland Co.; Bullpasture R. at head of gorge, 30 May 1977, 1 male, FLC. Isle of Wight Co.; locality unknown, 5 Jan. 1976 (emerged 15 Mar. 1976), 1 male, J. O'Hop, ODU. Louisa Co.; N. Anna R. at Rt. 208, date unknown, nymph, collector unknown, (Roback and Westfall 1967). Montgomery Co.; Pandapas Pd., 12 Mar. 1977 (emerged 26 Mar. 1977), 1 male, P. K. Powell, VPI&SU; Pandapas Pd., 24 May 1973, 3 males, FLC; Pandapas Pd., 14 June 1974, 1 male, FLC; Pandapas Pd., 5 July 1973, 1 male, FLC; Pandapas Pd., 5 July 1973, FLC, VPI&SU; Pandapas Pd., 11 Sept. 1976, 1 male, BCK, VPI&SU. Patrick Co.; Rock Castle Cr., 21 May 1978, 1 male, FLC. Prince Edward Co.; locality unknown, 16 Apr. 1977, 1 male, Keil and Cannons, VPI&SU. Stafford Co.; locality unknown, 24 Apr. 1974, 1 male, T. Bailey, VPI&SU. Sussex Co.; Nottoway R. at Rt. 40 nr. Homeville, 15 Apr. 1978, 1 male nymphal exuviae, FLC. Wythe Co.; New R., 24 Apr. 1976, 1 male, C. Sherman, VPI&SU; New R., 24 May 1976, 1 male, T. Schaveelberger, VPI&SU. City of Norfolk; Dismal Swamp, Mar. or Apr., observed transforming, J. G. Needham, (MDR notes). City of Suffolk; Washington Ditch in Dismal Swamp Wildlife Refuge, 3 Feb. 1975, 1 female (reared), J. Hancock, ODU; Blackwater R. below Franklin at Rt. 189, 11 Apr. 1976, 1 male, J. O'Hop, ODU; Williamson Ditch in Dismal Swamp Wildlife Refuge, 17 Apr. 1978, 1 male (teneral), FLC; Washington Ditch in Dismal Swamp Wildlife Refuge, 16 May 1970, 1 male, 1 female, J. O'Hop, ODU.

Flight Season.--Jan. 25 (FL) to Sept. 11 (VA); in Virginia Apr. 11 to Sept. 11. Known season in neighboring states are: Kentucky- Apr. 18 to

May 9; Maryland- May 25; North Carolina- March to May; Pennsylvania- Apr. 24 to July 23; Tennessee- May 12 to Aug. 25; West Virginia- June 3-11.

Biology.--*Didymops transversa* inhabits slow-flowing streams, ponds, and lakes. Adult males patrol along shore lines at from 15-50 cm above water. Females oviposit near shore by repeatedly tapping their abdomen.

Remarks.--Since this species is among the earliest Anisoptera to emerge in the spring, it has undoubtedly been missed at many localities because of its early season.

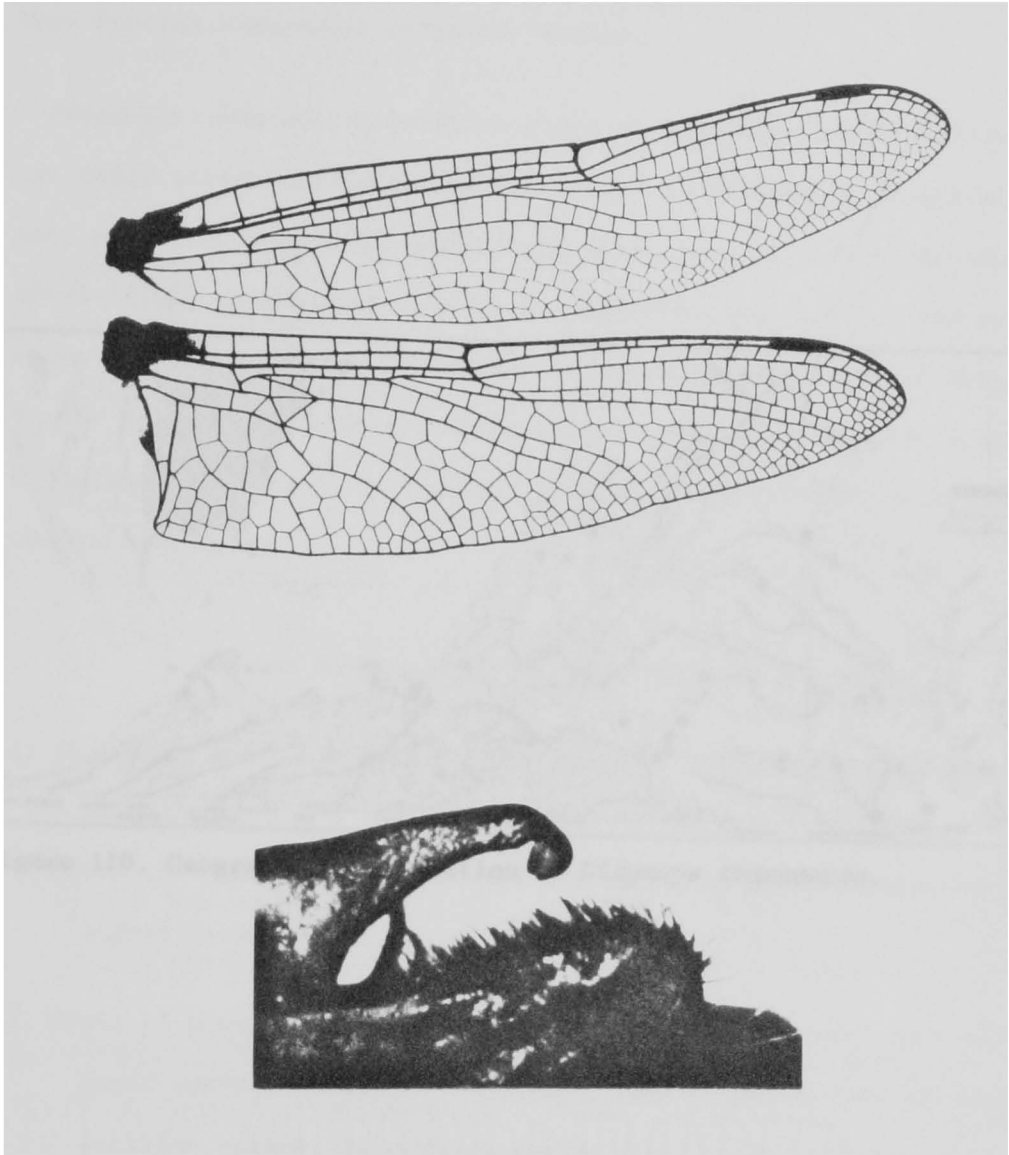


Figure 109. Wings x3 and genital lobe and posterior hamuli in lateral view x45 of *Bidymops transversa*.

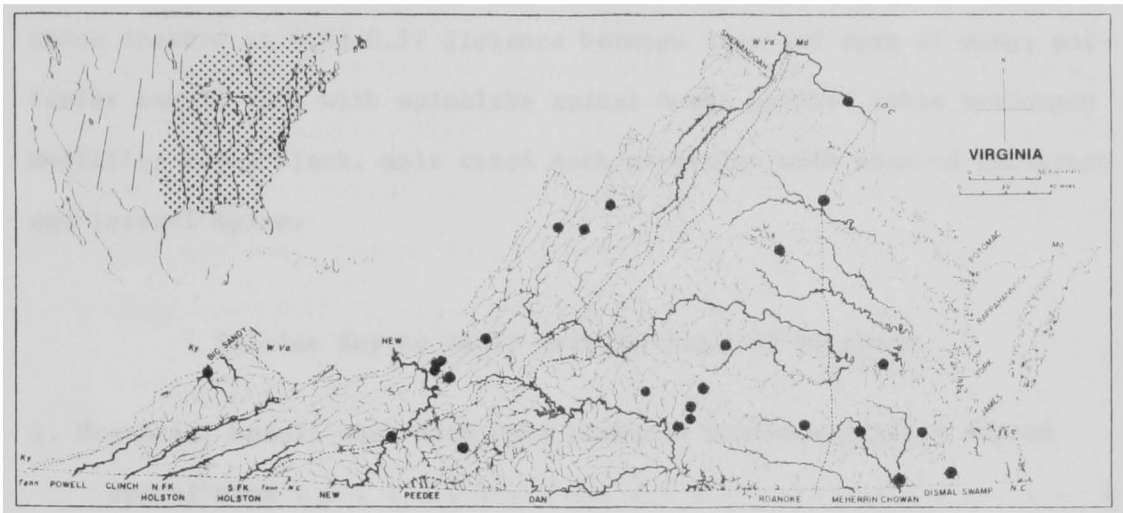


Figure 110. Geographic distribution of *Didymops transversa*.

Genus *Macromia* Rambur 1842

Rambur 1842. Ins. Neur., p. 137.

Type Species.--*Macromia cingulata* Rambur.

Diagnosis.--General coloration black striped with bright yellow; ocellar ridge biconically elevated; eye seam ca. as long as length of occiput; posterior margin of occiput not semicircular; fore wings each with 14-21 (11-13 in aberrant western *M. magnifica*) antenodals, and with nodus located at 0.54-0.57 distance between base and apex of wing; posterior hamuli each with spinelike apical hook; genital lobes prolonged medially; cerci black, male cerci each generally with sigmoid curvature and lateral spine.

Species Key to Adult Male *Macromia* of Virginia

1. Posterior hamuli each with apex produced posteroventrally beyond apical hook 2
 - Posterior hamuli each with apex not produced posteroventrally beyond apical hook 3

2. Keels of middle tibiae $1/5-3/8$ length of tibiae; cerci each with inner surface distinctly concave opposite end of lateral carinae; auricles yellow; lateral mesanepisternal yellow stripes well developed *M. georgina* p. 551
 - Keels of middle tibiae $2/5-1/2$ length of tibiae; cerci each with inner surface not distinctly concave opposite end of lateral carina; auricles generally brown; lateral mesanepisternal yellow stripes generally absent or vestigial... *M. illinoiensis* p. 553

3. Cerci slightly longer than epiproct, each more than 5 times longer than width at midlength; mesanepisternal yellow stripes well developed; abdominal segment 7 without ventrobasal yellow areas
 *M. taeniolata* p. 558
- Cerci slightly shorter than epiproct, each less than 5 times longer than width at midlength; mesanepisternal yellow stripes absent or vestigial; abdominal segment 7 with ventrobasal yellow areas . . . 4
4. Keels of middle tibiae ca. 1/6 length of tibiae; posterior hamuli each narrowest at base of apical hook in lateral view; fore wings each with triangle 1-celled *M. alleghaniensis* p. 550
- Keels of middle tibiae ca. 1/2 length of tibiae; posterior hamuli each narrowest before base of apical hook in lateral view; fore wings each with triangle generally 2-celled
 *M. margarita* p. 556

Species Key to Adult Female *Macromia* of Virginia

1. Lateral mesanepimeral pale stripes well developed 2
 Lateral mesanepimeral pale stripes vestigial or absent 3
2. Lobes of vulvar lamina contiguous basally, evenly convex apically;
 lateral yellow stripes of abdominal segment 2 confluent dorsally .
 *M. georgina* p. 551
- Lobes of vulvar lamina not contiguous basally, truncate apically;
 lateral yellow stripes of abdominal segment 2 not confluent
 dorsally *M. taeniolata* p. 558

- 3. Lobes of vulvar lamina triangular; hind tibiae less than 12 mm long
 *M. illinoiensis* p. 553
- Lobes of vulvar lamina not triangular; hind tibiae more than 12 mm
 long 4

- 4. Hind tibiae ca. 13 mm long; lateral yellow stripes of abdominal
 segment 2 not interrupted laterally... *M. alleghaniensis* p. 550
- Hind tibiae ca. 15 mm long; lateral yellow stripes of abdominal
 segment 2 interrupted laterally *M. margarita* p. 556

Macromia alleghaniensis Williamson

(Figures 111a,113a,114a)

Williamson 1909. Proc. U.S. Nat. Mus. 37:376.

Length 65-74 mm; abdomen 49-56 mm; hind wings 42-50 mm.

Diagnosis.--Lateral mesanepisternal yellow stripes absent or vestigial; males with keel of middle tibiae 0.1-0.2 length of tibiae; female hind tibiae ca. 13 mm long; fore wings each with supratriangle 3 or 4-celled, triangle in male 1-celled, in female 1 or 2-celled, and subtriangle 1 or 2-celled; auricles yellow; female with stripes of abdominal segment 2 not interrupted laterally, these stripes interrupted dorsally in both sexes; posterior hamuli each with apex not produced posteroventrally, and each narrowest at base of apical hook; male with ventrobasal yellow area of abdominal segment 7 confluent with dorsal spots; male cerci each with ventromedial surface slightly concave opposite end of lateral carinae, in dorsal view each cercus 3.8 times as long as wide at midlength.

Distribution.--Known from the states of AL, FL, GA, KY, MD, MS, NJ, NC, OH, PA, TN, and VA. Known from the Virginia counties of Alleghany, Augusta, Charlotte, Craig, Essex, Nelson, Pulaski, Russell, and Wythe. Known distribution among the counties of neighboring states include: Kentucky- Adair, Grayson, Green, Marion, and Rockcastle; Maryland- Frederick; North Carolina- Cherokee, Durham, Harnett, Orange, Scotland, Swain, and Warren; Pennsylvania- Bucks and Fayette; Tennessee- Cumberland, Greene, Hawkins, Monroe, Sevier, and Sullivan.

Virginia Records.--Alleghany Co.; Dunlap Cr. at Rt. 159, 10 July 1973, 1 male, FLC. Augusta Co.; Calfpasture R. at Rt. 688, 4 June 1977, 1

male, FLC. Charlotte Co.; Twittys Cr. at Rt. 642, 14 June 1975, 2 males, FLC. Craig Co.; Johns Cr. at Rt. 311, 14 June 1974, 4 males, FLC; Johns Cr. at Rt. 311, 1 Aug. 1973, 2 males, FLC. Essex Co.; Dunbrooke, 31 July 1899, 1 male, RPC, USNM. Nelson Co.; locality unknown, 26 June 1928, 1 male, WR, USNM; locality unknown, 2 July 1927, 1 female, WR, USNM. Pulaski Co.; Little R. at Rt. 693, 24 July 1980, 1 male, BCK. Russell Co.; Cleveland, 4 Aug. 1899, 1 female, C. C. Adams, (Det. E. B. Williamson, Williamson 1909). Wythe Co.; Wytheville, 27 June 1935, 1 male, CA, (Det. MDR, MDR notes), MZUM.

Flight Season.--June 4 (VA) to Sept. 14 (TN); in Virginia June 4 to Aug. 4. Known season in neighboring states are: Kentucky- June 23 to July; Maryland- June 10; North Carolina- June 19 to Aug. 26; Pennsylvania- June 24 to Sept. 8; Tennessee- June 27 to Sept. 14.

Biology.--*Macromia alleghaniensis* inhabits pools of slow-moving streams and rivers. Adult males patrol near shore at from 40-100 cm above water, generally along a stretch 100 m or so in length. Oviposition generally occurs near shore at the head of rapids.

Remarks.--Although seldom abundant, this species is much more common in Virginia than previous records indicate.

Macromia georgina (Selys)

Syn.: *australensis* Williamson

(Figures 111b, 113b, 114b)

Selys 1878. Bull. Acad. Belg. 45:197 (in *Epophthalmia*).

Length 69-79 mm; abdomen 50-57 mm; hind wings 43-53 mm.

Diagnosis.--Lateral mesanepisternal yellow stripes well developed; males with keel of middle tibiae 0.2-0.3 length of tibiae; female hind tibiae ca. 12 mm long; fore wings each with supratriangle 3 or 4-celled, triangle 1 or 2-celled, and subtriangle 1 or 2-celled; auricles yellow; female with stripes of abdominal segment 2 not interrupted laterally, these stripes confluent dorsally in both sexes; posterior hamuli each with apex greatly produced posteroventrally, and each narrowest at base of apical hook; male with ventrobasal yellow area of abdominal segment 7 separated from dorsal spots; male cerci each with ventromedial surface concave opposite end of lateral carinae, in dorsal view each cercus 4.3 times as long as wide at midlength.

Distribution.--Known from the states of AL, AR, FL, GA, IN, KS, KY, MD, MS, NJ, NC, OK, PA, SC, TN, TX, and VA. Known from the Virginia counties of Charlotte, Craig, Louisa, Nelson, and Southampton. Known distribution among the counties of neighboring states include: Kentucky- Butler; Maryland- Montgomery, Wicomico, and Worcester; North Carolina- Cumberland, Davie, Durham, Edgecomb, Franklin, Guilford, Halifax, Harnett, Hertford, Lincoln, Moore, Nash, Orange, Pender, Vance, and Wake; Pennsylvania- Bucks.

Virginia Records.--Charlotte Co.; Twittys Cr., 10 June 1975, 1 female, FLC; Twittys Cr. at Rt. 642, 14 June 1975, 2 males, FLC; Twittys Cr., 22 July 1978, 1 male, FLC; Twittys Cr. at Rt. 642, 25 Aug. 1975, 1 male, FLC. Craig Co.; locality unknown, 16 June 1975, 1 female, T. Bailey, VPI&SU. Louisa Co.; N. Anna R. at Rt. 658, 19 June 1970, 1 female (with exuviae), JRV, VPI&SU. Nelson Co.; locality unknown, 6 Aug. 1925, 1 male, WR, USNM; locality unknown, 7 Aug. 1926, 1 male, WR, USNM. South-

ampton Co.; Nottoway R. at Rt. 258, 10 Oct. 1978, 1 male, FLC; Nottoway R. at Rt. 653, 10 Oct. 1978, 2 males, 1 female, FLC.

Flight Season.--May 27 (NC) to Oct. 13 (NC); in Virginia June 10 to Oct. 10. Known season in neighboring states are: Maryland- July 10 to Sept. 23; North Carolina- May 27 to Oct. 13.

Biology.--*Macromia georgina* inhabits slow-flowing streams and rivers, and lakes. Adult males patrol parallel to the shore line at from 0.5-1.5 m. Oviposition occurs in the swifter parts of slow-flowing streams.

Remarks.--Dark individuals of this species are often confused with *M. illinoiensis*. This species is rare west of the Piedmont in Virginia.

Macromia illinoiensis Walsh

(Figures 112a,113c,114c)

Walsh 1862. Proc. Acad. Phila., p. 397.

Length 61-77 mm; abdomen 43-52 mm; hind wings 39-49 mm.

Diagnosis.--Lateral mesanepisternal yellow stripes absent or vestigial (occasionally well developed); males with keel of middle tibiae $2/5-1/2$ length of tibiae; female hind tibiae ca. 11-13 mm long; fore wings each with supratriangle 2-4-celled, triangle 1-2-celled, and subtriangle 1-celled; auricles brown (occasionally yellow); female with stripes of abdominal segment 2 interrupted (occasionally not interrupted) laterally, these stripes separated dorsally in both sexes; posterior hamuli each with apex moderately produced posteroventrally, and each narrowest at base of apical hook; male with ventrobasal yellow area of abdominal segment 7 absent or vestigial; male cerci each with ventromedial surface

slightly concave to level opposite end of lateral carinae, in dorsal view each cercus 4.0 times as long as wide at midlength.

Distribution.--Known from the states of AL, AR, GA, IL, IN, IA, KS, KY, ME, MD, MA, MI, MN, MS, MO, NH, NJ, NY, NC, OH, PA, RI, SC, SD, TN, VT, VA, WV, and WI, and the provinces of N.B., N.S., Ont., and Que. Known from the Virginia counties of Alleghany, Bath, Botetourt, Carroll, Charlotte, Craig, Culpeper, Fairfax, Floyd, Grayson, Loudoun, Louisa, Montgomery, Nelson, Orange, Rockbridge, Russell, Tazewell, Washington, and Wythe. Known distribution among the counties of neighboring states include: Kentucky- Adair, Allen, Bell, Butler, Carter, Cumberland, Edmonson, Green, Harrison, Hart, Henderson, Letcher, Marion, Metcalfe, Powell, Robertson, Rockcastle, Russell, Taylor, Todd, Trigg, Union, Warren, and Washington; Maryland- Montgomery; North Carolina- Cherokee and Swain; Pennsylvania- Allegheny, Bucks, Cameron, Centre, Chester, Clinton, Dauphin, Delaware, Fayette, Franklin, Fulton, Huntingdon, Juniata, Luzerne, Lycoming, McKean, Monroe, Montgomery, Northumberland, Perry, Philadelphia, Potter, Somerset, Union, and Wayne; Tennessee- Blount, Davidson, Greene, Hancock, Harlan, Hawkins, Johnson, Knox, Sevier, Sullivan, Washington, and Wilson; West Virginia- Hampshire, Pendleton, and Randolph.

Virginia Records.--Alleghany Co.; Dunlap Cr. at Rt. 60, 15 June 1973, 1 male, FLC. Bath Co.; Cowpasture R. at Rt. 632 S. of Nimrod Hall, 27 June 1973, 1 male, S. W. Dunkle; Cowpasture R. at Millboro Springs, 1 Aug. 1973, 2 males, FLC. Botetourt Co.; Rt. 615, 29 May 1977, 1 male, FLC; Craig Cr. at Rt. 706 nr. Oriskany, 29 May 1977, 2 males, FLC; Craig Cr. at Rt. 706 nr. Oriskany, 17 June 1978, 1 male, FLC; Craig Cr. at Patterson Cr., 18 June 1978, 1 male, FLC. Carroll Co.; New R. at Rts.

606 and 721, 11 June 1980, 1 male, BCK; New R. at Fries Bridge, 23 Aug. 1976, 1 male, C. R. Parker, VPI&SU. Charlotte Co.; Twittys Cr., 16 May 1975 (reared), 1 male, FLC; Twittys Cr. at Rt. 642, 14 June 1975, 6 males, FLC; Twittys Cr., 18 June 1975, 1 male, FLC; Twittys Cr. at Rt. 642, 22 July 1978, 1 male, FLC; Twittys Cr. at Rt. 642, 24 July 1973, 1 male, FLC. Craig Co.; Johns Cr. at Rt. 311, 28 May 1977, 1 female, FLC; Johns Cr. at Rt. 311, 1 Aug. 1973, 3 males, FLC; Johns Cr. at Rt. 311, 14 Aug. 1973, 1 male, FLC. Culpeper Co.; Hazel R. at Rt. 707, 14 July 1979, 4 males, 1 female, BCK. Fairfax Co.; Great Falls, "June 4 to Sept. 3" (Donnelly 1961); Bull Run Cr., 14 Aug. 1980, 2 males, 2 females, BCK, (Det. BCK); Bull Run nr. Centreville, 15 Aug. 1953, 1 male, TWD, (Det. TWD, Donnelly personal communication); Woods opposite Plummers Island MD, 19 Sept. 1916, 1 female, H. S. Barber, USNM. Floyd Co.; Little R. at Rt. 615, 27 May 1977, 1 female, FLC; Little R. at Rt. 615, 3 June 1977, 6 males, 2 females, FLC; Little R. at Rt. 615, 3 June 1977, 1 female, BCK. Grayson Co.; New R. at Rt. 58, 1 May 1977 (emerged 14 May to 3 June 1977), 2 males (with exuviae), 3 females (with exuviae), FLC; New R. at Rt. 810, 23 May 1978 (emerged 27,28 May 1978), 2 males, 1 female, FLC; New R. at Fox Cr. at Rt. 58, 19 June 1977, 1 male, FLC. Loudoun Co.; Leesburg, 26 Aug. 1978, 1 male, A. J. Kennedy, USNM. Louisa Co.; Holliday Mill Pd. at Rt. 719, 3 Aug. 1970, 1 male, RRM, VCU; Holliday Mill Pd. at Rt. 719, 11 Aug. 1970, 2 males, RRM, VCU. Montgomery Co.; locality unknown, 9 July 1975, 1 male, C. Hopkins, VPI&SU; locality unknown, 30 July 1976, 1 female, C. Hopkins, VPI&SU. Nelson Co.; locality unknown, 2 July 1927, 1 female, WR, (Det. MDR), USNM; locality unknown, 26 July 1928, 1 male, WR, (Det. MDR), USNM; locality unknown, 6

Aug. 1925, 1 male, WR, (Det. MDR), USNM; locality unknown, 6 Aug. 1926, 1 male, WR, USNM: locality unknown, 7 Aug. 1926, 1 male, WR, (Det. MDR), USNM; Wingina, 14 Aug. 1928, 1 male, WR, (Det. MDR), USNM. Orange Co.; Mine Run, 15 July 1980, 1 male, 1 female, BCK. Rockbridge Co.; 0.5 mile from Lyle Rd. in Goshen, 20 June 1978, 1 female, M. Meschter. Russell Co.; Cleveland, 1 Aug. 1899, 1 male, C. C. Adams, FSCA; Cleveland, 1,2,4, Aug. 1899, 8 males, 1 female, C. C. Adams, (Det. E. B. Williamson, Williamson 1909). Tazewell Co.; Cedar Bluff, 1 Aug. 1899, 1 female, C. C. Adams, (Det. E. B. Williamson, Williamson 1909). Washington Co.; Abingdon, 13 Aug. 1901, 1 female, C. C. Adams, (Det. E. B. Williamson, Williamson 1909). Wythe Co.; Wytheville, 27 June 1935, 1 female, CA, (Det. CA), MZUM; Wytheville, 29 June 1935, 6 males, CA, (Det. CA), MZUM; Wytheville, 30 June 1935, 1 male, VA, (Det. CA), MZUM.

Flight Season.--May 3 (OH) to Sept. 30 (TN); in Virginia May 27 to Sept. 19. Known season in neighboring states are: Kentucky- May 5 to Sept.; Maryland- June 2 to July 4; North Carolina- July to Aug.; Pennsylvania- May 24 to Aug. 23; Tennessee- June 27 to Sept. 30; West Virginia- June 13 to Aug. 2.

Biology.--*Macromia illinoiensis* inhabits streams and rivers with moderate gradient. Adult males exhibit a variable flight pattern during patrol. Oviposition occurs at the head of rapids or in pool areas.

Remarks.--Light-colored individuals of this species are often confused with *M. georgina*. This species is the most common *Macromia* in Virginia.

Macromia margarita Westfall

(Figure 115a)

Westfall 1947. J. Elisha Mitchell Sci. Soc. 63:32.

Length 72-78 mm; abdomen 49-57 mm; hind wings 46-52 mm.

Diagnosis.--Lateral mesanepisternal yellow stripes absent or vestigial; males with keel of middle tibiae $1/2-4/7$ length of tibiae; female hind tibiae ca. 15 mm long; fore wings each with supratriangle 3-5-celled, triangle 1-2-celled, and subtriangle 1-2-celled; auricles yellow; female with stripes of abdominal segment 2 interrupted laterally, these stripes separate dorsally in both sexes; posterior hamuli each with apex not produced posteroventrally, and each narrowest before base of apical hook; male with ventrobasal yellow area of abdominal segment 7 confluent with or narrowly separated from dorsal spots; male cerci each with ventromedial surface slightly concave opposite end of lateral carinae, in dorsal view each cercus 4.3 times as long as wide at midlength.

Distribution.--Known from the states of NC and GA. Known distribution among the counties of neighboring states include: North Carolina-Transylvania.

Flight Season.--June 20 (NC) to Aug. 18 (NC).

Biology.--*Macromia margarita* inhabits rivers with moderate gradient.

Remarks.--The distribution of this species is apparently limited to the southern Appalachians. However, previous records of *M. taeniolata* from western Tennessee, West Virginia, and Pennsylvania may be referable to this species. *Macromia taeniolata* is distinguished by its shorter tibial keels, larger size, and more elongate cerci. *Macromia margarita* may occur in western Virginia.

Macromia taeniolata Rambur

(Figures 112b, 113d, 115b)

Rambur 1842. Ins. Neur., p. 139.

Length 75-91 mm; abdomen 51-67 mm; hind wings 46-59 mm.

Diagnosis.--Lateral mesanepisternal yellow stripes well developed; males with keel of middle tibiae $1/20$ - $1/4$ length of tibiae; female hind tibiae ca. 13-14 mm long; fore wings each with supratriangle 3-5-celled, triangle 1 or 2-celled, and subtriangle 1 or 2-celled; auricles yellow; female with stripes of abdominal segment 2 not interrupted laterally, these stripes separate dorsally in both sexes; posterior hamuli each with apex not produced posteroventrally, and each narrowest before base of apical hook; male with ventrobasal yellow area of abdominal segment 7 absent or vestigial; male cerci each with ventromedial surface concave opposite end of lateral carinae, in dorsal view each cercus 5.1 times as long as wide at midlength.

Distribution.--Known from the states of AL, AR, DC, FL, GA, IL, IN, IA, KS, KY, LA, MD, MI, MS, NC, OH, OK, PA(?), SC, TN, TX, VA and WV(?). Known from the Virginia counties of Accomack, Arlington, Charles City, Fairfax, King William, Russell, and Southampton, and the cities of Norfolk, Suffolk, and Virginia Beach. Known distribution among the counties of neighboring states include: Kentucky- Adair, Butler, Cumberland, Edmonson, Gallatin, Green, Marion, Powell, Union, Warren, and Washington; Maryland- Worchester; North Carolina- Duplin; Tennessee- Cheatham, Grainger(?), Obion, Sevier(?), Sullivan(?), Humphreys, and Sequatchie(?); West Virginia- Pendleton(?) and Raleigh(?).

Virginia Records.--Accomack Co.; Chincoteague, 5 Sept. 1970, 1 male, S. M. Amsbaugh, VPI&SU. Arlington Co.; Rosslyn, 30 July 1899, 1 female, G. N. Collins, USNM. Charles City Co.; Harrison Lake nr. Roxbury, 28 May 1938, 1 female, R. Hess, (Det. A. D. Hess); Harrison Lake nr. Roxbury, 21 July 1938, 1 male, R. Hess, (Det. A. D. Hess). Fairfax Co.; Great Falls, 4 June 1899, 1 male, 1 female, G. N. Collins, USNM; Dyke, 17 Aug. 1916, 1 male, RPC, USNM. King William Co.; locality unknown, 9 June 1975, 1 male, J. O'Hop, ODU. Russell Co.; Cleveland, 4 Aug. 1899, 1 female, C. C. Adams, (Det. E. B. Williamson, Williamson 1903). Southampton Co.; Nottoway R. at Rt. 753, 11 June 1975, 1 male, FLC; Nottoway R. at Rt. 258, 10 Oct. 1978, 1 male, 1 female, FLC; Nottoway R. at Rt. 653, 10 Oct. 1978, 4 males, FLC. City of Norfolk, locality unknown, 13 June 1975, 1 male, FLC. City of Suffolk, Dismal Swamp Wildlife Refuge, 5 Aug. 1974, 1 male, J. Hancock, ODU; Lake Drummond feeder ditch, 13 Aug. 1974, 1 male, FLC. City of Virginia Beach; locality unknown, 2 Feb. 1980 (emerged 19 May 1980), 1 female, J. O'Hop.

Flight Season.--Apr. 26 (FL) to Nov. 11(FL); in Virginia May 28 to Oct. 10. Known season in neighboring states are: District of Columbia- July 10 to Aug. 23; Kentucky- June to Aug. 12; Maryland- July 10; North Carolina- Sept. 23; Tennessee- July 12 to Aug. 25; West Virginia- June 1 to Aug. 6(?).

Biology.--*Macromia taeniolata* inhabits pools of large rivers. Males normally patrol near shore at from 0.5-2 m. Oviposition occurs in pools or in swift water.

Remarks.--*Macromia taeniolata* is the largest species of *Macromia* in Virginia; it is primarily an inhabitant of large coastal plain rivers.

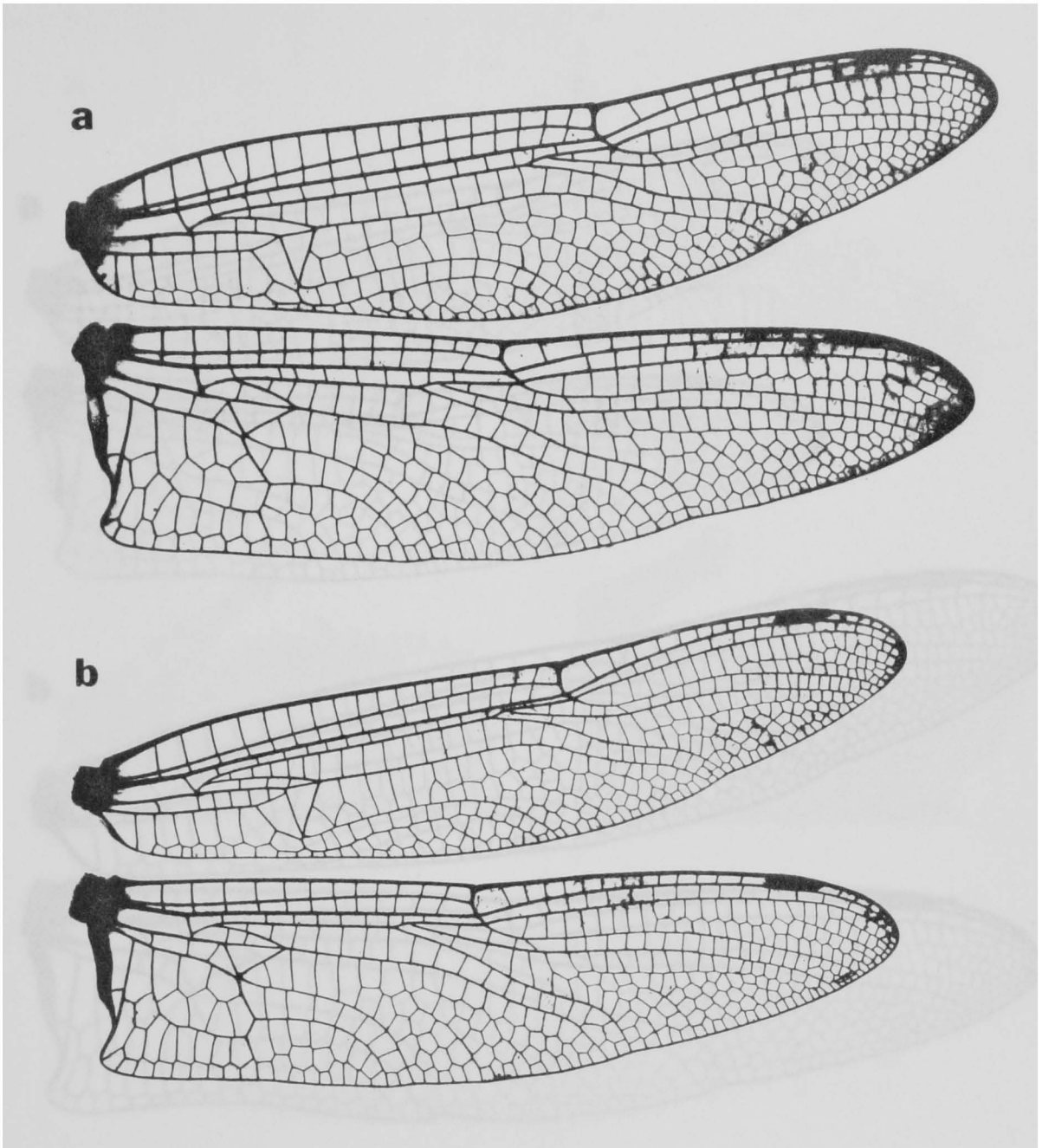


Figure 111. Wings of *Macromia* x3: (a) *M. alleghaniensis*;
(b) *M. georgina*.

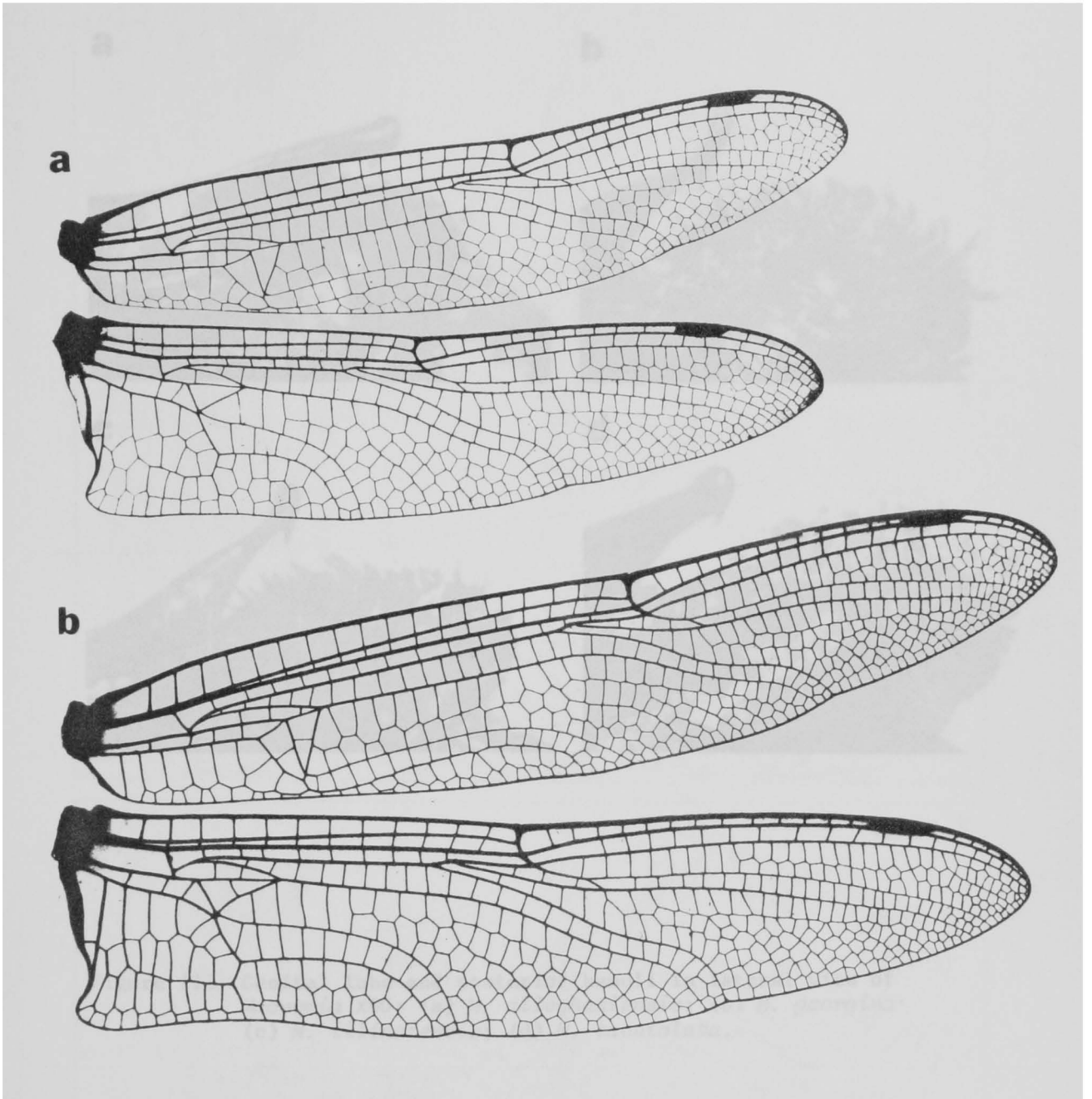


Figure 112. Wings of *Macromia* x3: (a) *M. illinoisensis*; (b) *M. tachiolata*.

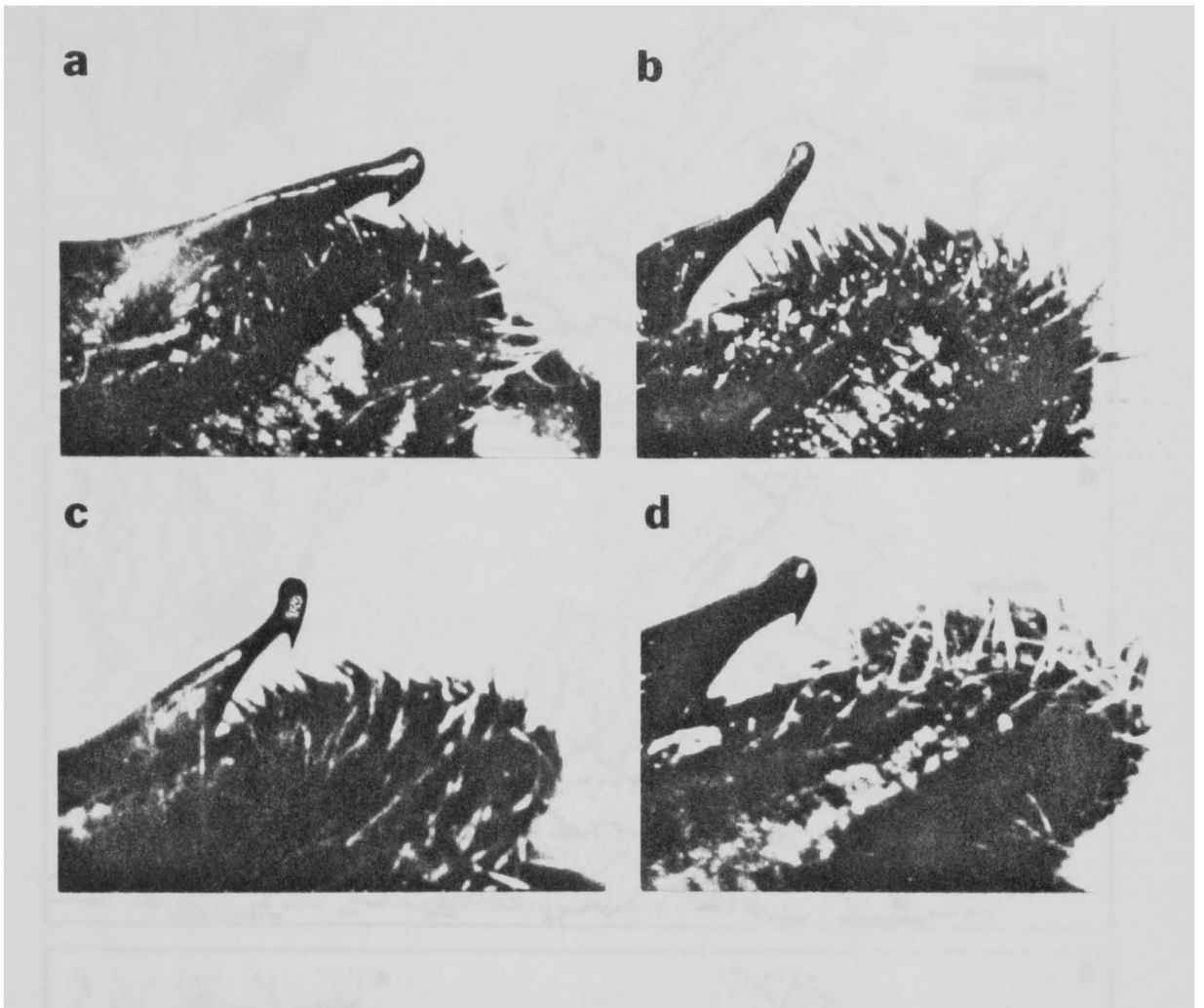


Figure 113. Genital lobe and posterior hamuli in lateral view of *Macromia* x60: (a) *M. alleghaniensis*; (b) *M. georgiana*; (c) *M. illinoensis*; (d) *M. tuciolata*.

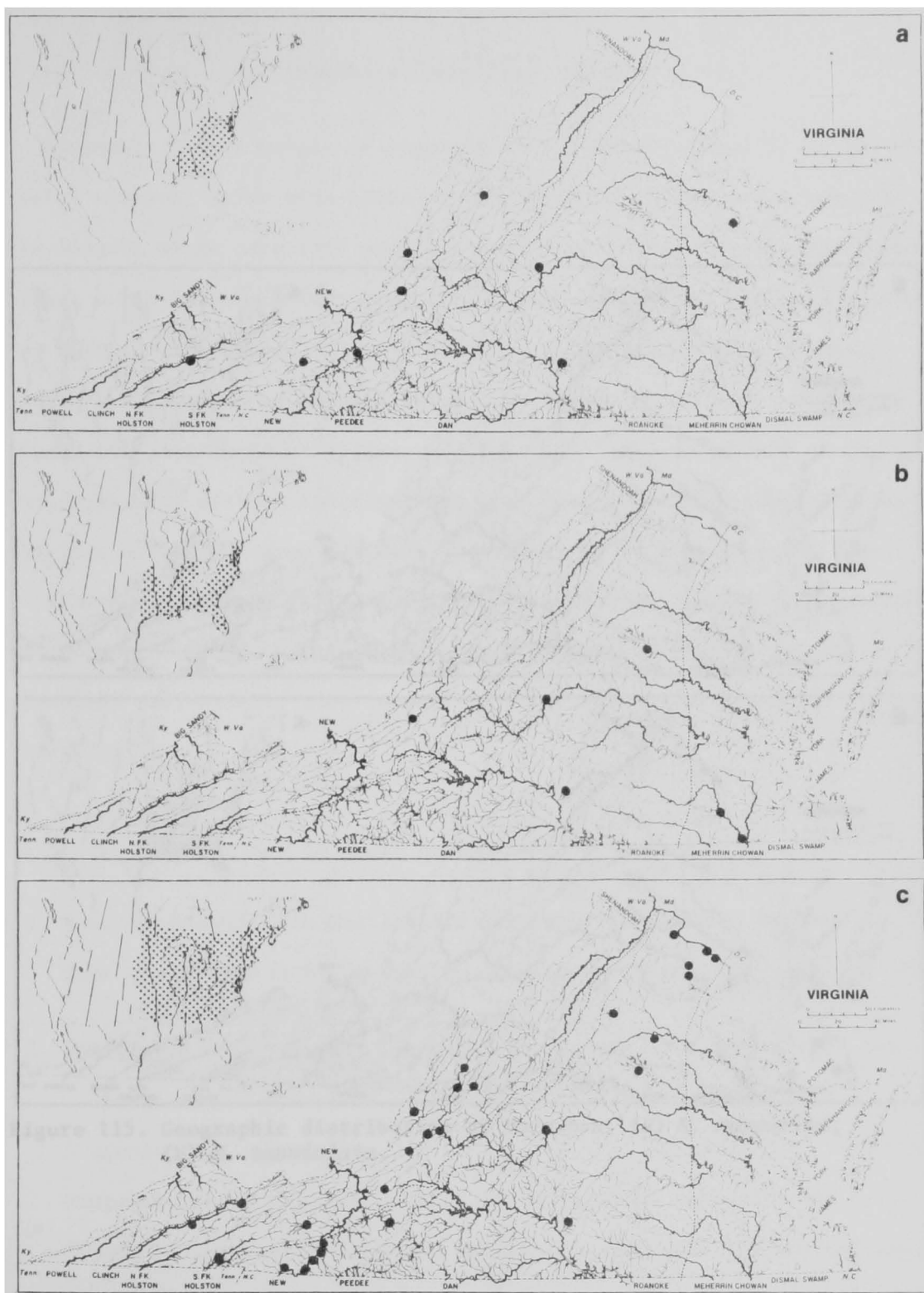


Figure 114. Geographic distribution of *Macromia*: (a) *M. alleghaniensis*; (b) *M. georgina*; (c) *M. illinoiensis*.

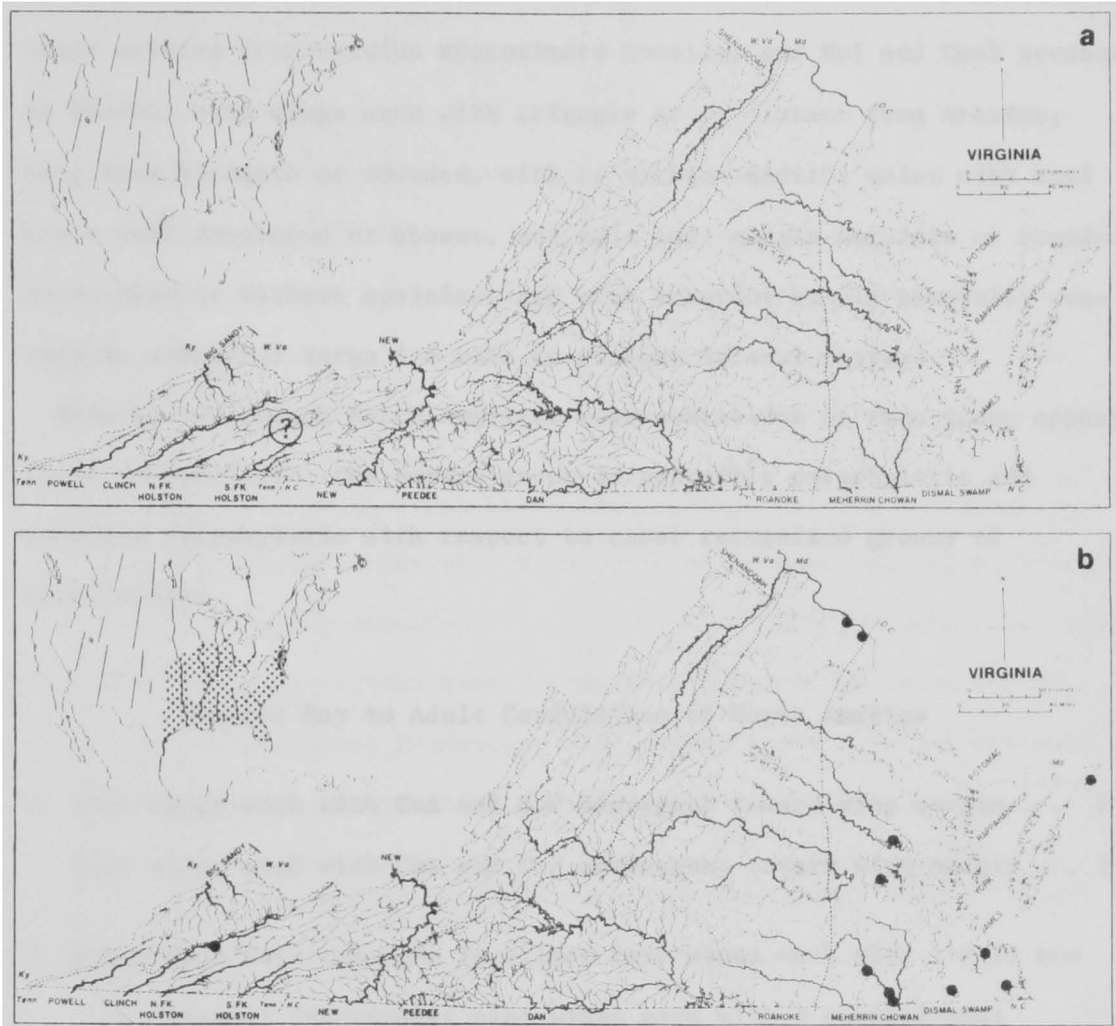


Figure 115. Geographic distribution of *Macromia*: (a) *M. margarita*;
(b) *M. taeniolata*.

Subfamily Corduliinae Selys

Diagnosis.--Hind margin of compound eyes sinuate laterally; mesopleural sulci sinuate; males with tibial keels; hooks of tarsal claws unequal in length; wings each with supplementary costal braces weakly developed, veins arising from arculus approximate basally, and Mpl and Cupl present or absent; hind wings each with triangle at or distant from arculus, anal loop elongate or rounded, with or without midrib, males with anal brace well developed or absent, and male anal margin angulate or rounded; males with or without auricles, and with anterior hamuli generally vestigial; abdominal terga 4-8 with or without lateral carinae.

Remarks.--Although North American representatives of this group appear to be monophyletic, the entire group is apparently paraphyletic and possibly polyphyletic with respect to other recognized groups of Libellulidae.

Generic Key to Adult Corduliinae of North America

1. Fore wings each with CuA and CuP divergent toward wing margin . . . 2
 Fore wings each with CuA and CuP convergent toward wing margin . . . 3
2. Wings each with triangle 1-celled; fore wings each with 1 cell row
 in trigonal interspace; hind wings each with 1 cubital-anal
 crossvein *Williamsonia* p. 671
- Wings each with triangle 2-4-celled; fore wings each with 2-4 cell
 rows in trigonal interspace; hind wings each with 2-4 cubital-anal
 crossveins *Neurocordulia* p. 593

- 3. Male hind wings each with 3 cell rows between fibulum and wing margin; vulvar lamina divided to base, lateral lobes straplike . . . 4
- Male hind wings each with 2 cell rows between fibulum and wing margin; vulvar lamina not divided to base, lateral lobes not straplike 5

- 4. Wings each with brown area at nodus and apex; fore wings each with 2 cell rows between Cu₁P and CuP; male fore tibiae each with keel ca. 0.7 length of tibia *Epicordulia* p. 578
- Wings each without brown area at nodus and apex; fore wings each with 1 cell row between Cu₁P and CuP; male fore tibiae each with keel ca. 0.5 length of tibia *Tetragoneuria* p. 645

- 5. Fore wings each with basal brown area extended at least halfway to first antenodal crossvein; male epiproct truncate apically, apical margin slightly concave *Helocordulia* p. 585
- Fore wings each without basal brown area extended at least halfway to first antenodal crossvein; male epiproct not truncate apically, apical margin not slightly concave 6

- 6. Hind wings each with 2 cubital-anal crossveins; male middle tibiae each without keel; vulvar lamina scooplike
- *Somatochlora* p. 610
- Hind wings each with 1 cubital-anal crossvein; male middle tibiae each with keel; vulvar lamina not scooplike 7

7. Fore wings each with 1 cell row in trigonal interspace, and 1 cell row between Cup1 and CuP; male with epiproct not forked, and middle tibiae each with keel less than 1/5 length of tibia
 *Dorocordulia* p. 572
- Fore wings each with 2 cell rows in trigonal interspace, and 2 cell rows between Cup1 and CuP; male with epiproct forked, and middle tibiae each with keel more than 1/5 length of tibia
 *Cordulia* p. 567

Genus *Cordulia* Leach 1815

Leach 1815. Edin. Encycl. 9:137.

Type Species.--*Libellula aenea* Linnaeus.

Diagnosis.--General coloration metallic green; male middle tibiae each with keel 1/3-2/5 length of tibia; fore wings each with basal brown area absent, subtriangle 2 or 3-celled, triangle 1 or 2-celled, 2 cell rows in trigonal interspace, 2 cell rows between Cup1 and CuP, and CuA and CuP convergent toward wing margin; hind wings each with basal brown area absent, triangle 1-celled, 1 cubital-anal crossvein, and 2 cell rows between fibulum and hind wing margin; vulvar lamina bilobate, narrowly cleft to base; male epiproct divaricate.

Remarks.--Although previously regarded as closely related to *Somatochlora* this is not supported by comparing the diagnoses of these genera.

Cordulia shurtleffi Scudder

(Figures 116,117)

Scudder 1866. Proc. Boston Soc. Nat. Hist. 10:217.

Length 42-50 mm; abdomen 29-37 mm; hind wings 27-32 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AK, CA, CO, CT, ID, ME, MA, MI, MT, NV, NH, NJ, NY, OR, PA, UT, VT, VA, WA, WV, WI, and WY, and the provinces of Alta., B.C., Lab., Man., N.B., Nfld., NW. Terr., N.S., Ont., Que., Sask., and Yukon. Known from the Virginia counties of Bath and Highland. Known distribution among the counties of neighboring states include: Pennsylvania- Centre, Clearfield, Clinton, Huntingdon, Luzerne, Lycoming, McKean, Monroe, Northampton, Perry, Pike, Sullivan, Warren, Westmoreland, and Wyoming; West Virginia- Pendleton and Ritchie.

Virginia Records.--Bath Co.; Beaver pd. along Rt. 600, 18 June 1978, 3 males, 1 female, FLC. Highland Co.; Buck Run beaver ponds, 10 June 1979, 1 male, BCK; Buck Run beaver ponds, 12 June 1980, 7 males, 3 females (2 pair and 1 triplet in tandem), 11 nymphal exuviae, FLC; Buck Run beaver ponds, 18 June 1978, 12 males, FLC; Small pond at Rt. 250 E. of Monterey, 23 June 1978, 2 males, FLC; Buck Run beaver ponds, 1 July 1972, 16 males, OSF, USNM; Buck Run beaver ponds, 3,4 July 1971, 21 males, 1 female, OSF, USNM; Buck Run beaver ponds, 8 Aug. 1978, 3 males, FLC; Buck Run beaver ponds, 20 Aug. 1978, 2 males, FLC.

Flight Season.--May 2 (B.C.) to Aug. 26 (B.C.); in Virginia June 10 to Aug. 20. Known season in neighboring states are: Pennsylvania- May 24 to Aug. 21; West Virginia- May 20 to Aug. 8.

Biology.--*Cordulia shurtleffi* inhabits boggy ponds and lakes. Adult males generally patrol near shore at from 15-40 cm above water. Ovi-

position occurs near shore in emergent vegetation.

Remarks.--This species is surprisingly abundant in Bath and Highland counties, indicating that it probably occurs further south.

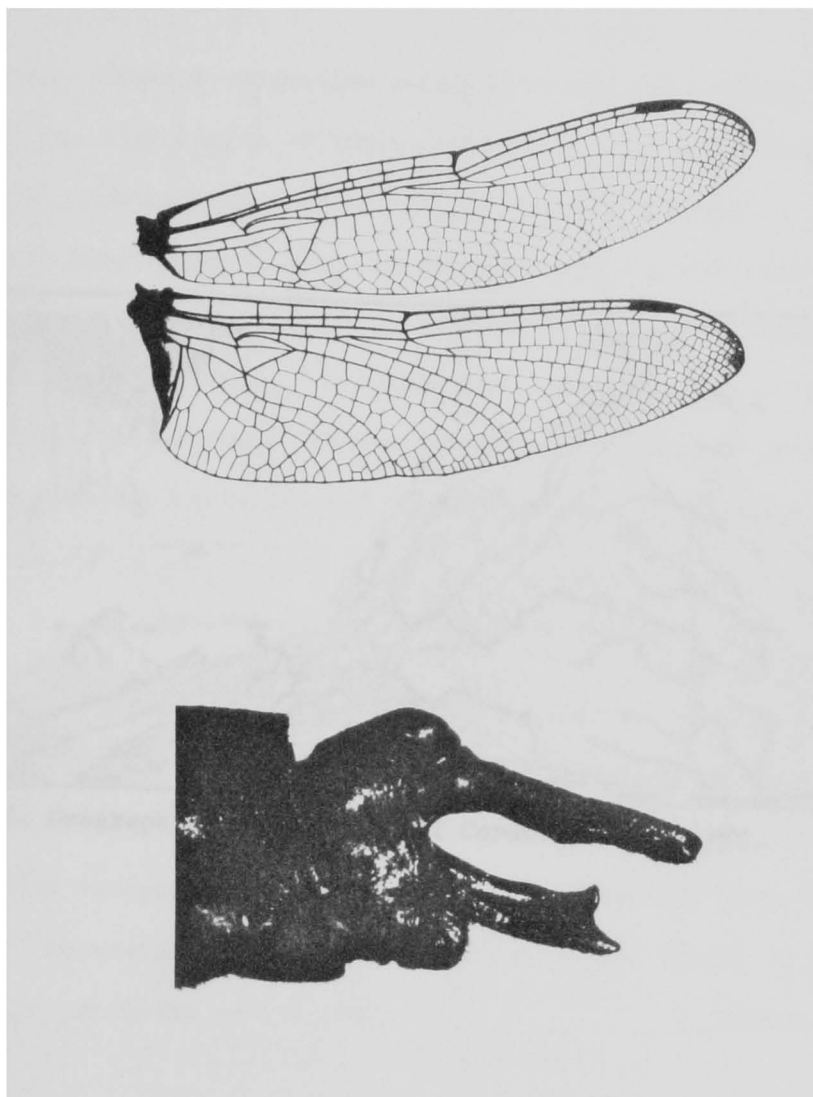


Figure 116. Wings x3 and male terminalia in lateral view x17 of *Cordulia shurtleffi*.

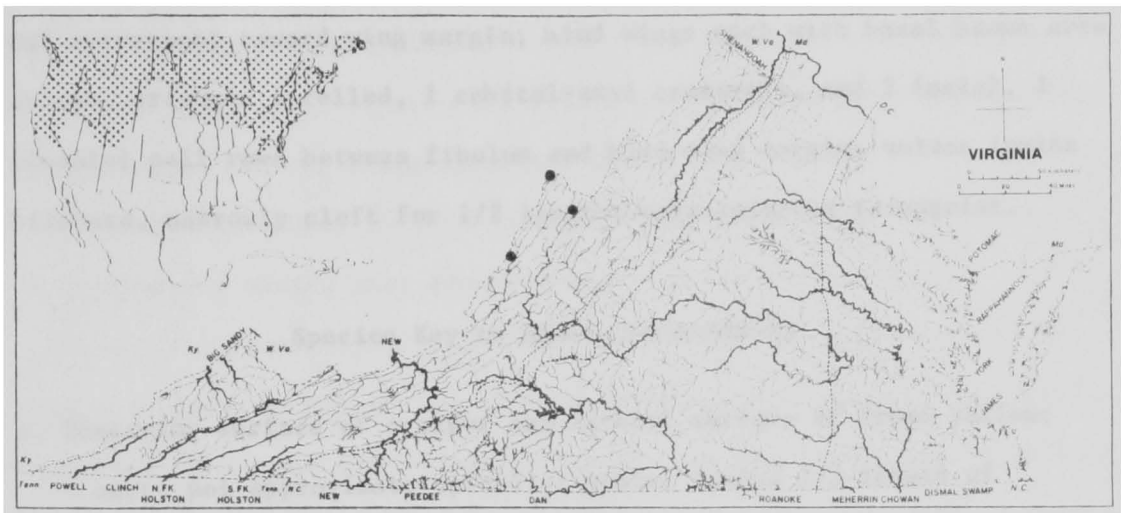


Figure 117. Geographic distribution of *Cordulia shurtleffi*.

Genus *Dorocordulia* Needham 1901

Needham 1901. Bull. N.Y. State Mus. 47:485.

Type Species.--*Cordulia libera* Selys.

Diagnosis.--General coloration metallic green; male middle tibiae each with keel ca. 1/10 length of tibia; fore wings each with basal brown area absent, subtriangle 2 or 3-celled, triangle 1-celled, 1 cell row in trigonal interspace, 1 cell row between Cup1 and CuP, and CuA and CuP convergent toward wing margin; hind wings each with basal brown area absent, triangle 1-celled, 1 cubital-anal crossvein, and 2 (male), 3 (female) cell rows between fibulum and hind wing margin; vulvar lamina bilobate, narrowly cleft for 1/2 length; male epiproct triangular.

Species Key to Adult *Dorocordulia*

1. Posterior surface of occiput and lateral surface of frons yellow;
 cerci not approximate apically; vulvar lamina 1/3 length of
 sternum 9 with narrow medial cleft *D. lepida* p. 572
- Posterior surface of occiput and lateral surface of frons black;
 cerci approximate apically; vulvar lamina 1/2 length of sternum
 9 with notchlike medial cleft *D. libera* p. 573

Dorocordulia lepida (Hagen)

(Figures 118a, 119a, 120a)

Hagen 1871. In Selys, Bull. Acad. Belg. 31:264 (in *Cordulia*).

Length 35-40 mm; abdomen 24-28 mm; hind wings 25-29 mm.

Diagnosis.--Lateral surface of frons and posterior surface of occiput yellow; teneral females with laterobasal yellow spots on abdominal segments 3-7; abdominal segment 7 without well-developed middorsal ridge, segments 7-9 not greatly expanded; vulvar lamina ca. 1/3 length of sternum 9, divided ca. 1/2 to base by narrow cleft; lateral margins of cerci parallel apically, apices not approximate.

Distribution.--Known from the states of CT, ME, MD, MA, NH, NJ, NY, and PA, and the provinces of N.B., N.S., and Que. Known distribution among the counties of neighboring states include: Maryland- Montgomery; Pennsylvania- Centre, Lackawanna, and Wayne.

Flight Season.--June 11 (ME) to Aug. 31 (New England). Known season in neighboring states are: Pennsylvania- June 16 to 31.

Biology.--*Dorocordulia lepida* inhabits lowland bog-ponds. Males patrol near emergent vegetation at from 20-60 cm above water. Oviposition (observed only once) occurs in and around stands of emergent vegetation.

Remarks.--Although previously unreported from Virginia, this species probably occurs in bog-ponds of northeastern Virginia.

Dorocordulia libera (Selys)

(Figures 118b, 119b, 120b)

Selys 1871. Bull. Acad. Belg. 31:263 (in *Cordulia*).

Length 37-43 mm; abdomen 26-31 mm; hind wings 26-31 mm.

Diagnosis.--Lateral surface of frons and posterior surface of occiput black; teneral females without laterobasal yellow spots on abdominal

segments 3-7; abdominal segment 7 with well-developed middorsal ridge, segments 7-9 greatly expanded; vulvar lamina ca. 1/2 length of sternum 9, divided ca. 1/2 to base by notchlike cleft; lateral margins of cerci convergent apically, apices approximate.

Distribution.--Known from the states of CT, IN, ME, MA, MI, MN, NH, NJ, NY, OH, PA, VT, and WI, and the provinces of N.B., N.S., Ont., and Que. Known distribution among the counties of neighboring states include: Pennsylvania- Centre, Clinton, Huntingdon, Luzerne, Monroe, Northampton, Jefferson, Sullivan, Union, and Wayne.

Flight Season.--May 4 (MA) to Aug. 29 (New England). Known season in neighboring states are: Pennsylvania- June 1 to Aug. 15.

Biology.--*Dorocordulia libera* inhabits upland bog-ponds and marsh-bordered lakes. Males fly 20-60 cm above water while following the shore line, but typically fly at 1.0-1.5 m when hovering over shoreline vegetation. Oviposition generally occurs among emergent vegetation where the female is typically well hidden.

Remarks.--A very distinctive species, the metallic coloration and expanded apical abdominal segments cause the males to appear wasplike while hovering. Although previously unrecorded from Virginia, this species possibly occurs in the bog-ponds of Highland county.

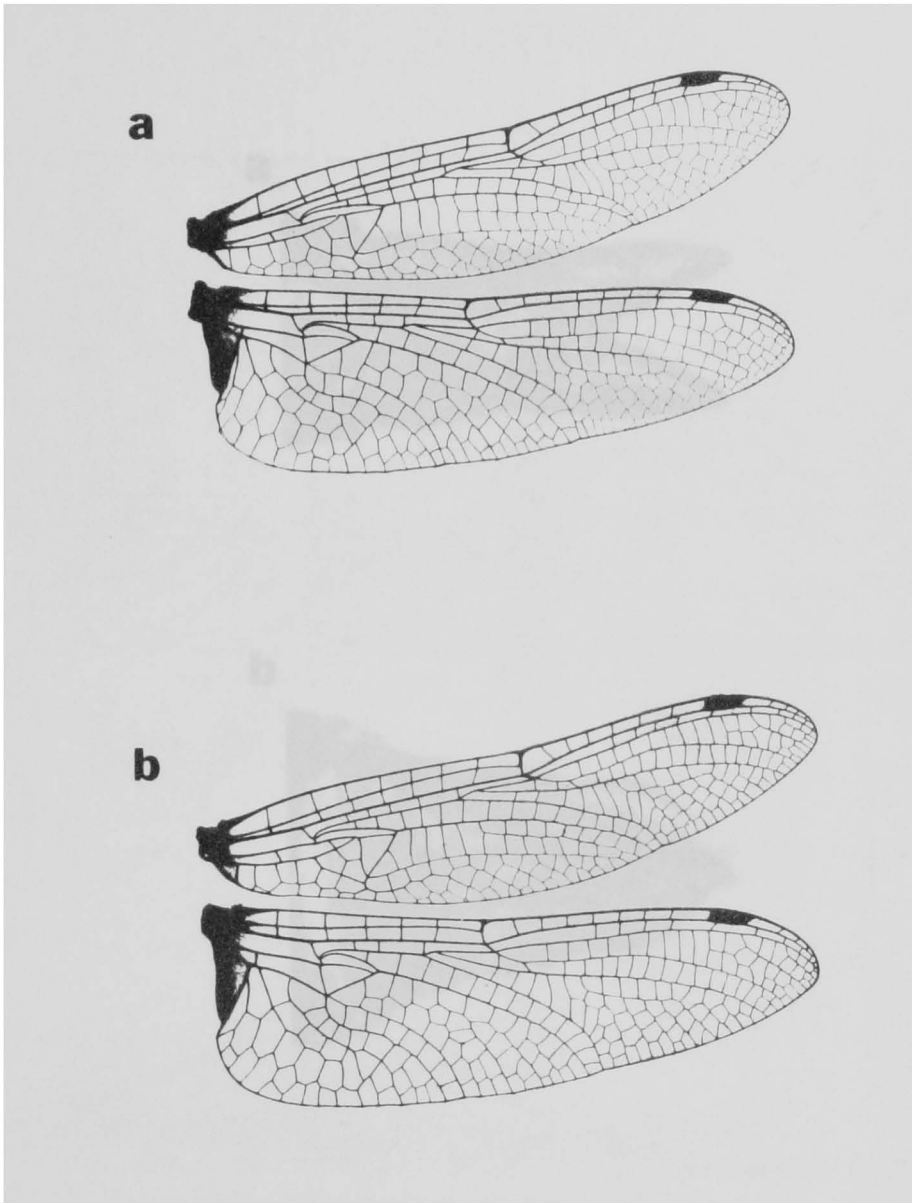


Figure 118. Wings of *Dorocordulia* x3: (a) *D. lepidus*; (b) *D. libera*

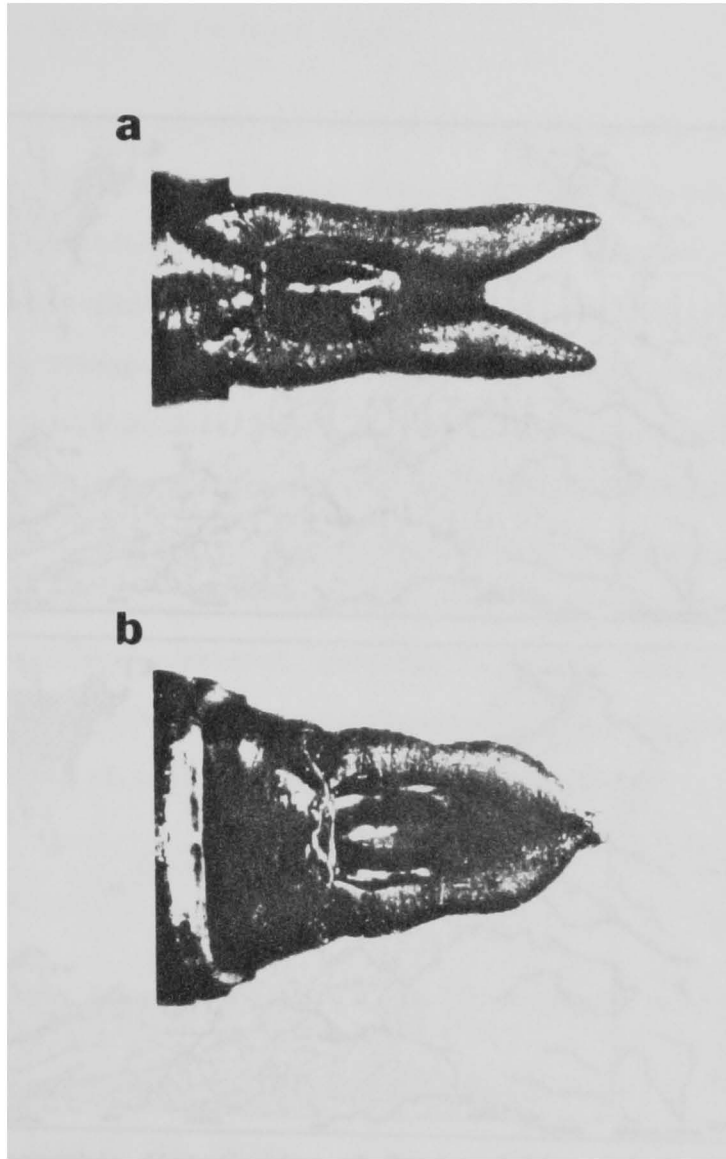


Figure 119. Male terminalia in dorsal view of *Dorocondulia* x20:
(a) *D. lepida*; (b) *D. libera*.

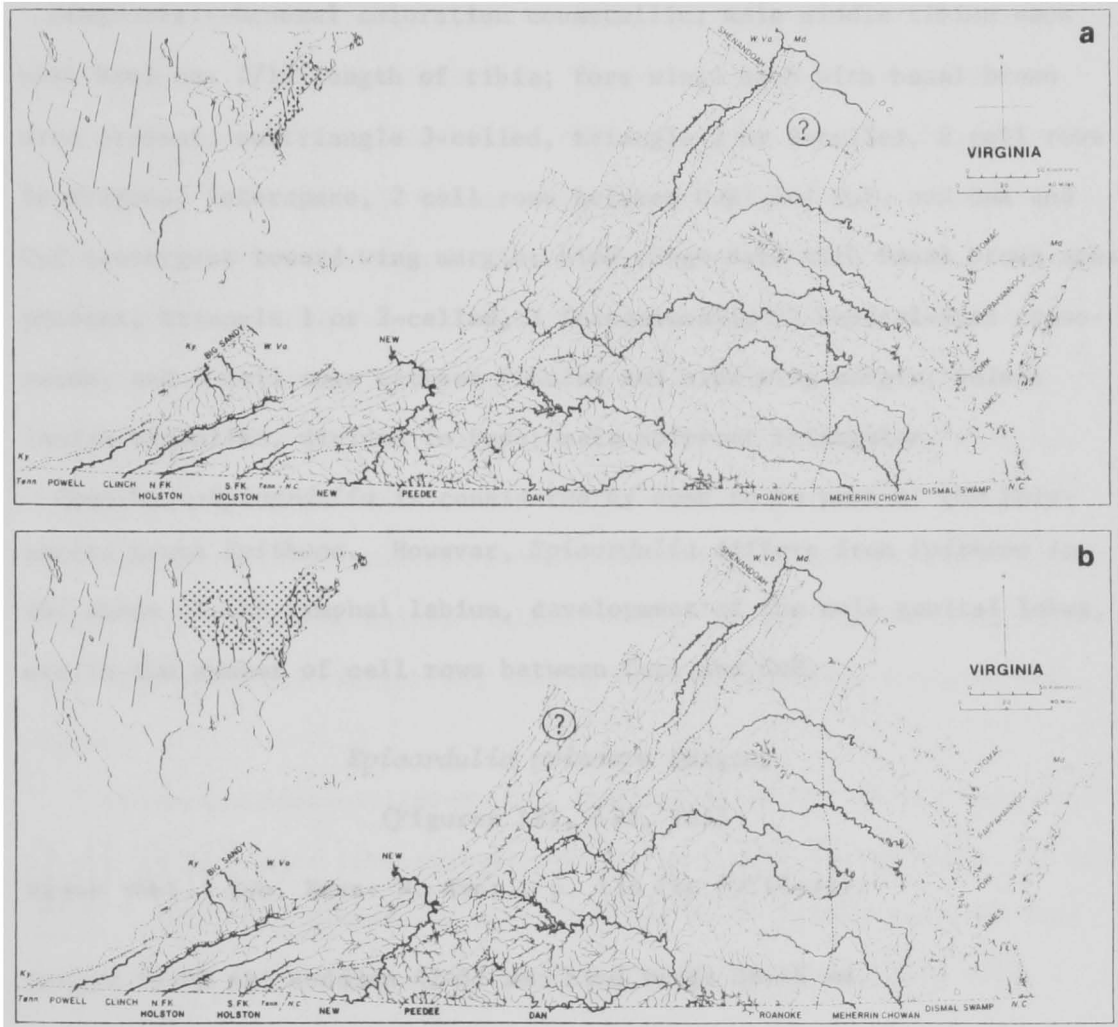


Figure 120. Geographic distribution of *Dorocordulia*: (a) *D. lepidu*; (b) *D. libera*.

Genus *Epicordulia* Selys 1871

Selys 1871. Bull. Acad. Belg. 31:259.

Type Species.--*Epithea princeps* Hagen.

Diagnosis.--General coloration nonmetallic; male middle tibiae each with keel ca. 7/10 length of tibia; fore wings each with basal brown area present, subtriangle 3-celled, triangle 2 or 3-celled, 2 cell rows in trigonal interspace, 2 cell rows between Cup1 and CuP, and CuA and CuP convergent toward wing margin; hind wings each with basal brown area present, triangle 1 or 2-celled, 1 (occasionally 2) cubital-anal cross-veins, and 3 cell rows between fibulum and hind wing margin; vulvar lamina straplike, divided to base; male epiproct triangular.

Remarks.--*Epicordulia* is considered by some to be part of the Palearctic genus *Epithea*. However, *Epicordulia* differs from *Epithea* in the shape of the nymphal labium, development of the male genital lobes, and in the number of cell rows between Cup1 and CuP.

Epicordulia princeps (Hagen)

(Figures 121, 122, 123)

Hagen 1861. Syn. Neur. N. Amer., p. 134 (in *Epithea*).

Length 59-69 mm; abdomen 42-51 mm; hind wings 38-46 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AL, AR, CT, DC, GA, IL, IN, IA, KS, KY, LA, ME, MD, MA, MI, MN, MS, MO, NE, NH, NJ, NY, NC, OH, OK, PA, RI, TN, TX, VT, VA, WV, and WI, and the provinces of Ont. and Que. Known from the Virginia counties of Alleghany, Bath, Bedford, Botetourt,

Charles City, Cumberland, Dickenson, Fairfax, Floyd, Giles, Greenville, Hanover, Henrico, James City, Louisa, Montgomery, Prince William, Pulaski, Roanoke, Rockingham, Southampton, Washington, Wise, Wythe, and York, and the city of Newport News. Known distribution among the counties of neighboring states include: Kentucky- Barren, Bell, Breckinridge, Bullitt, Carter, Clinton, Edmonson, Fayette, Fulton, Grayson, Green, Hardin, Harrison, Hart, Henderson, Hopkins, Letcher, Metcalfe, Monroe, Muhlenberg, Pike, Powell, Rockcastle, Taylor, Todd, Trigg, Union, Washington, and Wayne; Maryland- Montgomery; North Carolina- Avery, Durham, Moore, Knox, New Hanover, and Wake; Pennsylvania- Allegheny, Beaver, Bedford, Bucks, Butler, Cambria, Centre, Chester, Crawford, Dauphin, Delaware, Erie, Franklin, Fulton, Greene, Juniata, Luzerne, Lycoming, Perry, Philadelphia, Pike, Sullivan, Washington, Wayne, Westmoreland, Wyoming, and York; Tennessee- Blount, Campbell, Claiborne, Cocke, Coffee, Cumberland, Davidson, Giles, Jackson, Knox, Madison, Monroe, and Sullivan; West Virginia- Hampshire, Mason, Raleigh, Ritchie, Summers, and Taylor.

Virginia Records.--Alleghany Co.; Jackson R. at Rt. 64 nr. Lowmoor, 29 May 1977, 1 male (observation), FLC. Bath Co.; Douthat Lake, 27 June 1973, 1 male, SD; Cowpasture R. at Rt. 632 S. of Nimrod Hall, 29 June 1973, 1 male, SD. Bedford Co.; Peaks of Otter Lake, 22 July 1978, 1 male, FLC. Botetourt Co.; Craig Cr. at Rt. 706 nr. Oriskany, 28 May 1977, 1 male, FLC; Craig Cr. at Rt. 706 nr. Oriskany, 29 May 1977, 1 female, BCK, FLC Collection. Charles City Co.; Berkeley Mills at Rt. 5, 5 July 1938, 1 male, MED, (Det. MED, MDR notes). Cumberland Co.; Bear Cr. Lake, 23 May 1977, 3 males, 2 nymphal exuviae, FLC. Dickenson Co.;

Lake at Breaks Interstate Park below dam, 14 June 1979, 1 male, JRV, VPI&SU; John W. Flannagan Reservoir, 12 July 1980, 1 male, FLC. Fairfax Co.; Great Falls, "May 31-July 31", (Donnelly 1961); Great Falls, 2 June 1914, 1 male, RPC, USNM; Great Falls, 25 June 1914, 1 male, RPC, USNM; Great Falls, 8 July 1915, 1 male, RPC, USNM; Dyke, 17 Aug. 1916, 1 male, RPC, USNM. Floyd Co.; Little R. at Rt. 615, 21 May 1977, 1 male, BCK, FLC Collection. Giles Co.; Little R. at Eggleston, 26 June 1973, 1 male, SWD; Mountain Lake, 11 Aug. 1949, 1 male, C. F. Byers, (Det. C. F. Byers, Byers 1951); New R. at Spruce Run, 12 Aug. 1973, 2 males, FLC. Greensville Co.; Emporia, 26 July 1961, 1 female, R. D. Cuyler, (Det. R. D. Cuyler, Cuyler 1968). Hanover Co.; S. Anna R. at Rt. 657, 12 June 1978, 1 male, BCK; S. Anna R. falls at Rt. 657, 12 June 1978, 1 male, OSF, USNM. Henrico Co.; James R. at Richmond, date unknown, nymph, Roback, (Roback and Westfall, 1967). James City Co.; Lake Matoaka, 1 July 1938, 1 male, MED, (Det. MED, MDR notes); Jamestown Island Pd., 19 July 1938, 1 male (observation), MED, (Det. MED, MDR notes). Louisa Co.; N. Anna R., 10 June 1978, 1 male, BCK; N. Anna R. at Rt. 601, 21 June 1977, 2 males, BCK. Montgomery Co.; Pandapas Pd., 14 June 1974, 1 male, FLC; Blacksburg, 21 June 1954, 1 female, R. L. Hoffman, (Det. R. H. Gibbs), USNM; Pandapas Pd., 15 July 1974, 1 male, FLC; Pandapas Pd., 28 July 1973, 3 males, FLC; Pandapas Pd., 15 Aug. 1978, 1 male, FLC. Prince William Co.; Youngs Branch at Rts. 29 and 211, "May 31-July 31", (Donnelly 1961). Pulaski Co.; Claytor Lake State Park, 28 June 1973, 1 male, FLC. Roanoke Co.; Roanoke R. at Blue Ridge Parkway, 20 May 1977, 2 males, FLC. Rockingham Co.; Hone Quarry lake and Branch, 1 July 1973, SWD. Southampton Co.; Nottoway R. at Rt. 653, 10 Oct. 1978, 3

males, FLC. Washington Co.; Pond along Rt. 663, 15 June 1980, 1 male, FLC. Wise Co.; North Fork Reservoir at Phillips Cr. Recreation Area at Rt. 834, 12 July 1980, 1 male, FLC. Wythe Co.; Wytheville, 28 June 1935, 3 males, CA, (Det. CA, MDR notes). York Co.; Jones Pd., 15 July 1938, 2 males (observation), MED, (Det. MED, MDR notes). City of Newport News, Reservoir nr. Fort Eustis, 7 July 1938, 2 males, MED and T. D.M., (Det. MED, MDR notes); Lees Mill Pd. at Fort Eustis, 30 July 1938, 1 male (observation), MED, (Det. MED, MDR notes); Mariner's Museum on large pond, 30 July 1938, 1 male (observation), MED, (Det. MED, MDR notes).

Flight Season.--May 12 (TN) to Oct. 10 (VA); in Virginia May 20 to Oct. 10. Known season in neighboring states are: District of Columbia- May 28 to July 27; Kentucky- May to Aug. 4; Maryland- July 6 to 20; North Carolina- June 7 to Aug. 31; Pennsylvania- May 15 to Aug. 7; Tennessee- May 12 to Sept. 4; West Virginia- June 13 to Aug. 13.

Biology.--*Epicordulia princeps* inhabits ponds, lakes, and slow-flowing rivers. Adult males patrol over open water and near shore at from 0.5-2 m above water. Oviposition apparently occurs over open water, the female tapping the water several times while flying erratically. Egg masses are apparently formed but the method of oviposition is seemingly different than that of *Tetragoneuria*.

Remarks.--This species is easily recognized by its large size and large wing spots. Specimens from eastern Virginia are intermediate in wing pattern between the typical *E. princeps* and the larger southern form *E. regina* (Hagen), (FL, GA, LA, and MS). Specimens from the coastal plain of the Carolinas may show that *E. "regina"* merely represents the southern end of a cline in wing pattern and body size.

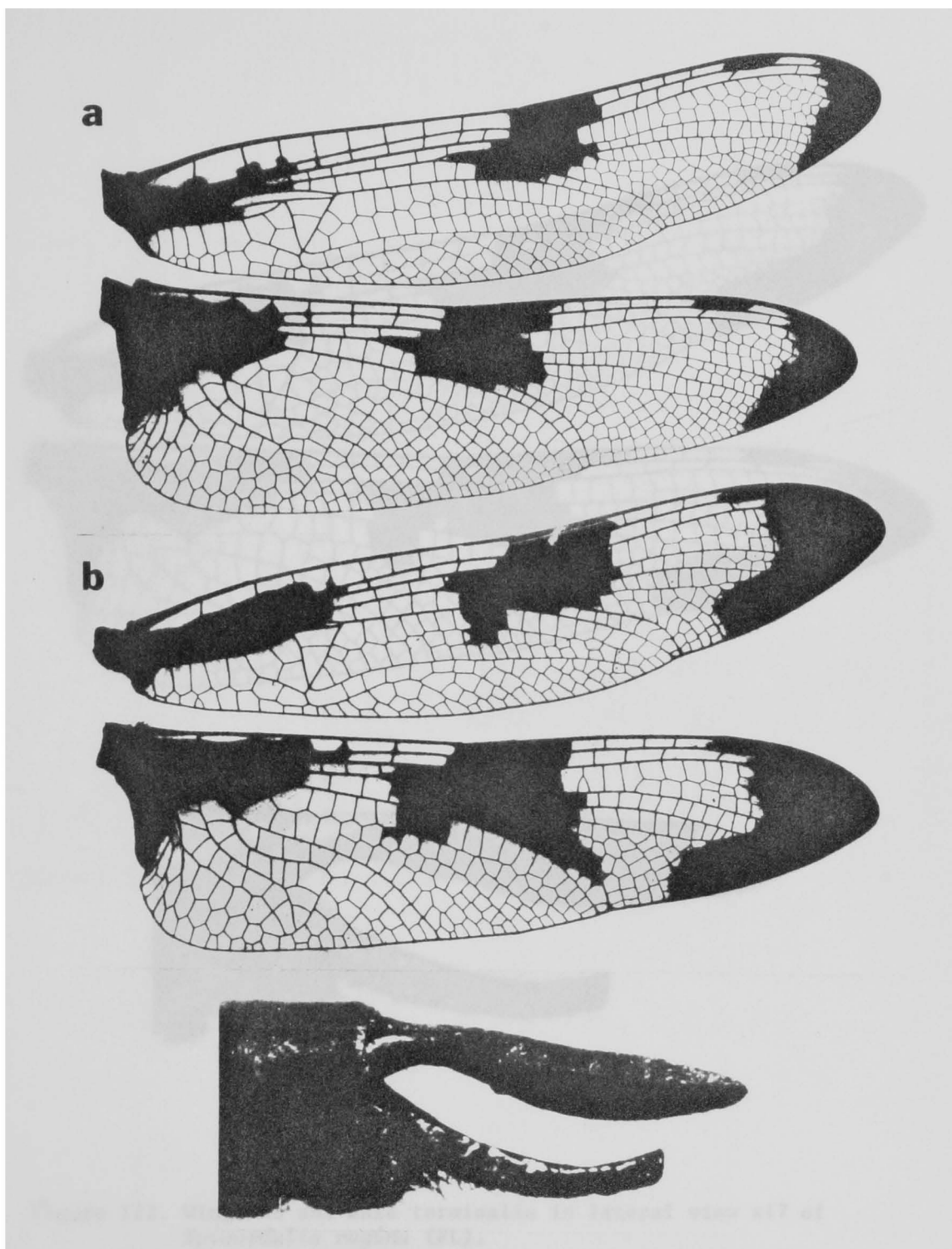


Figure 121. Wings x3: (a) western VA; (b) eastern VA; and male terminalia in lateral view x17 of *Epicordulia princeps*.

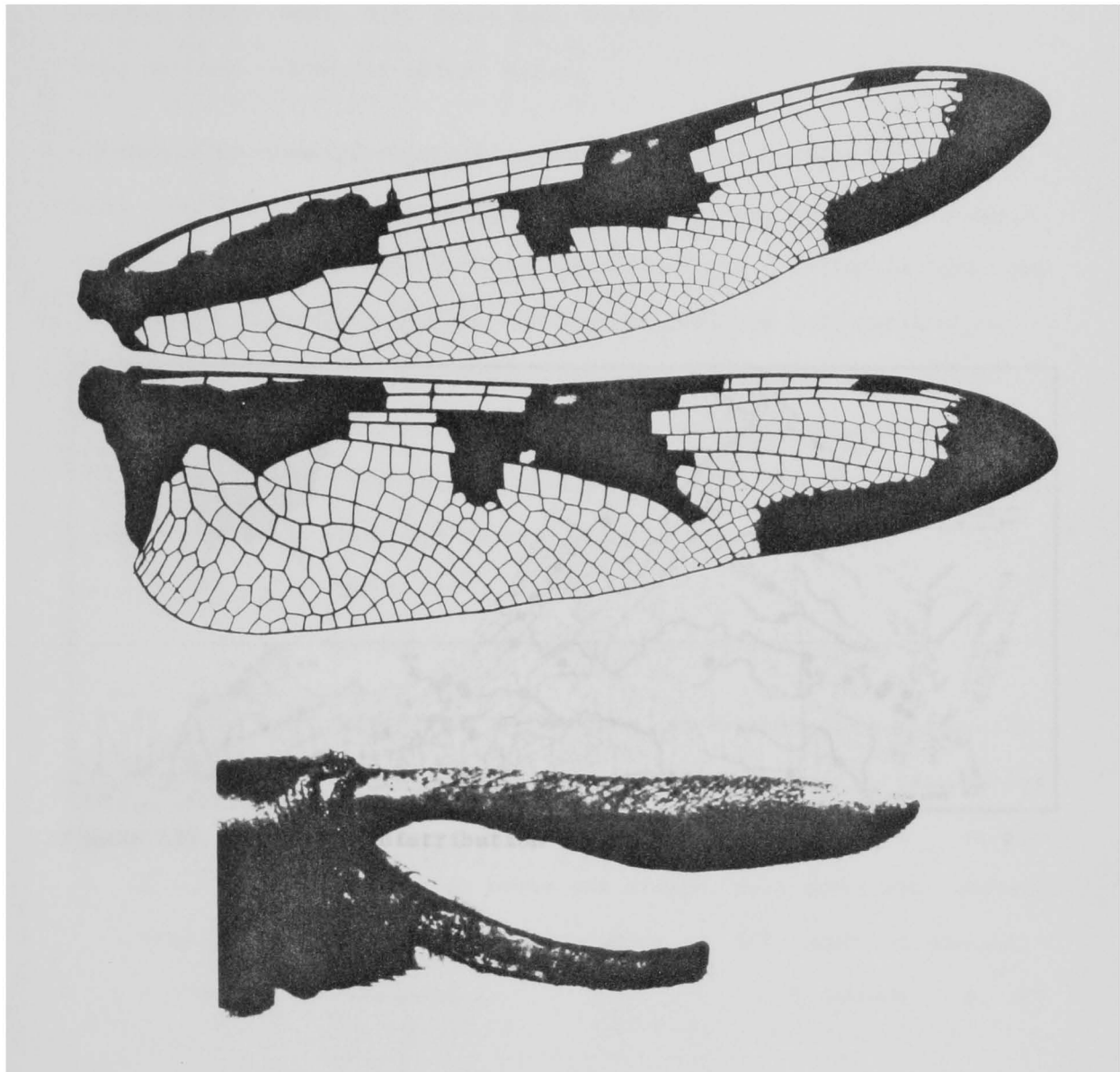


Figure 122. Wings x3 and male terminalia in lateral view x17 of *Epicondulia regina* (FL).

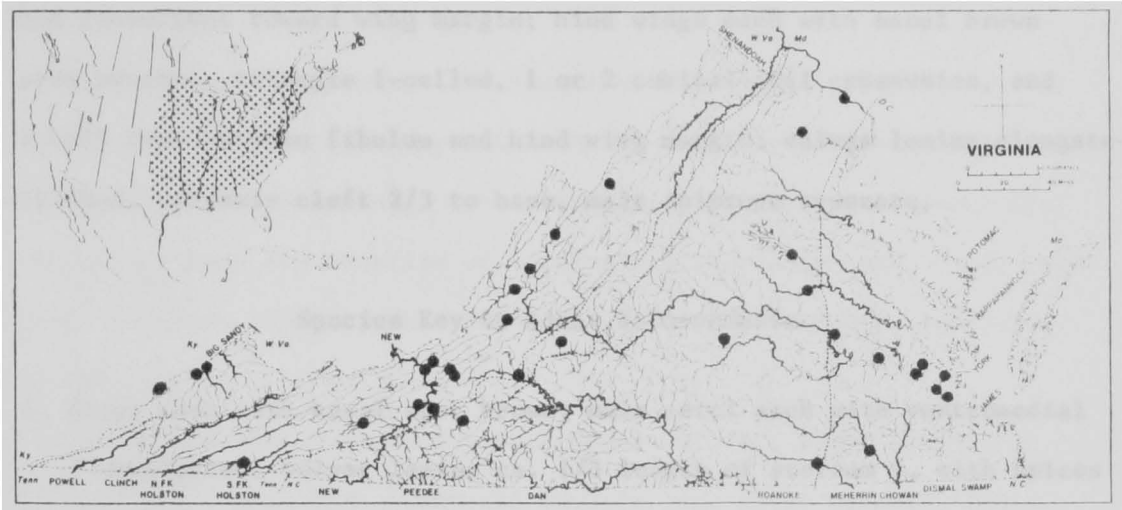


Figure 123. Geographic distribution of *Epicordulia princeps*.

Genus *Helocordulia* Needham 1901

Needham 1901. Bull. N.Y. State Mus. 47:485.

Type Species.--*Cordulia uhleri* Selys.

Diagnosis.--General coloration nonmetallic; male middle tibiae each with keel $3/5$ - $7/10$ length of tibia; fore wings each with basal brown area present, subtriangle 2 or 3-celled, triangle 2-celled, 2 cell rows in trigonal interspace, 1 cell row between Cu_{1l} and CuP , and CuA and CuP convergent toward wing margin; hind wings each with basal brown area present, triangle 1-celled, 1 or 2 cubital-anal crossveins, and 2 cell rows between fibulum and hind wing margin; vulvar lamina elongate-bilobed, narrowly cleft $2/3$ to base, male epiproct truncate.

Species Key to Adult *Helocordulia*

1. Wings each with basal spot brown; male cerci each with ventromedial angulation; vulvar lamina ca. $1/3$ length of sternum 9, with apices divaricate *H. selysii* p. 585
- Wings each with basal spot brown and orange; male cerci each without ventromedial angulation; vulvar lamina ca. $1/2$ length of sternum 9, with apices parallel *H. uhleri* p. 587

Helocordulia selysii (Hagen)

(Figures 124a, 125a, 126a)

Hagen 1878. In Selys, Bull. Acad. Belg. 45:189 (in *Cordulia*).

Length 38-43 mm; abdomen 29-32 mm; hind wings 26-29 mm.

Diagnosis.--Labrum orange, anteclypeus light brown, clypeus light brown, and anterior surface of frons orange; thorax brown with black stripes; wings each without orange area in midbasal space distal to basal brown spot; abdominal segments 4-8 without large ventrobasal orange spots; vulvar lamina ca. 1/3 length of sternum 9, cleft nearly to base, and with lateral lobes divaricate; male cerci each with ventromedial angulation, viewed dorsally inner margins appearing subparallel in apical half.

Distribution.--Known from the states of AL, FL, GA, MS, NC, SC, TX, and VA. Known from the Virginia counties of Brunswick, Campbell, Charlotte, Fluvanna, Lunenburg, Mecklenburg, and Southampton. Known distribution among the counties of neighboring states include: North Carolina- Alamance, Bladen, Chatham, Durham, Guilford, Orange, Scotland, and Wake.

Virginia Records.--Brunswick Co.; Genito Cr. nr. White Plains, 20 Mar. 1977, 1 male, FLC. Campbell Co.; Falling R. at Rt. 615, 2 May 1980, 1 male, BCK. Charlotte Co.; Spring Cr. at Rt. 654, 18 May 1978, 5 males, FLC. Fluvanna Co.; locality unknown, date unknown, 1 male, collector unknown, USNM. Lunenburg Co.; Nottoway R. at Rt. 49, 14 Apr. 1978, 1 male, SWB, FLC Collection. Mecklenburg Co.; Allens Cr. at Rt. 678, 14 Apr. 1978, 1 male, FLC. Southampton Co.; Nottoway R. at Rt. 653, 1 female, FLC.

Flight Season.--Mar. 10 (FL) to May 18 (VA); in Virginia Mar. 20 to May 18. Known season in neighboring states are: North Carolina- Mar. 20 to Apr. 30.

Biology.--*Helocordulia selysii* inhabits slow-flowing streams. Adult males patrol along the shoreline at from 10-50 cm above water. Oviposition (observed only once) occurs near shore, the female tapping the abdomen every 0.5 m or so. Where both species of *Helocordulia* inhabit the same stream *H. selysii* is found where the current is slower and the bottom less rocky, *H. uhleri* is found in the more rapid upstream sections.

Remarks.--This species is more abundant in eastern Virginia than previous records indicate; it has been missed primarily because of its early season.

Helocordulia uhleri (Selys)

(Figures 124b, 125b, 126b)

Selys 1871. Bull. Acad. Belg. 31:274 (in *Cordulia*).

Length 40-46 mm; abdomen 28-34 mm; hind wings 25-29 mm.

Diagnosis.--Labrum orange, anteclypeus whitish, clypeus light brown, and anterior surface of frons orange; thorax orange-brown with black stripes; wings each with orange area in midbasal space distal to basal brown spot; abdominal segments 4-8 with large ventrobasal orange spots; vulvar lamina ca. 1/2 to as long as length of sternum 9, cleft 2/3 to base, and with lateral lobes parallel; male cerci each without ventromedial angulation, viewed dorsally inner margins appearing convergent in apical half.

Distribution.--Known from the states of AL, CT, KY, LA(?), ME, MD, MA, NH, NJ, NY, NC, OK(?), PA, TN, VT, VA, and WV, and the provinces of N.B. N.S., Ont., and Que. Known from the Virginia counties of Alleghany,

Augusta, Bath, Botetourt, Charlotte, Craig, Fairfax, Fluvanna, Giles, Grayson, Hanover, Highland, Louisa, Mecklenburg, Montgomery, Rockbridge, and Stafford. Known distribution among the counties of neighboring states include: Kentucky- Bell, Floyd, Letcher, and McCreary; North Carolina- Durham, Orange, and Wake; Pennsylvania- Centre, Clearfield, Clinton, Fayette, Huntingdon, Lycoming, McKean, Northampton, Pike, Potter, and Somerset; Tennessee- Hardin; West Virginia- Hampshire, Hardy, and Randolph.

Virginia Records.--Alleghany Co.; Griffith, 25 Apr. 1954, 1 female, R. L. Hoffman, USNM; Potts Cr. at Boiling Springs, 13 May 1953, 1 male, R. L. Hoffman, (Det. LKG); Jordan Mines, 13 May 1953, 1 male, R. L. Hoffman, VPI&SU; Potts Cr. at Boiling Springs, 15 May 1951, 2 males, R. L. Hoffman, (Det. LKG). Augusta Co.; Calfpasture R. at Rt. 688 nr. Deerfield, 30 May 1977, 7 males, FLC; Calfpasture R. at Rt. 688, 4 June 1977, 4 males, FLC. Bath Co.; Blowing Springs campground, 29 Apr. 1967, 3 males, OSF, USNM. Botetourt Co.; Patterson Cr. at Rt. 685 ford, 29 May 1977, 1 male, FLC; Craig Cr., 17 June 1978, 1 female, FLC. Charlotte Co.; Twittys Cr. upstream from reservoir, 18 May 1978, 2 males, FLC. Craig Co.; Barbours Cr. at Rts. 611 and 617, 29 May 1973, 5 males, FLC; Barbours Cr. at Rt. 614, 29 May 1977, 1 male, FLC; Barbours Cr., 1 June 1975, 1 male, FLC, VPI&SU; Craig Cr., 23 June 1978, 1 female, FLC. Fairfax Co.; Pohick Cr., date unknown, 1 male, C. Cook, (Det. C. Cook), C. Cook Collection; locality unknown, date unknown, 1 male, C. Cook, (Det. C. Cook), R. L. Hoffman Collection. Fluvanna Co.; locality unknown, date unknown, 1 female, collector unknown, (Det. MDR), USNM. Giles Co.; Mountain Lake, 7 May 1938, 1 male, CC, (Det. MED, MDR notes);

Mountain Lake, 14 June 1974, 4 males, 1 female, FLC; Mountain Lake, 25 June 1935, 9 males, 2 females, CA, (Det. CA); Mountain Lake at Pond Drain Cr., 27 June 1974, 1 male, 1 female, FLC. Grayson Co.; New R. at Rt. 810 nr. Galax, 19 June 1977, 1 male (with nymphal exuviae), BCK. Hanover Co.; N. Anna R. 1 mile W. of Rt. 1, 22 Apr. 1977, 1 male, 2 females (teneral), BCK, FLC Collection. Highland Co.; Shaws Fork at Rt. 250 nr. Headwaters, 30 May 1977, 1 male, FLC. Louisa Co.; N. Anna R. at Rt. 601, 13 May 1978, 1 male, BCK; N. Anna R. at Rt. 601, 27 May 1978, 1 male, BCK; N. Anna R., 2 June 1977, 1 male, BCK; N. Anna R. at Rt. 208, date unknown, nymph, Roback, (Roback and Westfall, 1967). Mecklenburg, 31 May 1980, 1 male, BCK. Montgomery Co.; Poverty Cr. at Rt. 621, 27 May 1962, 2 males, D. Innes, VPI&SU. Rockbridge Co.; Maury R. at Guys Run, 16 June 1979, 1 female, BCK. Stafford Co.; locality unknown, 29 Apr. 1974, 1 male, T. Bailey, VPI&SU.

Flight Season.--Mar. 24 (NC) to July 26 (Que.); in Virginia Apr. 22 (teneral) to June 27. Known season in neighboring states are: Kentucky- May 19 to June; North Carolina- Mar. 24 to Apr. 26; Pennsylvania- May 8 to July 15; West Virginia- June 1 to July 5.

Biology.--*Helocordulia uhleri* inhabits streams and upland lakes. Adult males patrol near shore at from 15-60 cm above the water. Oviposition occurs over open water or near shore while flying at from 5-15 cm above the water and tapping the abdomen every 10-70 cm.

Remarks.--This is a ubiquitous species which is seldom very abundant at any one locality.

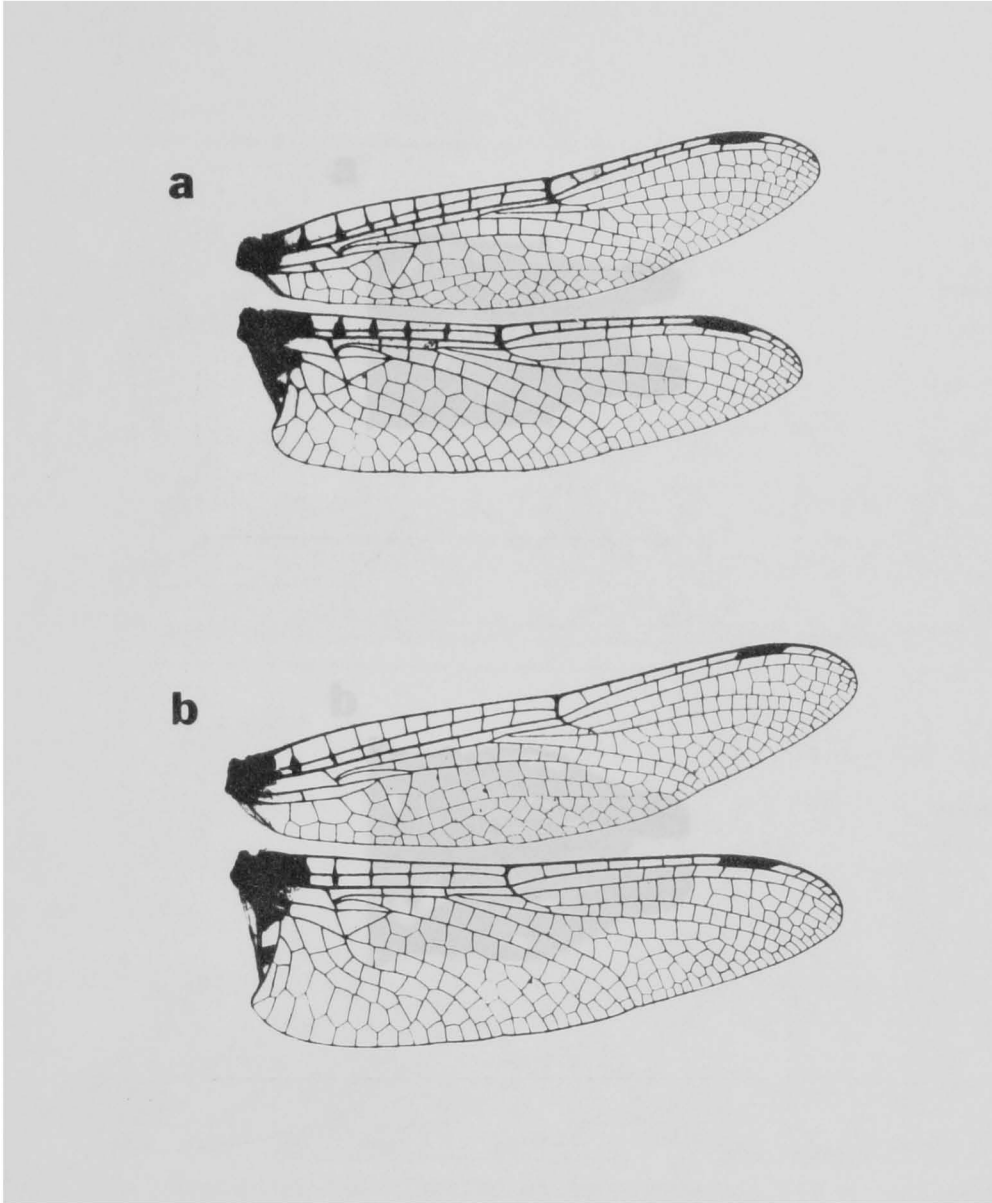


Figure 124. Wings of *Helocordulia* x3: (a) *H. selysii*; (b) *H. uhleri*

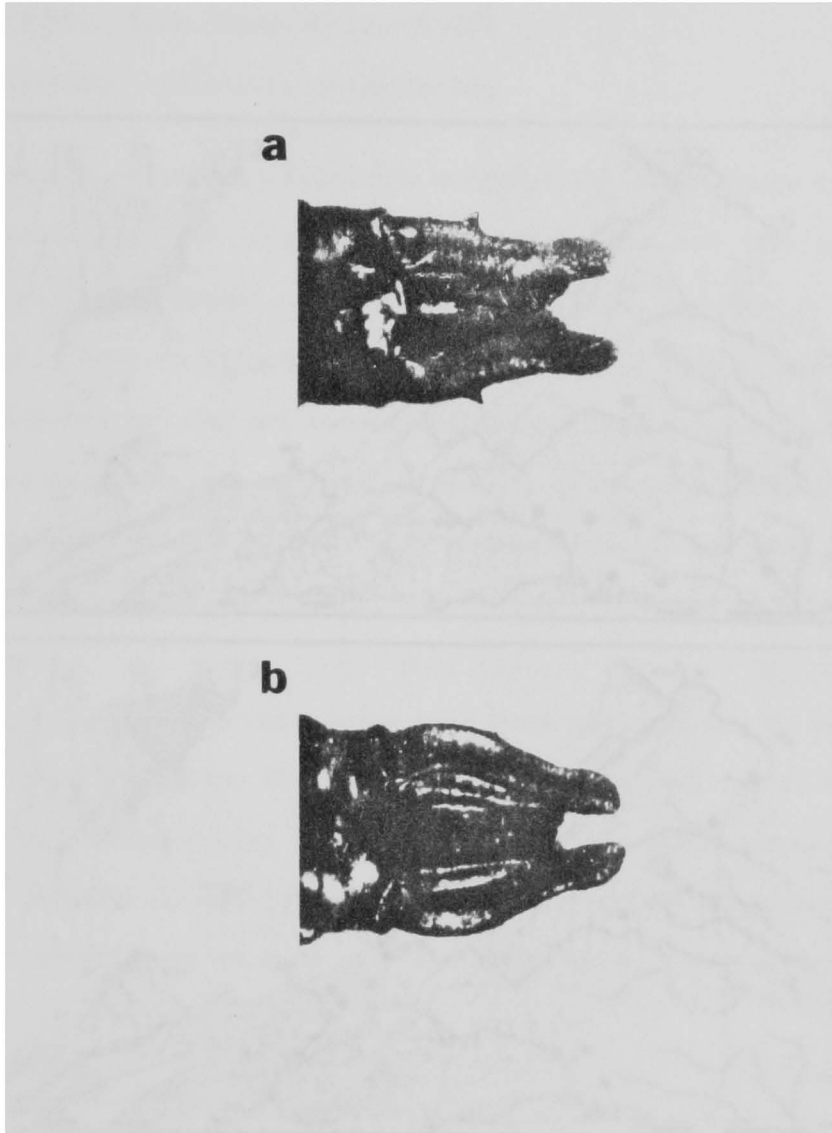


Figure 125. Male terminalia in dorsal view of *Helocentulia* x15:
(a) *H. selysii*; (b) *H. uhleri*.

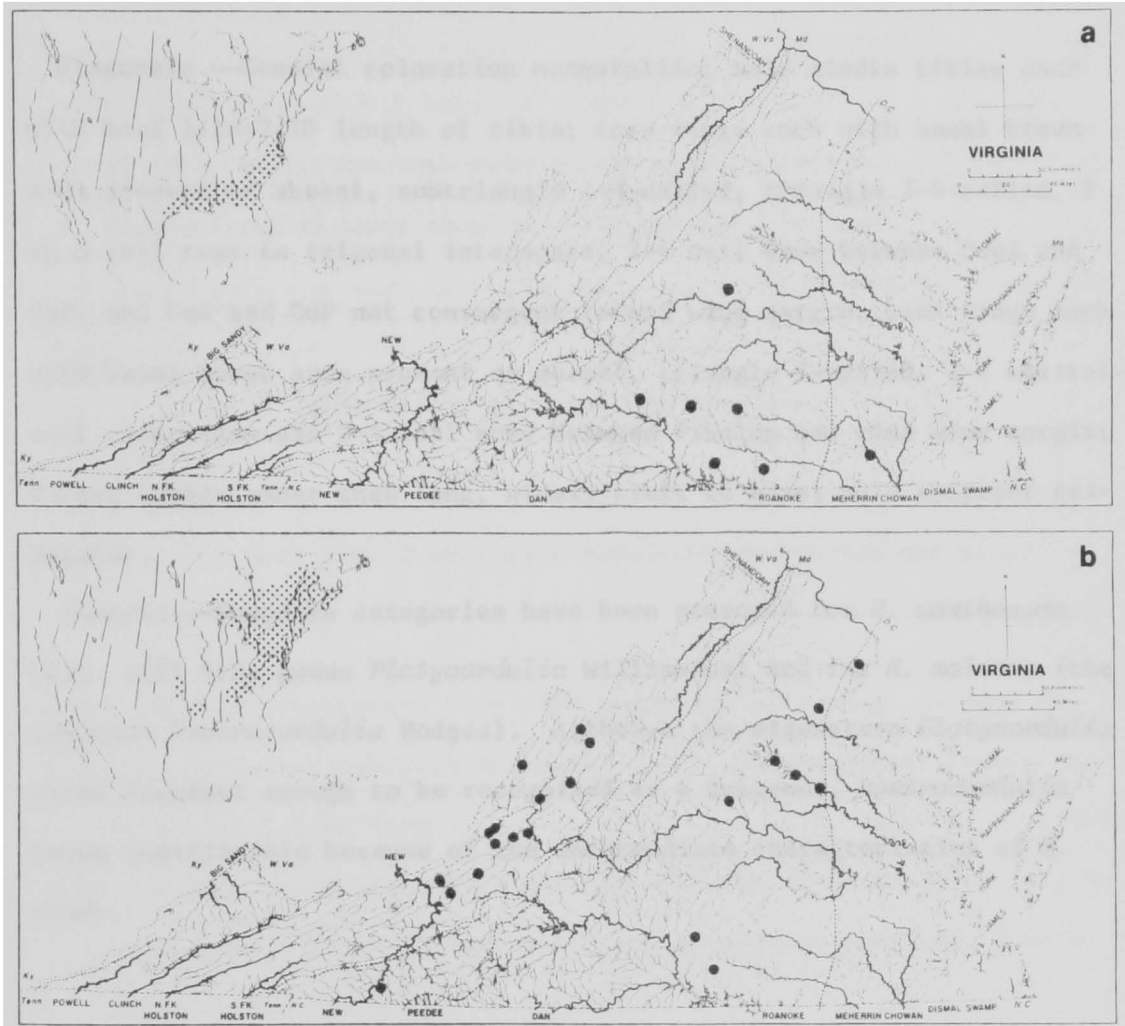


Figure 126. Geographic distribution of *Helocordulia*: (a) *H. selysii*; (b) *H. uhleri*.

Genus *Neurocordulia* Selys 1871Syn.: *Rostrocordulia* Hodges

Selys 1871. Bull. Acad. Belg. 31:278.

Type Species.--*Libellula obsoleta* Say.

Diagnosis.--General coloration nonmetallic; male middle tibiae each with keel 1/10-7/10 length of tibia; fore wings each with basal brown area present or absent, subtriangle 1-3-celled, triangle 2-4-celled, 2 or 3 cell rows in trigonal interspace, 2-4 cell rows between Cu_1 and Cu_P , and Cu_A and Cu_P not convergent toward wing margin; hind wings each with basal brown area present or absent, triangle 2-celled, 2-4 cubital-anal crossveins and 2-4 cell rows between fibulum and hind wing margin; vulvar lamina wider than long, widely cleft to base; male epiproct triangular.

Remarks.--Separate categories have been proposed for *N. xanthosoma* (Fig. 132) (the genus *Platycordulia* Williamson) and for *N. molesta* (the subgenus *Rostrocordulia* Hodges). Although the midwestern *Platycordulia* seems distinct enough to be recognized as a subgenus, *Rostrocordulia* seems questionable because of the intermediate characteristics of *N. clara*.

Subgeneric Key to Adult *Neurocordulia*

1. Hind wings each with 2 cell rows between toe of anal loop and wing margin; fore wings each with 4-6 cell rows in trigonal interspace at level of nodus; male cerci each with ventromedial spine
 *Platycordulia* p. 593
- Hind wings each with 1 cell row between toe of anal loop and wing margin; fore wings each with 3 cell rows in trigonal interspace at level of nodus; male cerci without ventromedial spine
 *Neurocordulia* p. 594

Species Key to Adult *Neurocordulia*

1. Hind wings each with 2 cell rows between fibulum and wing margin.. 2
 Hind wings each with 3 or 4 cell rows between fibulum and wing margin 4
2. Male middle trochanters each with ventroapical process as long as wide; female wings with antenodal spots dark-margined; female cerci 2.4-2.6 mm long *N. molesta* p. 597
- Male middle trochanters each without ventroapical process as long as wide; female wings without antenodal spots dark-margined; female cerci 1.4-2.1 mm long 3

3. Wings with antenodal spots transparent saffron; male fore tibiae each with keel slightly longer than width of tibia; female cerci 1.4-1.6 mm long *N. alabamensis* p. 595
- Wings with antenodal spots opaque brown; male fore tibiae each with keel slightly shorter than width of tibia; female cerci 1.9-2.1 mm long *N. virginiensis* p. 600
4. Wings with antenodal spots dark-margined; male hind tibiae each with keel ca. 1/10 length of tibia; female cerci 2.5-2.7 mm long *N. clara* p. 596
- Wings with antenodal spots not dark-margined; male hind tibiae each with keel ca. 3/5-7/10 length of tibia; female cerci 2.1-2.3 mm long 5
5. Wings each with midbasal crossvein and nodal brown spot; male fore tibiae each with keel ca. 1/2 length of tibia; female cerci 2.1-2.2 mm long *N. obsoleta* p. 599
- Wings each without midbasal crossvein and nodal brown spot; male fore tibiae each with keel ca. 1/4 length of tibia; female cerci 2.2-2.3 mm long *N. yamaskanensis* p. 602

Neurocordulia alabamensis Hodges

(Figures 128a,130a,131a)

Needham and Westfall 1955. Man. Drag. N.A., p. 356.

Length 39-46 mm; abdomen 28-33 mm; hind wings 29-33 mm.

Diagnosis.--Thorax pale brown with metathoracic yellow spot diffuse;

male fore tibiae each with keel less than 1/10 length of tibia; male middle trochanters not produced ventroapically; male middle tibiae each with keel less than 1/10 length of tibia; male hind tibiae each with keel less than 1/10 length of tibia; wings each with antenodal spots transparent saffron yellow, nodal spot vestigial, and midbasal space without crossvein; fore wings each with triangle 2 or 3-celled, 2 cell rows in trigonal interspace at level of nodus, and 1 or 2 cubital-anal crossveins; hind wings each with triangle 2-celled, 2 cubital-anal crossveins, 1 cell row between toe of anal loop and wing margin, 2 cell rows between fibulum and wing margin, and male anal triangle 2-celled; female cerci 1.4-1.6 mm long.

Distribution.--Known from the states of AL, FL, GA, LA, MS, NC, and SC. Known distribution among the states of neighboring counties include: North Carolina- Cumberland, Harnett, Hoke, Jones, Lee, Moore, Pender, Sampson, and Scotland.

Flight Season.--Late May (NC) to Aug. 2 (FL). Known season in neighboring states are: North Carolina- late May to July 18.

Biology.--*Neurocordulia alabamensis* inhabits streams and rivers. Nymphs cling to submerged logs. Adults feed and mate at dusk, the males typically flying at from 10-30 m above water. Oviposition has not been observed.

Remarks.--Although previously not reported from Virginia, this species probably occurs in streams of the Virginia coastal plain.

Neurocordulia clara Muttkowski

(Figures 128b,130b,131b)

Muttkowski 1910. Bull. Wis. Nat. Hist. Soc. 8:170.

Length 41-48 mm; abdomen 33-38 mm; hind wings 32-38 mm.

Diagnosis.--Thorax pale brown with yellow oblong spot surrounding metathoracic spiracle; male fore tibiae each with keel less than 1/10 length of tibia; male middle trochanters not produced ventroapically; male middle tibiae each with keel less than 1/10 length of tibia; male hind tibiae each with keel less than 1/10 length of tibia; wings each with antenodal spots transparent saffron, margined with brown, nodal spot vestigial, and midbasal space generally without crossveins; fore wings each with triangle 3-celled, 3 cell rows in trigonal interspace at level of nodus, and 2 cubital-anal crossveins; hind wings each with triangle 2-celled, 2 cubital-anal crossveins, 1 cell row between toe of anal loop and wing margin, 3 cell rows between fibulum and wing margin, and male anal triangle 2-celled; female cerci 2.5-2.7 mm long.

Distribution.--Known from the states of AL and FL.

Flight Season.--July to Aug.

Biology.--*Neurocordulia clara* inhabits rivers. Adults of this species become active at dusk.

Remarks.--This species has been considered a synonym of *N. obsoleta* and more recently a synonym of *N. molesta*. The male described here is from Gadsden county, Florida. The wing venation and markings are similar to those of the type female which was collected in nearby Alabama. This species may occur in the large coastal plain rivers of Virginia.

Neurocordulia molesta (Walsh)

(Figures 128c,130c,131c)

Walsh 1863. Proc. Entomol. Soc. Phila. 2:254 (in *Cordulia*).

Length 42-53 mm; abdomen 30-37 mm; hind wings 29-38 mm.

Diagnosis.--Thorax brown with oblong yellow spot surrounding metathoracic spiracle; male fore tibiae each with keel $1/10-1/8$ length of tibia; male middle trochanters produced ventroapically; male middle tibiae each with keel $1/10-1/8$ length of tibia; male hind tibiae each with keel $1/10-1/8$ length of tibia; wings each with antenodal spots transparent saffron, margined with light brown, nodal spot vestigial, and midbasal space without crossvein; fore wings each with triangle 2 or 3-celled, 3 cell rows in trigonal interspace at level of nodus, and 2 cubital-anal crossveins; hind wings each with triangle 2-celled, 2 cubital-anal crossveins, 1 cell row between toe of anal loop and wing margin, 2 cell rows between fibulum and wing margin, and male anal triangle 2-celled; female cerci 2.4-2.6 mm long.

Distribution.--Known from the states of AL, FL, GA, IL, IA, KS, KY, LA, MN, OH, OK, NC, SC, TN, TX, and WI. Known distribution among the counties of neighboring states include: Kentucky- Henderson; North Carolina- Cumberland and Harnett; Tennessee- Hardin.

Flight Season.--May 31 (NC) to June 22 (NC). Known season in neighboring states are: Kentucky- June 15; North Carolina- May 31 to June 22; Tennessee- June 2.

Biology.--*Neurocordulia molesta* inhabits rivers. Adults are most active toward dusk.

Remarks.--Although previously unreported from Virginia, this species

probably occurs in small rivers of the lower piedmont and coastal plain of southeastern Virginia.

Neurocorulia obsoleta (Say)

Syn.: *polysticta* Burmeister

(Figures 129a,130d,132a)

Say 1839. Proc. Entomol. Soc. Phila. 8:29 (in *Libellula*).

Length 43-48 mm; abdomen 33-37 mm; hind wings 28-33 mm.

Diagnosis.--Thorax brown with large yellow spot surrounding spiracle; male fore tibiae each with keel $\frac{3}{5}$ length of tibia; male middle trochanters not produced ventroapically; male middle tibiae each with keel $\frac{3}{5}$ length of tibia; male hind tibiae each with keel $\frac{2}{3}$ length of tibia; wings each with antenodal spots transparent brownish saffron, nodal spot well developed, and midbasal space with crossvein; fore wings each with triangle 3-celled, 3 cell rows in trigonal interspace at level of nodus, and 2 or 3 cubital-anal crossveins; hind wings each with triangle 2 or 3-celled, 2-4 cubital-anal crossveins, 1 cell row between toe of anal loop and wing margin, 3 cell rows between fibulum and wing margin, and male anal triangle 3-celled; female cerci 2.1-2.2 mm long.

Distribution.--Known from the states of AL, DC, FL, GA, IL, IN, KY, LA, ME, MD, MA, MI, NH, NV(?), NY, NC, OH, OK, PA, SC, TN, and VA. Known from the Virginia counties of Arlington, Botetourt, Fairfax, Hanover, Henrico, and Nelson. Known distribution among the counties of neighboring states include: Kentucky- Bell and Cumberland; Maryland- Montgomery; North Carolina- Camden, Chatham, Cumberland, Duplin, Durham, Harnett, Hertford,

Duplin, Durham, Harnett, Hertford, Moore, Orange, and Pasquotank; Pennsylvania- Bucks, Dauphin, and Wayne; Tennessee- Davidson and Hamilton.

Virginia Records.--Arlington Co.; locality unknown, spring 1906, N. Banks, (Banks 1907). Botetourt Co.; James R. nr. Buchanan, 24 June 1973, 1 female, FLC. Fairfax Co.; Great Falls, 2 June 1914, 1 male, 1 female, RPC, USNM; Great Falls, 8 June 1952, 1 male, TWD, (Det. TWD). Hanover Co.; S. Anna R. at Rt. 657, 22 Apr. 1978 (emerged 12 May 1978), 1 female, BCK; S. Anna R. at Rt. 657, 12 June 1978, 1 male, JRV, VPI&SU; S. Anna R. falls at Rt. 657, 12 June 1978, 1 female, OSF, USNM. Henrico Co.; James R. at Richmond, date unknown, nymph, Roback, (Roback and Westfall, 1967). Nelson Co.; Wingina, 6 July 1919, 1 female, W. T. Davis, (Det. W. T. Davis, Davis 1927).

Flight Season.--May 2 (NC) to Oct. 23 (TN); in Virginia June 2 to July 6. Known season in neighboring states are: District of Columbia- May 28; Kentucky- June to Aug.; Maryland- May 30 to July 6; North Carolina- May 2 to July 18; Pennsylvania- May 23 to July 23; Tennessee- May 26 to Oct. 23.

Biology.--*Neurocordulia obsoleta* inhabits rivers. Nymphs cling to submerged logs. Adults become active at dusk, the males flying at from 10-40 cm above water.

Remarks.--This species is much more common in Virginia than previous records indicate.

Neurocordulia virginensis Davis

(Figures 129b,130e,132b)

Davis 1927. Bull. Brooklyn Entomol. Soc. 22:155.

Length 42-49 mm; abdomen 31-36 mm; hind wings 32-36 mm.

Diagnosis.--Thorax brown with yellow spot surrounding metathoracic spiracle; male fore tibiae each with keel vestigial; male middle trochanters not produced ventroapically; male middle tibiae each with keel vestigial; male hind tibiae each with keel vestigial; wings each with antenodal spots transparent brownish saffron, nodal spot vestigial, and midbasal space without crossvein; fore wings each with triangle 3-celled, 3 cell rows in trigonal interspace at level of nodus, and 2 cubital-anal crossveins; hind wings each with triangle 2-celled, 2 cubital-anal crossveins, 1 cell row between toe of anal loop and wing margin, 2 cell rows between fibulum and wing margin, and male anal triangle 2-celled; female cerci 1.9-2.1 mm long.

Distribution.--Known from the states of AL, FL, GA, LA, MS, MO, NC, OK, TN, and VA. Known from the Virginia county of Buckingham. Known distribution among the counties of neighboring states include: North Carolina- Chatham and Durham; Tennessee- Hardin.

Virginia Records.--Buckingham Co.; locality unknown, 21 June 1919, 1 female, W. T. Davis, (Det. W. T. Davis, Davis 1927).

Flight Season.--Mar. 18 (FL) to June 24 (AL); in Virginia June 21. Known season in neighboring states are: North Carolina- June 2 to 20; Tennessee- June 1 to 2.

Biology.--*Neurocordulia virginensis* inhabits large rivers. Adults become active at dusk.

Remarks.--This species is more abundant in Virginia than previous

records indicate.

Neurocordulia yamaskanensis (Provancher)

(Figures 129c, 130f, 132c)

Provancher 1875. Nat. Can. 7:248 (in *Aeshna*).

Length 45-55 mm; abdomen 38-41 mm; hind wings 31-35 mm.

Diagnosis.--Thorax brown with round spot surrounding metathoracic spiracle; male fore tibiae each with keel $1/5$ length of tibia; male middle trochanters not produced ventroapically; male middle tibiae each with keel $3/10$ length of tibia; male hind tibiae each with keel $3/4$ length of tibia; wings each with antenodal spots transparent saffron, nodal spot absent, and midbasal space without crossvein; fore wings each with triangle 3-celled, 3 (occasionally 4) cell rows in trigonal interspace at level of nodus, and 2 or 3 cubital-anal crossveins; hind wings each with triangle 2-celled, 2 cubital-anal crossveins, 1 cell row between toe of anal loop and wing margin, 3 cell rows between fibulum and wing margin, and male anal triangle 2-celled; female cerci 2.2-2.3 mm long.

Distribution.--Known from the states of AL, CT, KY, ME, MI, MO, OH, PA, TN, VA, WV, and WI, and the provinces of Ont. and Que. Known from the Virginia counties of Alleghany, Floyd, Giles, Grayson, and Scott. Known distribution among the counties of neighboring states include: Kentucky- Adair, Green, Hart, and Whitley; Pennsylvania- Centre and Perry; West Virginia- Pendleton and Raleigh.

Virginia Records.--Alleghany Co.; Jackson R. at Indian Draft at Rt.

687, 29 May 1977, 2 males, 2 females, FLC. Floyd Co.; Little R. at Rt. 615, 3 June 1977, 1 female, FLC. Giles Co.; New R., 30 May 1968, nymphal exuviae, M. Koszta and M. Williams, VPI&SU; New R. at Spruce Run, 10 June 1974, 1 male, FLC, VPI&SU. Grayson Co.; New R. at Fox above dam, 25 June 1973, 1 male, SWD. Scott Co.; Clinch R. at Speers Ferry, date unknown, nymph, Roback, (Roback and Westfall, 1967).

Flight Season.--May 12 (KY) to Aug. 10 (KY); in Virginia May 29 to June 25. Known season in neighboring states are: Kentucky- May 12 to Aug. 10; Pennsylvania- June 8 to 15; West Virginia- May 29 to July 10.

Biology.--*Neurocordulia yamaskanensis* inhabits rivers. Nymphs have been collected clinging to rocks. Adults become active toward dusk at which time feeding, mating, and oviposition occurs. Adults fly at from 5-30 cm above water, the males often very near shore. Oviposition often occurs at from 1-5 m from shore.

Remarks.--This species is apparently limited in Virginia to upland rivers where it is occasionally observed in great abundance.

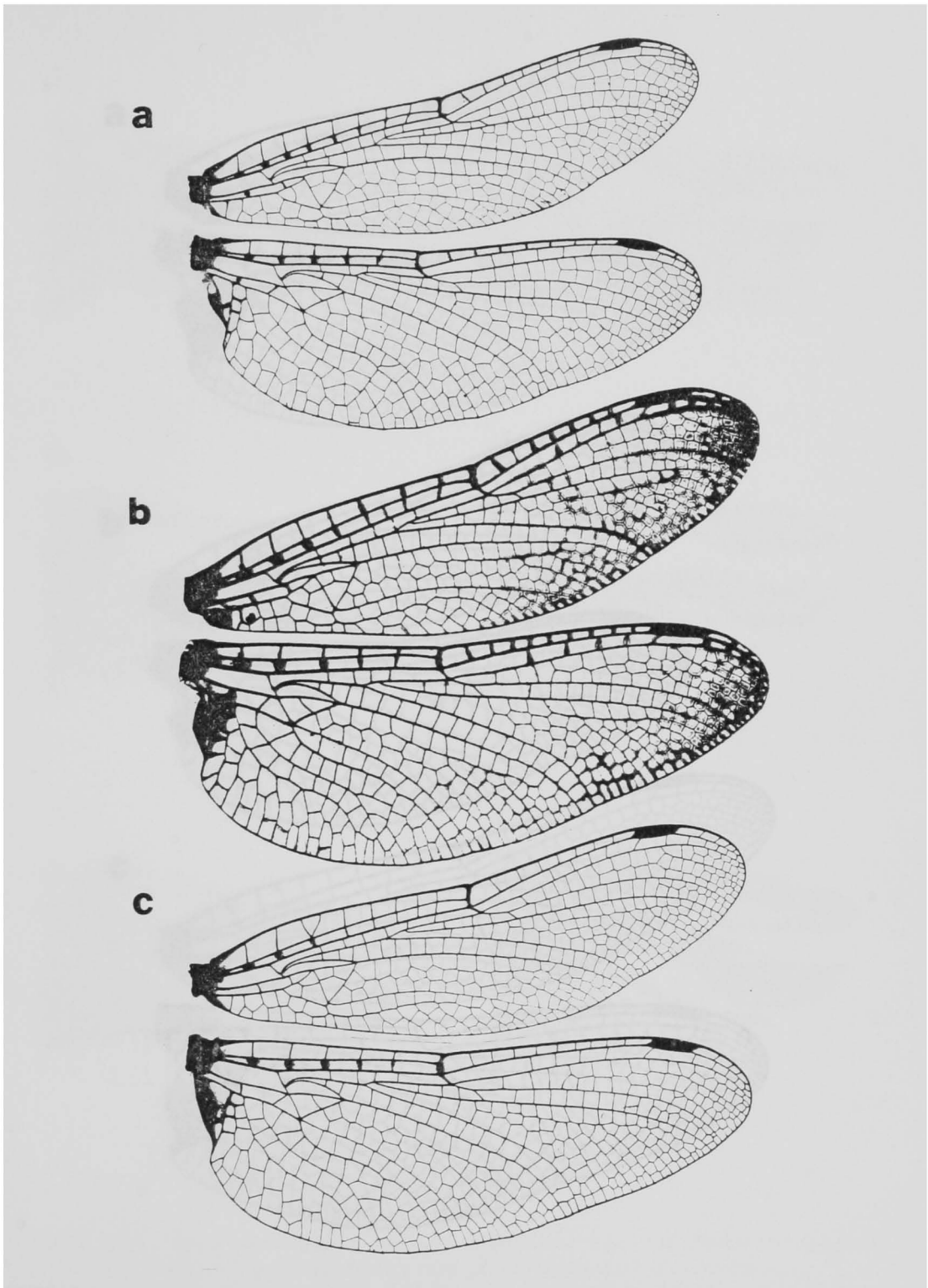


Figure 127. Wings of *Neurocordulia* x3: (a) *N. alabamensis*; (b) *N. clara*; (c) *N. molesta*.

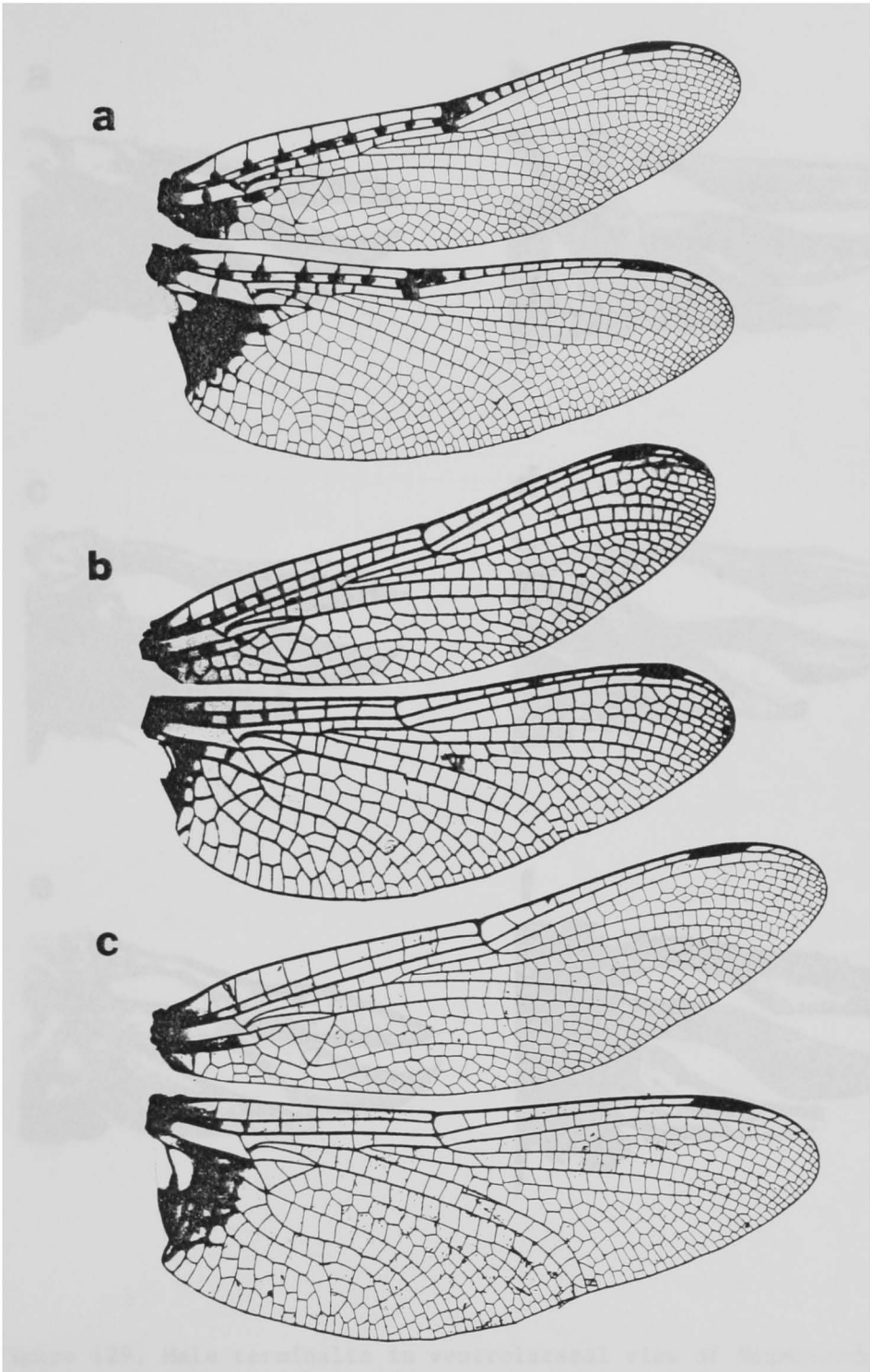


Figure 128. Wings of *Neurocordulia* x3: (a) *N. obsoleta*;
(b) *N. virginiensis*; (c) *N. yamaskanensis*.

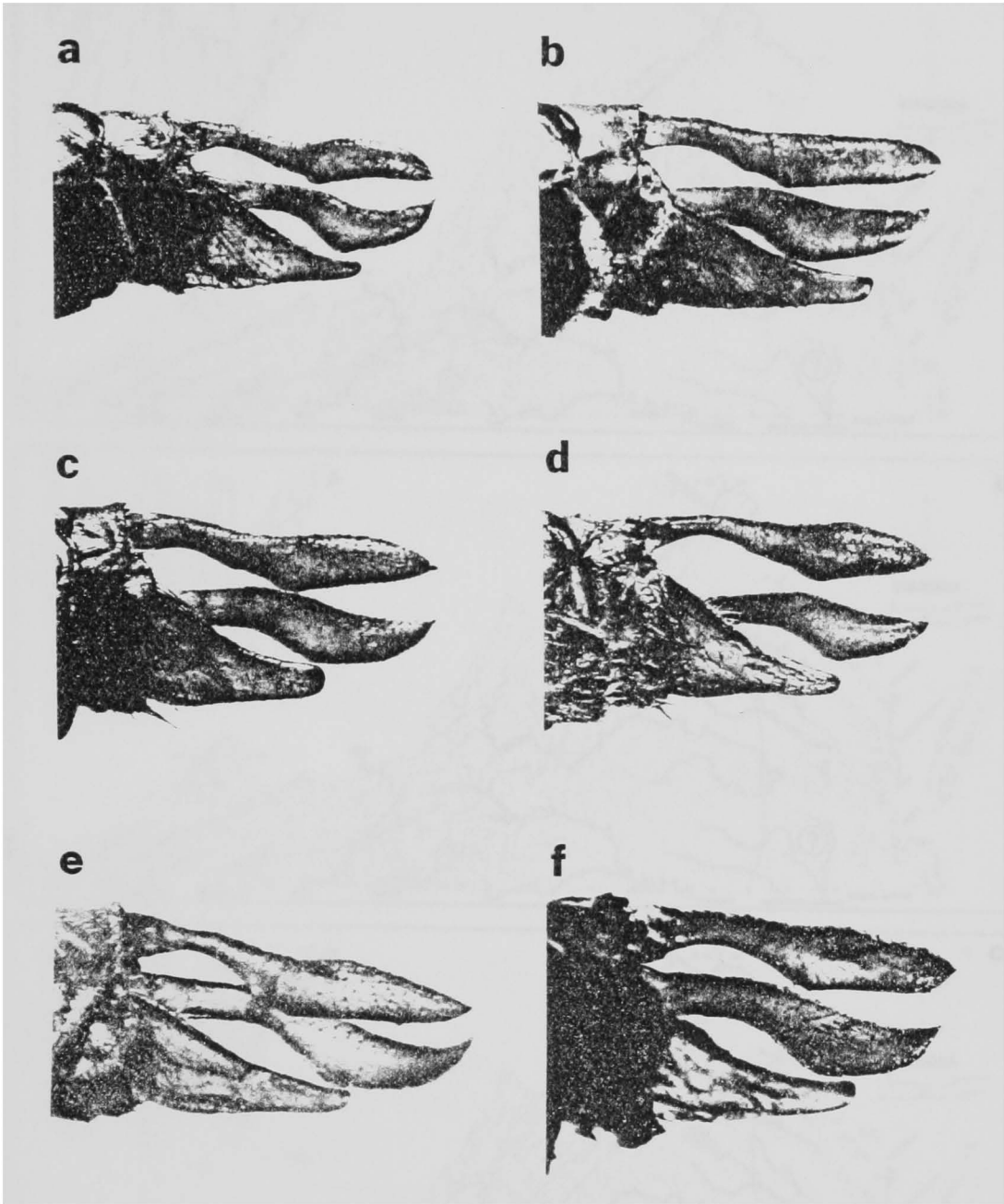


Figure 129. Male terminalia in ventrolateral view of *Neurocordulia* x17:
 (a) *N. alabamensis*; (b) *N. clara*; (c) *N. molesta*;
 (d) *N. obsoleta*; (e) *N. virginiensis*; (f) *N. yamaskanensis*.

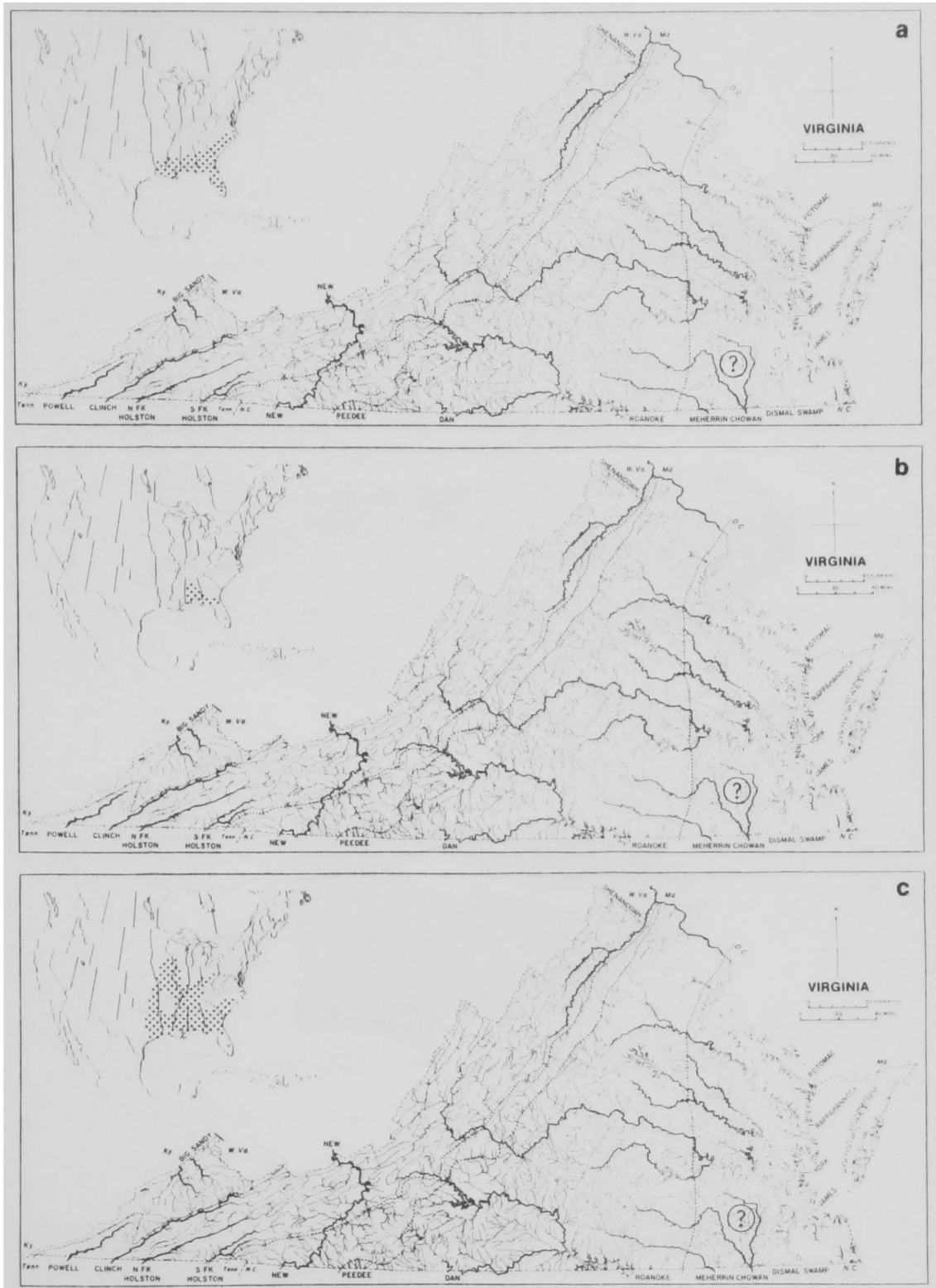


Figure 130. Geographic distribution of *Neurocordulia*: (a) *N. alabamensis*; (b) *N. clara*; (c) *N. molesta*.

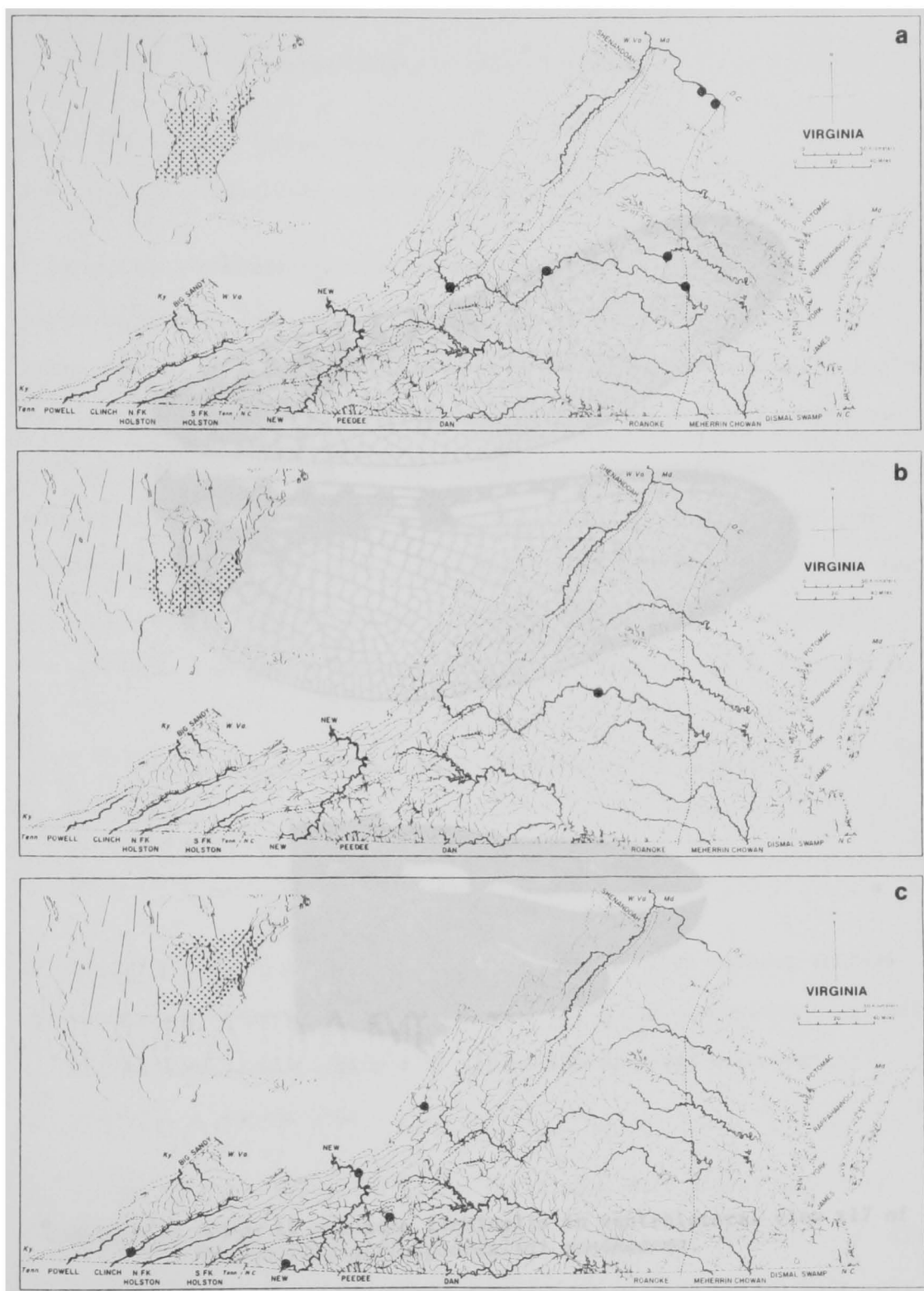


Figure 131. Geographic distribution of *Neurocordulia*: (a) *N. obsoleta*; (b) *N. virginiensis*; (c) *N. yamaskanensis*.

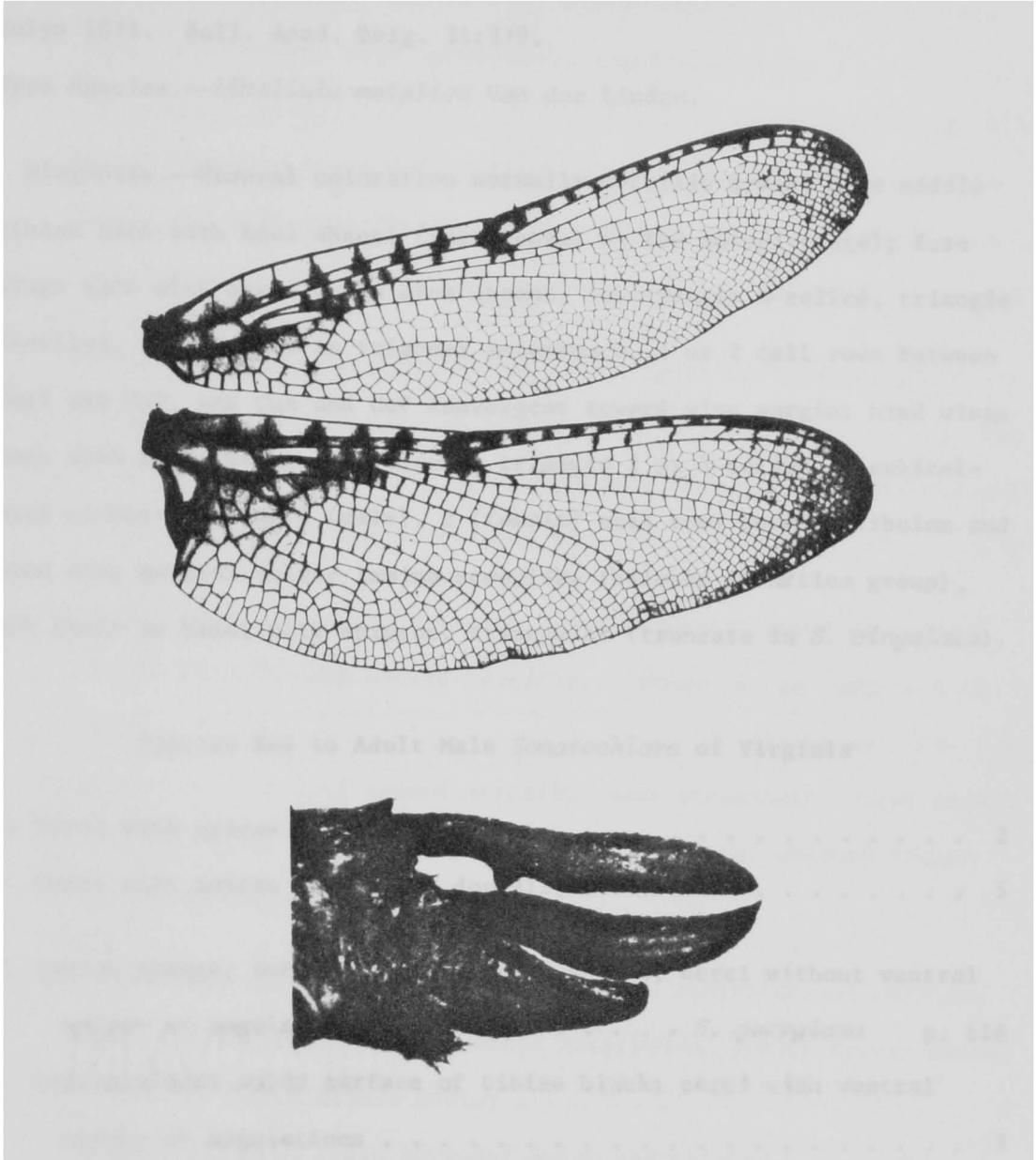


Figure 132. Wings x3 and male terminalia in ventrolateral view x17 of *Neurocordulia (Platycordulia) xanthosoma*.

Genus *Somatochlora* Selys 1871

Selys 1871. Bull. Acad. Belg. 31:279.

Type Species.--*Libellula metalica* Van der Linden.

Diagnosis.--General coloration normally metallic green; male middle tibiae each with keel absent (represented by low apical ridge); fore wings each with basal brown area absent, subtriangle 3-celled, triangle 2-celled, 2 cell rows in trigonal interspace, 1 or 2 cell rows between Cu_{1+2} and Cu_{3+4} , and CuA and CuP convergent toward wing margin; hind wings each with basal brown area absent, triangle 1 or 2-celled, 2 cubital-anal crossveins, and 2 (male), 3 (female) cell rows between fibulum and hind wing margin; vulvar lamina scooplike (bilobed in *Artica* group), not cleft to base; male epiproct triangular (truncate in *S. singularata*).

Species Key to Adult Male *Somatochlora* of Virginia

1. Cerci with apices curved dorsally 2
 Cerci with apices not curved dorsally 5
2. Labrum orange; outer surface of tibiae pale; cerci without ventral
 spines or angulations *S. georgiana* p. 618
 Labrum black; outer surface of tibiae black; cerci with ventral
 spines or angulations 3
3. Abdomen shorter than hind wings; cerci each with apical hair tuft
 and without inner ventrobasal carina *S. walshii* p. 627
 Abdomen longer than hind wings; cerci each without apical hair tuft
 and with inner ventrobasal carina 4

4. Lateral thoracic spots bright yellow; cerci each without subapical hair tuft, and with ventrobasal carina angulate; posterior hamuli each with ventral edge subapically angulate
. *S. elongata* p. 614
- Lateral thoracic spots dull yellow; cerci each with subapical hair tuft, and with ventrobasal carina rounded; posterior hamuli each with ventral edge subapically rounded . . *S. williamsoni* p. 628
5. Lateral thoracic pale spots absent; cerci each with ventroapical spine; postocular margin of head brown . . . *S. linearis* p. 620
- Lateral thoracic pale spots present; cerci each without ventroapical spine; postocular margin of head black 6
6. Epiproct directed upward apically, apex truncate; cerci each with dorsal tubercle and apices barblikeness; abdomen ca. as long as hind wings *S. tenebrosa* p. 624
- Epiproct not directed upward apically, apex acuminate; cerci each without dorsal tubercle and apices not barblikeness; abdomen longer than hind wings 7
7. Mesanepimeral pale spots not extended below ventrolateral carinae; abdominal segments 5-7 with small laterobasal yellow spots; dorsal surface of cerci evenly convex 8
- Mesanepimeral pale spots extended below ventrolateral carinae; abdominal segments 5-7 without small laterobasal yellow spots; dorsal surface of cerci not evenly convex 9

8. Lateral thoracic spots bright yellow; cerci each with lateral tubercle directed ventrad and without lateral carina above lateral tubercle *S. formipata* p. 617
- Lateral thoracic spots dull yellow; cerci each with lateral tubercle directed laterad and with lateral carina above lateral tubercle *S. incurvata* p. 619
9. Mesanepimeral pale stripes narrower than metanepimeral pale stripes; auricles pale; cerci apically divergent . . . *S. filosa* p. 615
- Mesanepimeral pale stripes not narrower than metanepisternal pale stripes; auricles brown; cerci apically convergent *S. provocans* p. 623

Species Key to Adult Female *Somatochlora* of Virginia

1. Vulvar lamina directed ventrally 2
- Vulvar lamina directed posteriorly 6
2. Labrum and medial portion of postclypeus black 3
- Labrum and medial portion of postclypeus yellowish-brown 4
3. Abdominal segments 4-7 without laterobasal yellow spots; lateral thoracic spots bright yellow; posterior opening of vulvar lamina less than 2 times as high as wide *S. elongata* p. 614
- Abdominal segments 4-7 with laterobasal yellow spots; lateral thoracic spots dull yellow; posterior opening of vulvar lamina more than 4 times as high as wide *S. williamsoni* p. 628

4. Tibiae brown; fore wings each with 2 cell rows in trigonal inter-
space at level of nodus; cerci 1.7-2.1 mm long
. *S. georgiana* p. 618
- Tibiae black; fore wings each with 3 cell rows in trigonal inter-
space at level of nodus; cerci 3.6-4.9 mm long 5
5. Postocular margin of head brown; lateral thoracic spots absent; cerci
each with lateroventral carina *S. linearis* p. 620
- Postocular margin of head black; lateral thoracic spots present;
cerci each without lateroventral carina . . *S. tenebrosa* p. 624
6. Abdomen without laterobasal spots on segments 5-7; metanepimeral
pale spots extended below ventrolateral carinae 7
- Abdomen with laterobasal spots on segments 5-7; metanepimeral pale
spots not extended below ventrolateral carinae 8
7. Mesanepimeral pale stripes narrower than metanepimeral pale stripes;
abdominal segment 4 with lateral carinae; cerci longer than vulvar
lamina *S. filosa* p. 615
- Mesanepimeral pale stripes not narrower than metanepimeral pale
stripes; abdominal segment 4 without lateral carinae; cerci
shorter than vulvar lamina *S. provocans* p. 623
8. Length of hind wing ca. equal to length of abdominal segments 1-10;
mesanepimeral yellow spots narrower than metanepimeral pale spots;
apex of vulvar lamina curved ventrally . . . *S. walshii* p. 627
- Length of hind wing ca. equal to length of abdominal segments 1-8;
mesanepimeral yellow spots not narrower than metanepimeral pale
spots; apex of vulvar lamina not curved ventrally 9

9. Lateral thoracic spots bright yellow; vulvar lamina not extended beyond apex of sternum 9 *S. foreipata* p. 617
- Lateral thoracic spots dull yellow; vulvar lamina extended beyond apex of sternum 9 *S. incurvata* p. 619

Somatochlora elongata (Scudder)

Syn.: *saturata* Hagen

(Figures 133a, 138a, 142a, 144a)

Scudder 1866. Proc. Boston Soc. Nat. Hist. 10:218 (in *Cordulia*).

Length 52-62 mm; abdomen 40-48 mm; hind wings 33-38 mm.

Diagnosis.--Labrum black; postocular margin of head black; lateral thoracic spots bright yellow; outer surface of tibiae black; fore wings each with 7-9 antenodal crossveins, and with maximum of 3 cell rows in trigonal interspace; abdominal segments 5-7 with laterobasal yellow spots; female vulvar lamina directed ventrally; male cerci each with apices curved dorsally, lateral carinae well developed in basal 1/3 with small basal tooth, ventral carinae extended to apex and angulate in basal 1/2, and without ventroapical spine; female cerci 3.9-4.5 mm long.

Distribution.--Known from the states of GA, ME, MD, MI, MN, NH, NY, NC, PA, VT, VA, WV, and WI, and the provinces of N.B., N.S., Ont., P.E.I. and Que. Known from the Virginia counties of Giles and Highland. Known distribution among the counties of neighboring states include: Maryland-Montgomery(?); North Carolina- Macon; Pennsylvania- Centre, Clearfield, McKean, Somerset, and Union; West Virginia- Pocahontas, Randolph, and Tucker.

Virginia Records.--Giles Co.; Sylvatica Pd. at Mtn. Lake Bio. Sta., 16 Apr. 1977 (emerged 5, 11 May 1977), 1 male, 2 females, P. K. Powell, VPI&SU; Mtn. Lake, 20 Aug. 1930, nymphs, J. G. Needham, (Det. J. G. Needham). Highland Co.; Buck Run beaver ponds, 8 Aug. 1978, 12 males, 3 females, FLC; Buck Run beaver ponds, 8 Aug. 1978, 1 male, BCK; Bear-wallow Run beaver ponds, 8 Aug. 1978, 3 males, JRV, VPI&SU; Buck Run beaver ponds, 20 Aug. 1978, 10 males, FLC; Buck Run beaver ponds, 31 Aug. to 2 Sept. 1974, 17 males, 1 female, OSF, USNM; Buck Run beaver ponds, 12 Sept. 1979, 1 male, 1 female, BCK.

Flight Season.--May 31 (WV) to Sept. 30 (PA); in Virginia Aug. 8 to Sept. 12. Known season in neighboring states are: Maryland- July 23; North Carolina- June 13 to Sept. 5; Pennsylvania- July 8 to Sept. 30; West Virginia- May 31 to Aug. 8.

Biology.--*Somatochlora elongata* inhabits pools of streams, ponds, and lake outlets. Adult males patrol near shore at from 30-60 cm above water. Oviposition occurs in and about emergent vegetation near shore.

Remarks.--This species is the most abundant *Somatochlora* inhabiting the upland ponds of western Virginia.

Somatochlora filosa (Hagen)

(Figures 133b, 138b, 142b, 144b)

Hagen 1861. Syn. Neur. N. Amer., p. 136 (in *Cordulia*).

Length 54-66 mm; abdomen 42-52 mm; hind wings 36-45 mm.

Diagnosis.--Labrum yellowish-brown; postocular margin of head black; lateral thoracic spots bright yellowish-white; outer surface of tibiae

dark brown; fore wings each with 7-9 antenodal crossveins, and with maximum of 3 cell rows in trigonal interspace; abdominal segments 5-7 without laterobasal yellow spots; female vulvar lamina directed posteroventrally; male cerci each with apices not curved dorsally, lateral carinae well developed in basal 1/3 without basal tooth or angulation, ventral carinae extended to apex and evenly convex in basal 1/2, and without ventroapical spine; female cerci 3.9-4.5 mm long.

Distribution.--Known from the states of AL, DC, FL, GA, IL, KY, MD, MS, NJ, NC, PA, SC, TN, and VA. Known from the Virginia county of Southampton, and the cities of Norfolk and Suffolk. Known distribution among the counties of neighboring states include: Kentucky- Edmonson, Fulton, and Union; Maryland- Calvert; North Carolina- Beaufort, Brunswick, Craven, Moore, Onslow, Pamlico, Pitt, and Wake; Pennsylvania- Delaware; Tennessee- Davidson and Van Buren.

Virginia Records.--Southampton Co.; Nottoway R. at Rt. 753, 10 Oct. 1978, 11 males, 2 females, FLC. City of Norfolk, locality unknown, 10 July 1973, 1 male, P. W. Larkins, VPI&SU. City of Suffolk; Dismal Swamp Wildlife Refuge, 12 Aug. 1974, 1 male, 1 female, J. Hancock, ODU; Cypress Chapel, 13 Sept. 1934, 1 male, LKG, (Det. LKG, Gloyd 1951); Cypress Chapel, 14 Sept. 1934, 4 males, 3 females, LKG and H. K. Gloyd, (Det. LKG, Gloyd 1951); Dismal Swamp Wildlife Refuge, 14 Sept. 1974, 1 male, P. Schucht, ODU; Lake Drummond, 28 Sept. 1915, 1 female, H. S. Barber, USNM.

Flight Season.--June 2 (TN) to Dec. 21 (FL); in Virginia July 10 to Oct. 10. Known season in neighboring states are: District of Columbia- Sept. 13; Kentucky- June 27 to July; Maryland- Aug. 22 to Sept. 7; North Carolina- July 10 to Oct. 15; Pennsylvania- June 24 to July 7; Tennessee-

June 2 to July 6.

Biology.--The nymphal habitat of *S. filosa* is unknown, the nymphal stage being known only from specimens reared from eggs. Adults feed along road cuts and along the edges of fields, generally flying at from 1-3 m.

Remarks.--This species is relatively common on the Virginia coastal plain; the nymphal habitat may be the upper reaches of small slow-flowing streams.

Somatochlora forcipata (Scudder)

Syn.: *chalybea* Hagen

(Figures 134a, 138c, 142c, 144c)

Scudder 1866. Proc. Boston Soc. Nat. Hist. 10:216 (in *Cordulia*).

Length 43-52 mm; abdomen 34-40 mm; hind wings 29-33 mm.

Diagnosis.--Labrum brown and black; postocular margin of head black; lateral thoracic spots bright yellow; outer surface of tibiae black; fore wings each with 7-10 antenodal crossveins, and with maximum of 2 or 3 cell rows in trigonal interspace; abdominal segments 5-7 with laterobasal yellow spots; female vulvar lamina directed posteroventrally; male cerci each with apices not curved dorsally, lateral carinae well developed in basal 1/2 and apical 1/3 (with basal lobe), ventral carinae extended to apex and evenly convex in basal 1/2, and without ventrolateral spine; female cerci 2.8-3.4 mm long.

Distribution.--Known from the states of ME, MI, NH, PA, VT, WV, and WI, and the provinces of Alta., Labr., Man., N.B., Nfld., NW. Terr.,

N.S., Ont., and Que. Known distribution among the counties of neighboring states include: Pennsylvania- Clearfield, Clinton, Monroe, and Tioga; West Virginia- Pocahontas.

Flight Season.--May 27 (Que.) to Aug. 27 (Que.). Known season in neighboring states are: Pennsylvania- June 1 to July 15; West Virginia- Aug. 11 to 13.

Biology.--*Somatochlora forcipita* inhabits small, spring-fed boggy streams. Adults feed along road cuts and forest openings at from 1-2 m. Males reportedly patrol along spring seeps at from 30-70 cm above water. Oviposition reportedly occurs in small pools along the course of spring seeps.

Remarks.--Although this species is previously unreported from Virginia, it undoubtedly occurs in the boggy streams of mountain plateaus. It is known from the nearby Cranberry Bog in West Virginia.

Somatochlora georgiana Walker

(Figures 134b, 139a, 142d, 145a)

Walker 1925. N. Amer. *Somatochlora*, p. 98.

Length 46-49 mm; abdomen 33-37 mm; hind wings 31-34 mm.

Diagnosis.--Labrum yellowish-brown; postocular margin of head brown; lateral thoracic spots bright yellowish-white; outer surface of tibiae yellowish-white; fore wings each with 6 or 7 antenodal crossveins, and with maximum of 2 cell rows in trigonal interspace; abdominal segments 5-7 without laterobasal yellow spots; female vulvar lamina directed ventrally; male cerci each with apices curved dorsally, lateral carinae

well developed in basal 1/2 without basal tooth or angulation, ventral carinae extended to apex and evenly convex in basal 1/2, and without ventroapical spine; female cerci 1.7-2.1 mm long.

Distribution.--Known from the states of AL, FL, GA, LA, MA, MS, NC, SC, TX, and VA. Known from the Virginia county of Charlotte. Known distribution among the counties of neighboring states include: North Carolina- Duplin, Durham, Moore, and Orange.

Virginia Records.--Charlotte Co.; Twittys Cr. at Rt. 642, 14 June 1975, 2 males, FLC; Twittys Cr. at Rt. 642, 12 July 1974, 1 female, FLC, FSCA; Twittys Cr. at Rt. 642, 22 July 1978, 2 females, FLC.

Flight Season.--June 14 (VA) to Aug. 23 (SC); in Virginia June 14 to July 22. Known season in neighboring states are: North Carolina- June 27 to July 12.

Biology.--*Somatochlora georgiana* apparently inhabits pools of streams. Adults feed at from 10-20 cm above roads and over forests. Adults fly erratically when apparently drinking at forest pools. Males patrol (observed only twice) at from 1-3 m over the stream in a somewhat undulating flight. Oviposition occurs at midstream while flying in a very erratic manner 2-20 cm over water.

Remarks.--This species is probably much more abundant than previously reported. It seems limited to the Piedmont in Virginia.

Somatochlora incurvata Walker

(Figures 135a, 139b, 142e, 145b)

Walker 1918. Can. Entomol. 50:365.

Length 49-59 mm; abdomen 38-47 mm; hind wings 31-37 mm.

Diagnosis.--Labrum black; postocular margin of head black; lateral thoracic spots dull yellow; outer surface of tibiae black; fore wings each with 7-9 antenodal crossveins, and with maximum of 3 cell rows in trigonal interspace; abdominal segments 5-7 with laterobasal yellow spots; female vulvar lamina directed posteriorly; male cerci each with apices not curved dorsally, lateral carinae extended to apex with basal angulation, ventral carinae extended to apex and evenly convex in basal 1/2, and without ventroapical spine; female cerci 3.1-3.6 mm long.

Distribution.--Known from the states of ME, MI, and PA, and the provinces of N.S. and Ont. Known distribution among the counties of neighboring states include: Pennsylvania- Clinton.

Flight Season.--July 18 (PA) to Oct. 15 (Canada). Known season in neighboring states are: Pennsylvania- July 18 to Aug. 9.

Biology.--*Somatochlora incurvata* inhabits sphagnum pools. Adult males reportedly hover 1-2 m above bog pools. Oviposition reportedly occurs in the water or mud of bog pools.

Remarks.--This wide-ranging but extremely local species may occur in Virginia. Unfortunately the most likely locality for its occurrence in Virginia (Laurel Bed), a large sphagnum bog in Russell county has been inundated.

Somatochlora linearis (Hagen)

Syn.: *procera* Selys

(Figures 135b, 139c, 142f, 145c)

Hagen 1861. Syn. Neur. N. Amer., p. 137 (in *Cordulia*).

Length 58-68 mm; abdomen 44-55 mm; hind wings 39-47 mm.

Diagnosis.--Labrum yellowish-brown; postocular margin of head brown; lateral thoracic spots absent; outer surface of tibiae dark brown; fore wings each with 7-11 antenodal crossveins, and with maximum of 3 cell rows in trigonal interspace; abdominal segments 5-7 with obscure laterobasal yellow spots; female vulvar lamina directed ventrally; male cerci each with apices not curved dorsally, lateral carinae well developed in basal 2/3 with basal tooth, ventral carinae level and well developed in basal 1/2, and with ventroapical spine; female cerci 4.5-4.9 mm long.

Distribution.--Known from the states of AL, AR, CT, FL, GA, IL, IN, KY, LA, MI, MS, MO, NJ, NY, NC, OH, OK, PA, SC, TN, TX, VA, and WV, and the province of Que.(?). Known from the Virginia counties of Bath, Charlotte, Craig, Fairfax, Montgomery, Nelson, Prince William, and Southampton, and the city of Suffolk. Known distribution among the counties of neighboring states include: Kentucky- Breckinridge, Edmonson, Fayette, Green, Hart, Pulaski, Trigg, Union, and Warren; Pennsylvania- Bucks, Carteret, Centre, and Greene; Tennessee- Grainger and Knox; West Virginia- Putnam and Ritchie.

Virginia Records.--Bath Co.; Jackson R. at Hidden Valley, 18 July 1973, 2 males, FLC. Charlotte Co.; Twittys Cr. at Rt. 642, 24 July 1973, 2 females, FLC. Craig Co.; Craig Cr. at Rt. 621, 10 Aug. 1973, 1 female, FLC; Craig Cr. at Rt. 621, 12 Aug. 1973, 1 male, FLC. VPI&SU; Craig Cr. at Rt. 621, 28 Aug. 1973, 1 male, FLC. Fairfax Co.; Bull Run nr. Centreville, 15 Aug. 1953, 1 female, TWD, (Det. TWD, Donnelly, field

notes). Montgomery Co.; Poverty Cr. 0.1 mile downstream from Pandapas Pd., 12 Aug. 1973, 3 males, FLC; Poverty Cr. downstream from Pandapas Pd., 15 Aug. 1978, 7 males, 1 female, FLC; locality unknown, 24 Aug. 1976, 1 female, T. Bailey, VPI&SU. Nelson Co.; Wingina, 5 Aug. 1916, 1 male, W. T. Davis, (Det. E. M. Walker, Walker 1925). Prince William Co.; Independent Hill, 29 July 1951, 1 male, C. Cook, FSCA. Southampton Co.; Assamoosick Swamp at Rt. 35, 10 Oct. 1978, 3 males, FLC; Nottoway R. at Rt. 653, 10 Oct. 1978, 1 male, 1 female, FLC; Nottoway R. at Rt. 753, 10 Oct. 1978, 1 female, FLC. City of Suffolk, Jericho Lane in Dismal Swamp Wildlife Refuge, 22 June 1975, 1 female (slightly teneral), FLC; Dismal Swamp Wildlife Refuge, 5 Aug. 1974, 1 male, J. Hancock, ODU; Dismal Swamp Wildlife Refuge, 12 Aug. 1974, 1 male, 1 female, J. Hancock, ODU; Dismal Swamp Wildlife Refuge, 14 Sept. 1974, 1 female, P. W. S., ODU; Dismal Swamp Wildlife Refuge, 15 Sept. 1974, 1 male, JFM, ODU; locality unknown, 20 Sept. 1975, 1 male, J. F. B., ODU.

Flight Season.--June 1 (IN) to Oct. 10 (VA); in Virginia June 22 (slightly teneral) to Oct. 10. Known season in neighboring states are: Kentucky- June 10 to Sept. 15; Pennsylvania- June 16 to Aug. 31; Tennessee- July 11 to Aug. 15; West Virginia- June 4 to Aug. 10.

Biology.--*Somatochlora linearis* inhabits small forest streams. Adults feed along road cuts and forest openings at from 1-5 m. Males patrol at from 10-50 cm above streams. Oviposition is generally in wet sand or gravel bordering a riffle, however it has also been observed in water and in dry sand. The adults frequently alight upon tree trunks from 1-4 m above the ground along dark forest streams.

Remarks.--This species is perhaps the most abundant *Somatochlora* in

Virginia.

Somatochlora provocans Calvert

(Figures 136a, 140a, 143a, 146a)

Calvert 1903. Entomol. News 14:39.

Length 53-57 mm; abdomen 37-43 mm; hind wings 33-38 mm.

Diagnosis.--Labrum yellowish-brown; postocular margin of head black; lateral thoracic spots bright yellowish-white; outer surface of tibiae dark brown; fore wings each with 7 or 8 antenodal crossveins, and with maximum of 3 cell rows in trigonal interspace; abdominal segments 5-7 without laterobasal yellow spots; female vulvar lamina directed posteriorly; male cerci each with apices not curved dorsally, lateral carinae well developed in basal 1/2 without basal tooth or angulation, ventral carinae extended to apex and evenly convex in basal 1/2, and without ventroapical spine; female cerci 2.1-2.3 mm long.

Distribution.--Known from the states of AL, FL, GA, KY, MS, NJ, NC, PA, TN, and VA. Known from the Virginia city of Suffolk. Known distribution among the counties of neighboring states include: Kentucky- Green and Trigg; North Carolina- Edgecombe, Moore, Wayne, and Wilson; Pennsylvania- Wayne; Tennessee- Sevier.

Virginia Records.--City of Suffolk; Jericho Lane in Dismal Swamp Wildlife Refuge, 22 June 1975, 1 female, FLC.

Flight Season.--June 22 (VA) to Aug. 28 (FL); in Virginia June 22. Known season in neighboring states are: Kentucky- June 28; North Carolina- June 23 to July 30; Pennsylvania- Aug.; Tennessee- July 12.

Biology.--*Somatochlora provocans* apparently inhabits the upper reaches of small slow-flowing streams. Adults frequent road cuts and forest openings toward dusk, generally flying and resting on trees at from 5-15 m above ground. Oviposition (observed at only one locality) occurs in wet mud bordering small streams.

Remarks.--This species is much more common on the coastal plain than previous records indicate; it is among the most difficult to collect of all Anisoptera.

Somatochlora tenebrosa (Say)

Syn.: *tenebrica* Hagen

(Figures 136b, 140b, 143b, 146b)

Say 1839. J. Acad. Phila. 8:19 (in *Libellula*).

Length 48-64 mm; abdomen 35-40 mm; hind wings 34-41 mm.

Diagnosis.--Labrum yellowish-brown; postocular margin of head black; lateral thoracic spots dull yellow; outer surface of tibiae dark brown; fore wings each with 7-10 antenodal crossveins, and with maximum of 3 cell rows in trigonal interspace; abdominal segments 5-7 without laterobasal yellow spots; female vulvar lamina directed ventrally; male cerci each with apices not curved dorsally, lateral carinae well developed in basal 1/3 without basal tooth or angulation, ventral carinae extended to apex and evenly concave, and without ventroapical spine; female cerci 3.6-4.5 mm long.

Distribution.--Known from the states of AL, CT, FL, GA, IL, IN, IA, KS, KY, ME, MD, MA, MI, MS, MO, NH, NJ, NY, NC, OH, PA, RI, SC, TN, VA, VT, and

WV, and the provinces of N.S., Ont., and Que. Known from the Virginia counties of Alleghany, Charles City, Charlotte, Craig, Fairfax, Giles, Hanover, Highland, James City, Louisa, Montgomery, Nelson, Prince William, Rockbridge, Spotsylvania, Wythe, and York. Known distribution among the counties of neighboring states include: Kentucky- Edmonson, Floyd, Fulton, Green, Letcher, Pulaski, and Trigg; North Carolina- Edgecombe, Macon, Transylvania, Wake, and Watauga; Pennsylvania- Bucks, Cambria, Centre, Clearfield, Clinton, Delaware, Elk, Huntingdon, Lancaster, Lebanon, Luzerne, Monroe, Northampton, Philadelphia, Pike, Somerset, Union, Warren, Washington, Wayne, and Westmoreland; Tennessee- Carter, Coffee, Cumberland, Grundy, Johnson, and Knox; West Virginia- Pocahontas.

Virginia Records.--Alleghany Co.; 2.5 miles S.E. of Longdale Furnace, 18 Sept. 1934, 1 male, LKG and H. K. Gloyd, (Det. LKG, Gloyd 1951). Charles City Co.; Rt. 5 at Rt. 602, 5 July 1938, 1 male, MED, (Det. MED, MDR notes). Charlotte Co.; Twittys Cr. at Rt. 642, 14 June 1975, 2 males, FLC; Twittys Cr. dam, 18 June 1975, 1 male, FLC; Horsepen Cr. at Rt. 637, 23 July 1974, 1 female, FLC; Twittys Cr. at Rt. 642, 24 July 1973, 2 males, 1 female, FLC; Twittys Cr. at Rt. 642, 25 Aug. 1975, 1 female, FLC. Craig Co.; Rt. 604, 16 July 1975, 1 female, SWB, VPI&SU. Fairfax Co.; Mt. Vernon, 6 July 1918, 1 female, E. Shoemaker, (Det. E. M. Walker), W&M. Giles Co.; Mtn. Lake, 15 Aug. 1949, 1 male, C. F. Byers, (Det. C. F. Byers, Byers 1951); Mtn. Lake, 20 Aug. 1944, 1 male, J. S. Rogers, (Det. J. S. Rogers), MZUM; Mtn. Lake, 25 Aug. 1899, 1 female, C. L. Pollard, USNM; Stoney Cr. at Rt. 722, 2 Sept. 1977, 2 males, BCK; Little Stoney Cr. cascades, 11 Sept. 1976, 1 female, BCK, VPI&SU;

spring-fed stream, 12 Sept. 1976, 1 male, BCK, VPI&SU; Big Stoney Cr. at Rt. 722, 25 Sept. 1977, 1 female, FLC. Hanover Co.; N. Anna R. 1 mile W. of Rt. 1, 2 Aug. 1978, 1 female, BCK. Highland Co.; Buck Run beaver ponds, 8 Aug. 1978, 1 male, FLC. James City Co.; Jamestown Rd., 3 Aug. 1938, 1 male, MED, (Det. MED, MDR notes). Louisa Co.; S. Anna R. at Rt. 522, 12 Sept. 1978, 1 male, BCK. Montgomery Co.; Blacksburg, date unknown, 1 male, collector unknown, VPI&SU; Christiansburg, 2 Sept. 1978, 1 male, JRV, VPI&SU. Nelson Co.; Wingina, 5 Aug. 1916, 1 male, 1 female, W. T. Davis, (Det. E. M. Walker) MZUM. Prince William Co.; Tributary of N. Br. Chopawamsic Cr., 4 July 1973, 1 male, OSF, USNM. Rockbridge Co.; Guys Run, 11 Aug. 1977, 1 female, L. Hornik, Meschter Collection. Spotsylvania Co.; Dr. Bass' home, 16 July 1980, 1 female, BCK. Wythe Co.; Stoney Fork Cr. at Walker Mtn., 27 Sept. 1936, 1 male, R. E. Stuart and E. C. Sensing, (Det. R. E. Stuart and E. C. Sensing), MZUM. York Co.; Naval Mine Depot at Yorktown, 15 Oct. 1936, 1 male, collector unknown, (Det. MED), W&M.

Flight Season.--June 14 (VA) to Oct. 15 (VA). Known season in neighboring states are: Kentucky- June to July 30; North Carolina- June to Sept.; Pennsylvania- July 8 to Sept 30; Tennessee- July 31 to Aug. 24; West Virginia- Aug. 13.

Biology.--*Somatochlora tenebrosa* inhabits small forest streams. Adults are often observed feeding at the edge of fields and along road cuts at dusk, generally flying at from 1-5 m. Oviposition occurs in shallow pools of small forest streams; on the single occasion observed, the female hovered at about 20 cm above the water dipping the abdomen every few seconds.

Remarks.--This species is abundant throughout Virginia although it has been collected only occasionally.

Somatochlora walshii (Scudder)

(Figures 137a, 140c, 143c, 146c)

Scudder 1866. Proc. Boston Soc. Nat. Hist. 10:217 (in *Cordulia*).

Length 41-52 mm; abdomen 28-40 mm; hind wings 25-34 mm.

Diagnosis.--Labrum black; postocular margin of head black; lateral thoracic spots bright yellow; outer surface of tibiae black; fore wings each with 7 or 8 (occasionally 9) antenodal crossveins, and with maximum of 3 cell rows in trigonal interspace; abdominal segments 5-7 with laterobasal yellow spots; female vulvar lamina directed posteroventrally; male cerci each with apices curved dorsally, lateral carinae well developed in basal 1/3 with 2 teeth, ventral carinae absent, and without ventroapical spine; female cerci 3.7-4.5 mm long.

Distribution.--Known from the states of CT, ME, MA, MI, MN, NH, NY, PA, VT, WA, and WI, and the provinces of Alta., B.C., Man., N.B., Nfld., N.S., Ont., and Que. Known distribution among the counties of neighboring states include: Pennsylvania- Butler, Centre, Clinton, and Luzerne.

Flight Season.--June 3 (Ont.) to Sept. 15 (PA). Known season in neighboring states are: Pennsylvania- June 15 to Sept. 15.

Biology.--*Somatochlora walshii* inhabits slow-flowing streams in bogs or marshes. Adult males patrol at from 50-120 cm over water. Oviposition occurs in and about stands of emergent vegetation.

Remarks.--This species possibly occurs in the upland bogs of western Virginia.

Somatochlora williamsoni Walker

(Figures 137b, 141, 143d, 147)

Walker 1907. Can. Entomol. 39:70.

Length 53-60 mm; abdomen 40-47 mm; hind wings 35-40 mm.

Diagnosis.--Labrum black; postocular margin of head black; lateral thoracic spots dull yellow; outer surface of tibiae black; fore wings each with 7-9 antenodal crossveins; and with maximum of 3 cell rows in trigonal interspace; abdominal segments 5-7 with laterobasal yellow spots; female vulvar lamina directed ventrally; male cerci each with apices curved dorsally, lateral carinae well developed in basal 1/3 with basal tooth, ventral carinae extended to midlength and evenly convex, and without ventroapical spine; female cerci 4.3-5.3 mm long.

Distribution.--Known from the states of CT, ME, MA, MI, MN, NH, NY, PA, TN, VT, VA, and WI, and the provinces of Man., Ont., and Que. Known from the Virginia county of Highland. Known distribution among the counties of neighboring states include: Pennsylvania- Crawford; Tennessee- Sevier.

Virginia Records.--Highland Co.; Buck Run beaver ponds, 25 July 1973, 1 male, FLC.

Flight Season.--June 19 (Man.) to Sept. 14 (Ont.); in Virginia July 25. Known season in neighboring states are: Pennsylvania- July 8 to 23; Tennessee- July 12.

Biology.--*Somatochlora williamsoni* inhabits slow-flowing forest streams and seepage pools surrounding bogs and ponds. Adults feed along road cuts and fields at from 3-6 m. Adult males typically hover at from 1-2 m over seepage pools, and from 10-90 cm over streams. Oviposition occurs in small seepage pools along bogs or marshes, and also reportedly in mud banks of streams.

Remarks.--The single male of this species collected in Virginia was observed hovering over seepage pools and a small spring seep at the edge of a bog pond. This species is also known from Tennessee, again from only a single specimen.

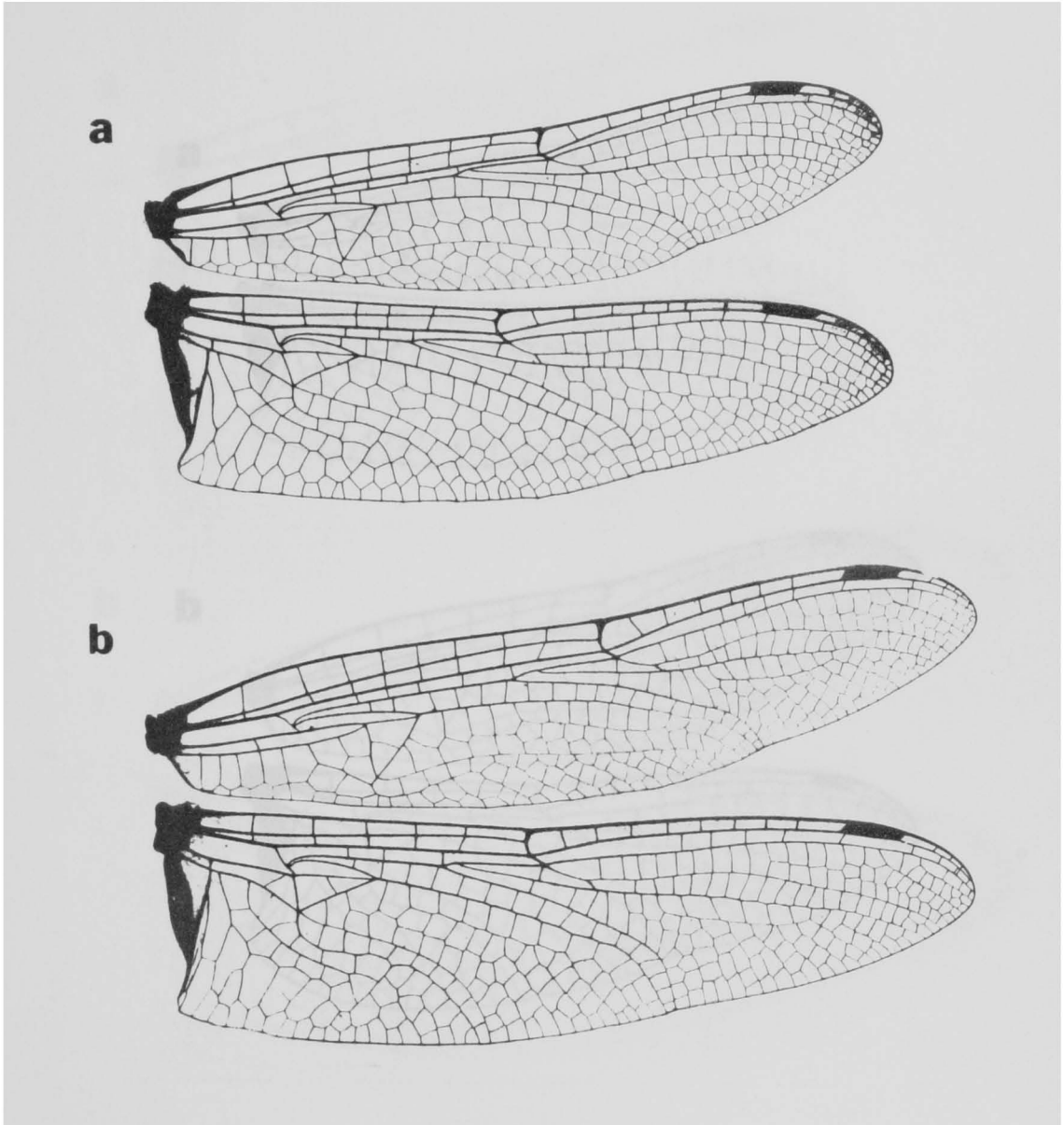


Figure 133. Wings of *Somatochlora* x3: (a) *S. elongata*; (b) *S. filosa*.

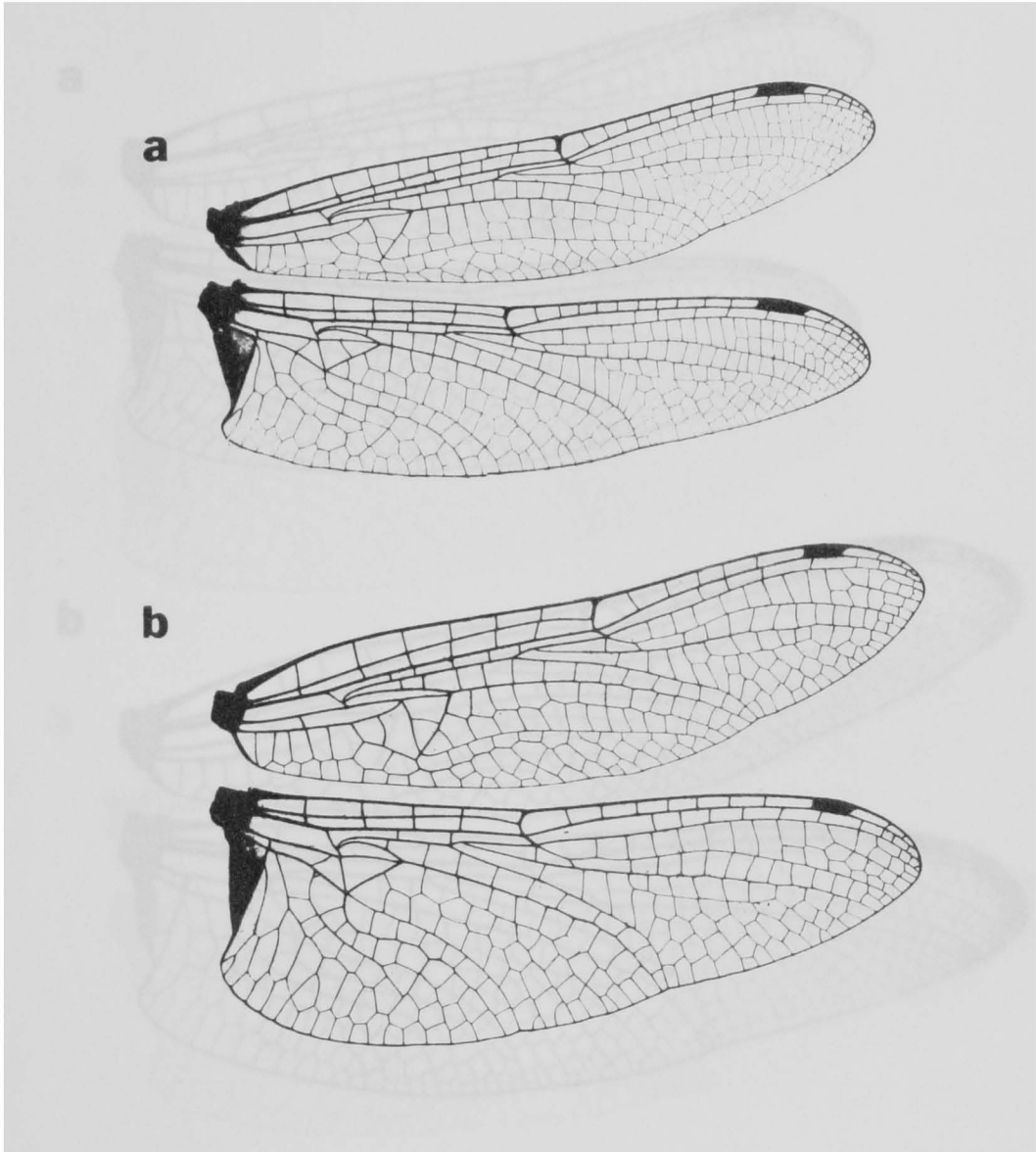


Figure 134. Wings of *Somatochlora* x3: (a) *S. forcipata*;
(b) *S. georgiana*.

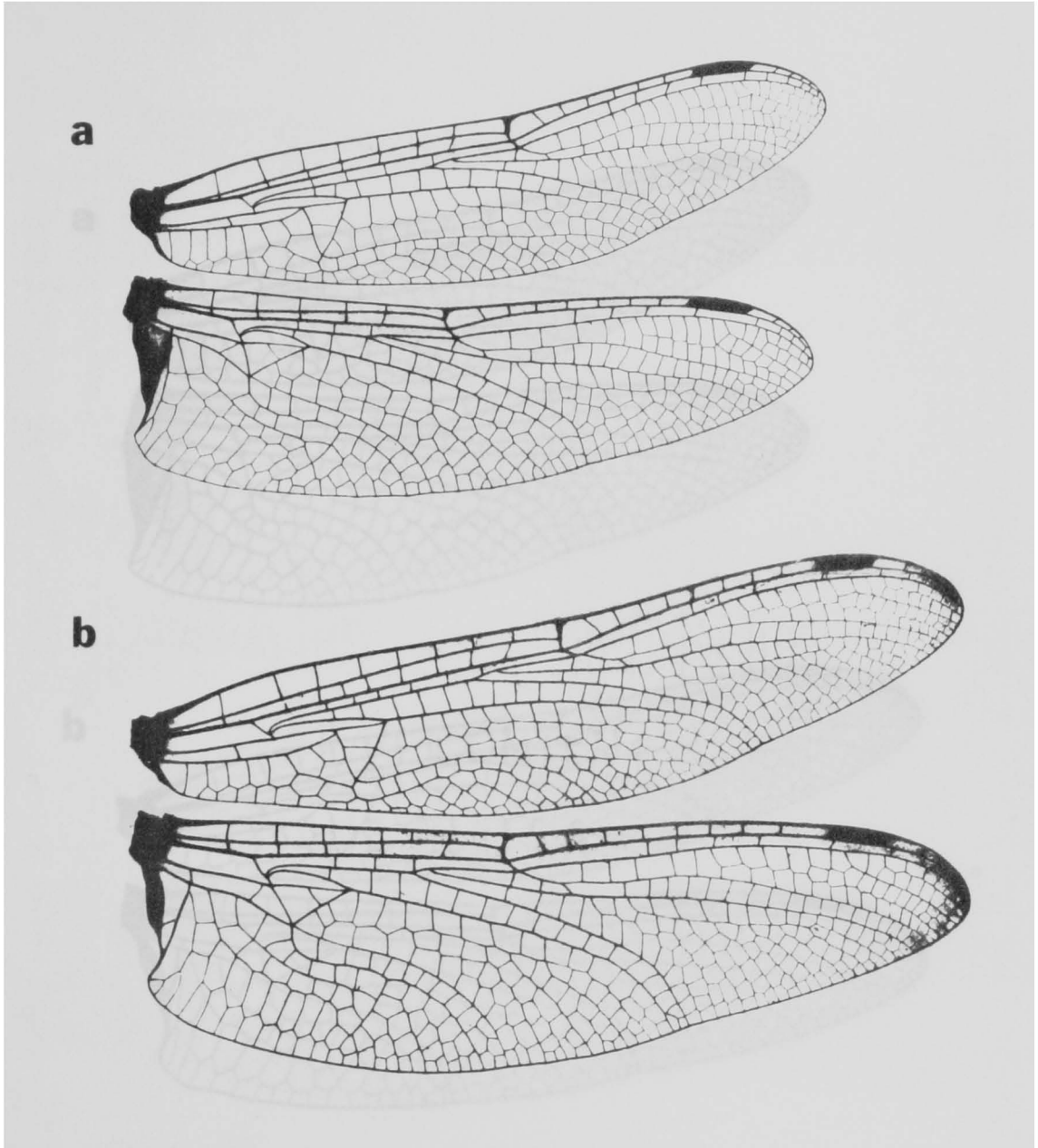


Figure 135. Wings of *Somatochlora* x3: (a) *S. incarvata*; (b) *S. linearis*.

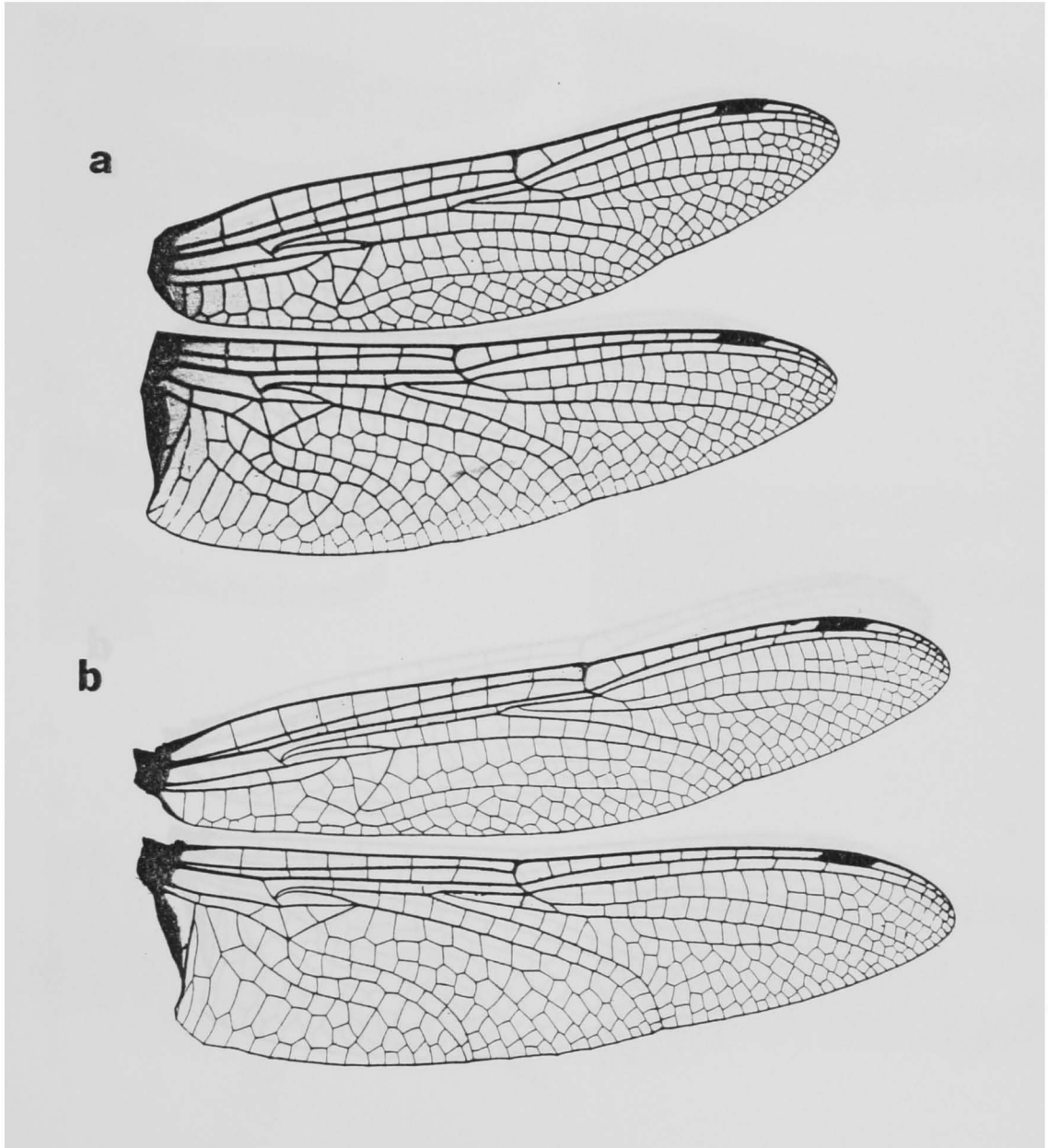


Figure 136. Wings of *Somatochlora* x3: (a) *S. provocans*;
(b) *S. tenebrosa*.

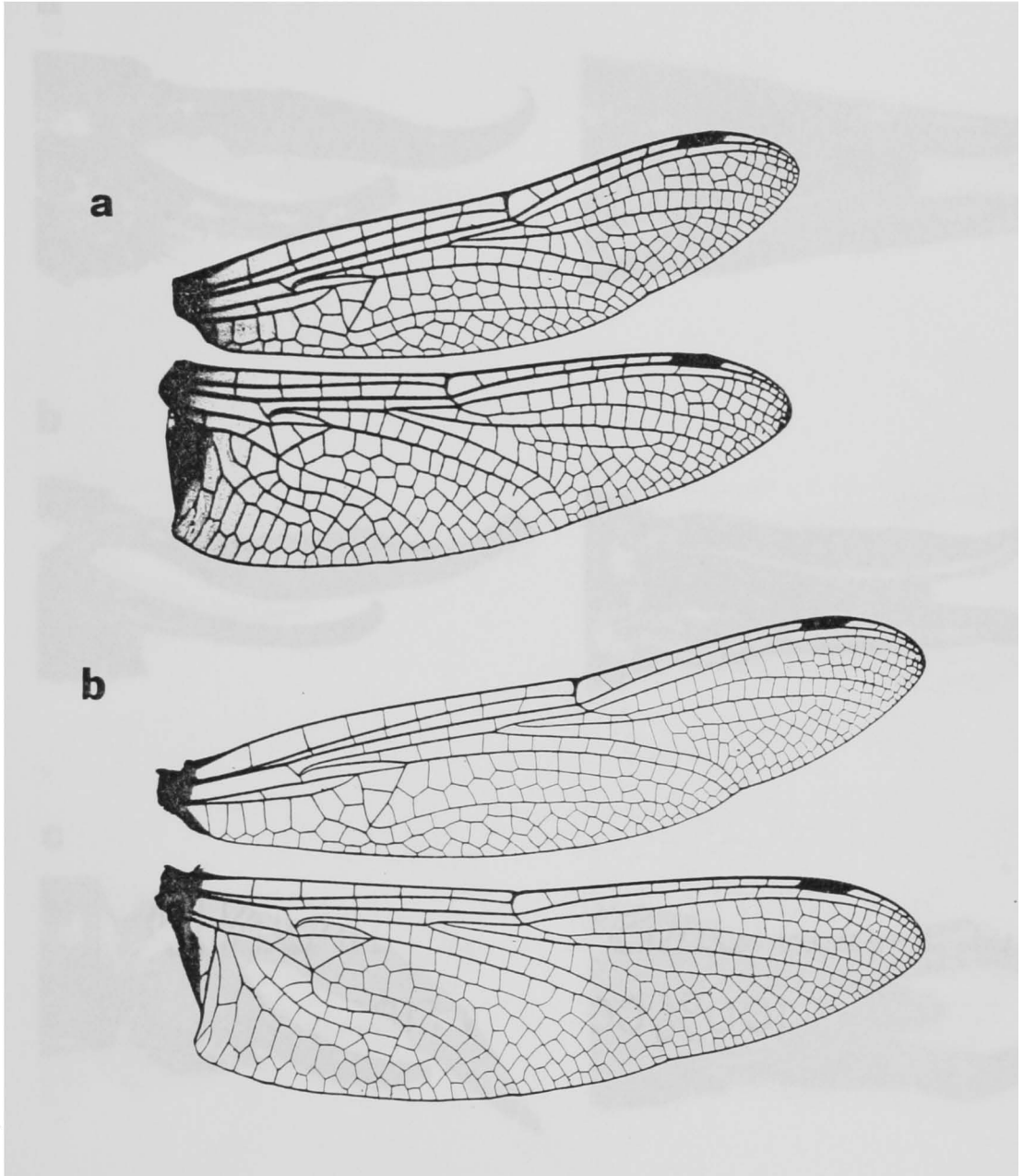


Figure 137. Wings of *Somatochlora* x3: (a) *S. walshii*;
(b) *S. williamsoni*.

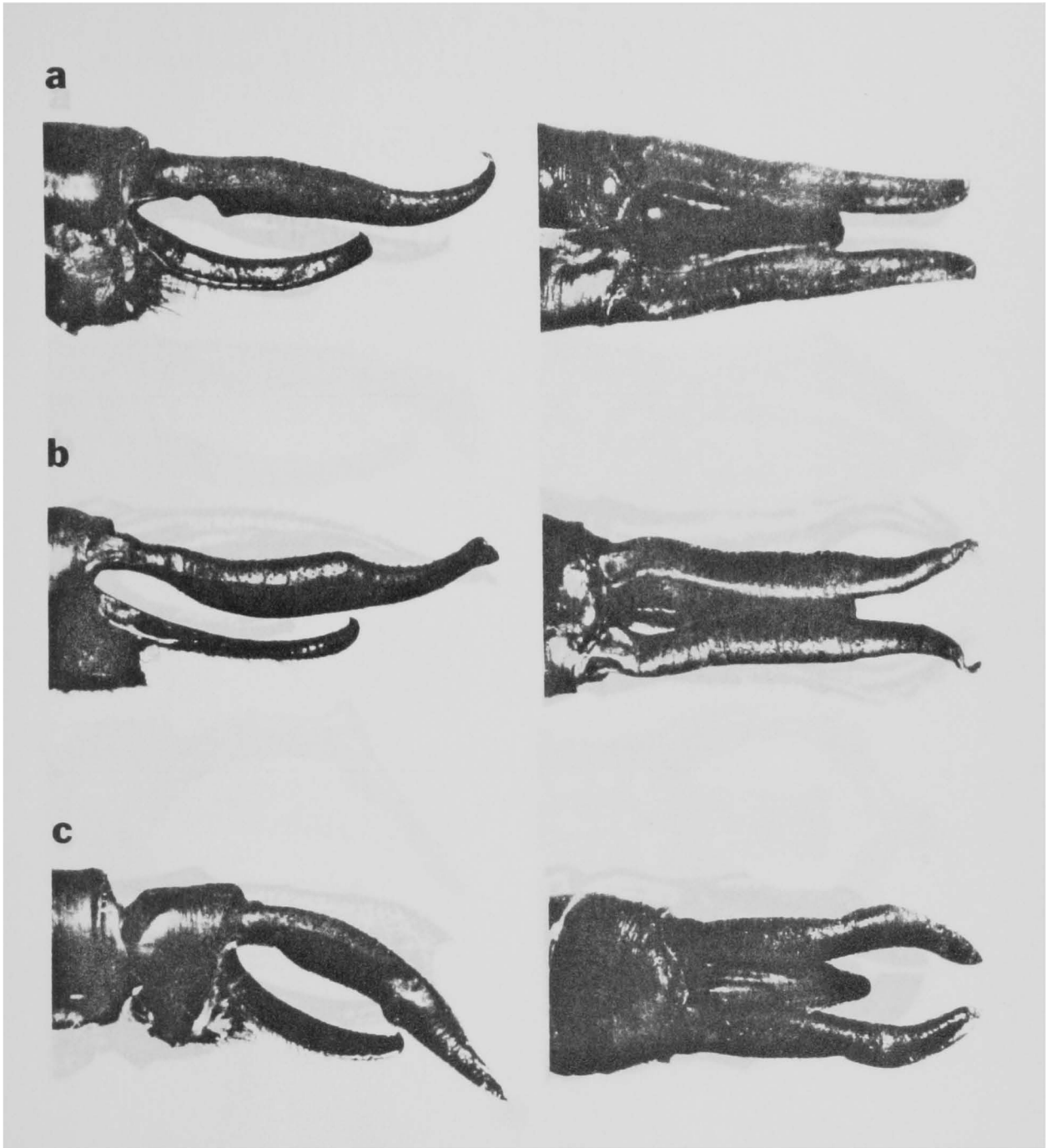


Figure 138. Male terminalia in lateral and dorsal view of *Somatochlora* x15: (a) *S. elongata*; (b) *S. filosa*; (c) *S. forcipata*.

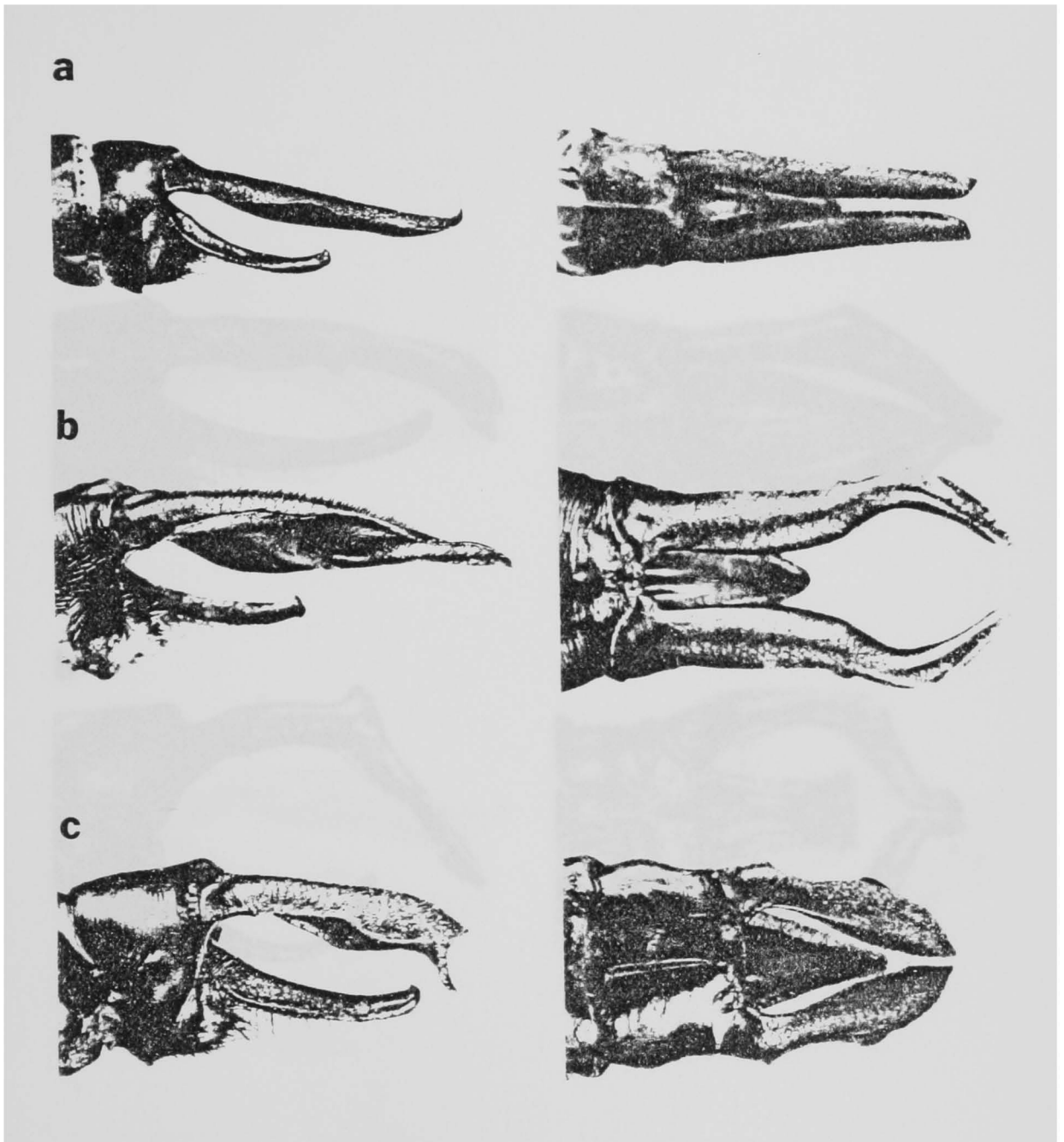


Figure 139. Male terminalia in lateral and dorsal view of *Sematoshiora* x15: (a) *S. georgiana*; (b) *S. incurmata*; (c) *S. linearis*.

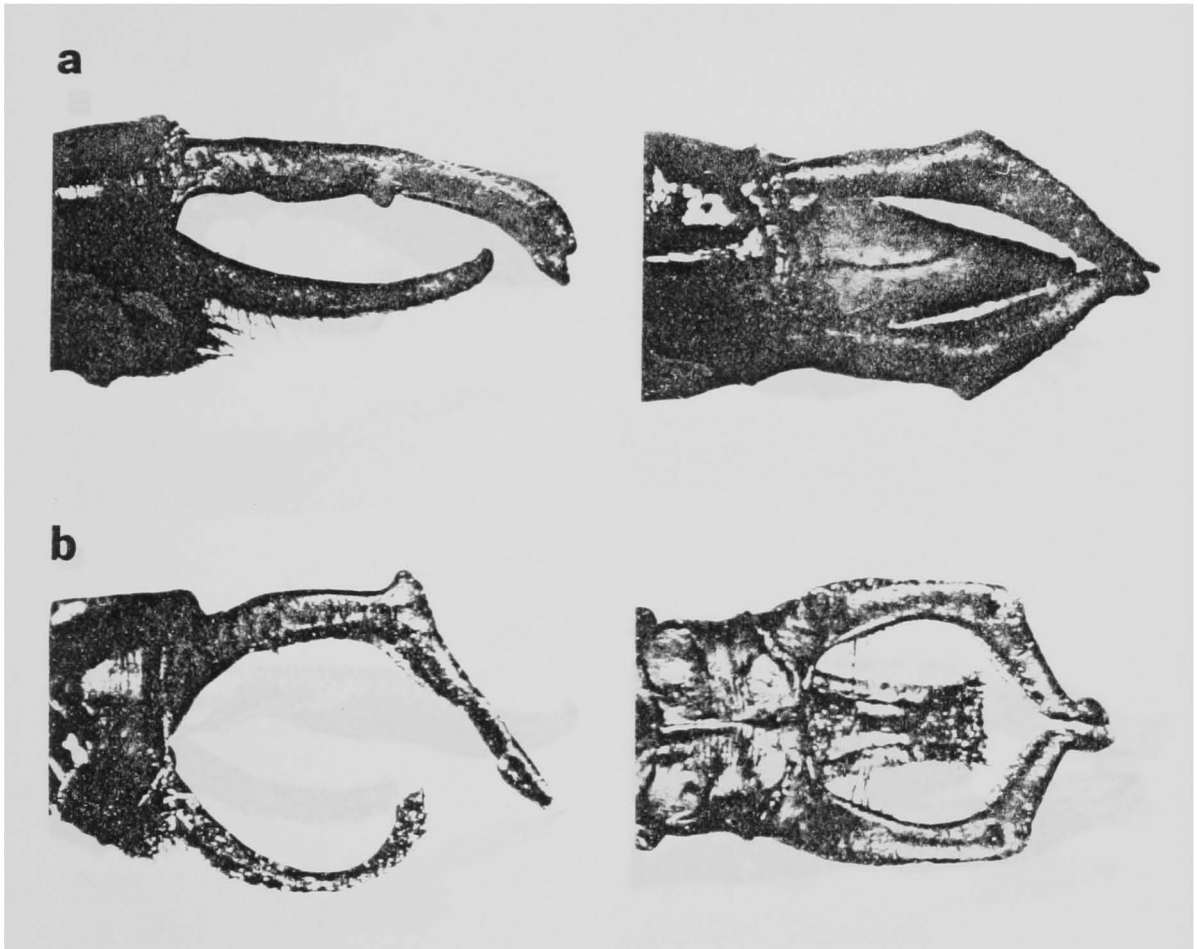


Figure 140. Male terminalia in lateral and dorsal view of *Somatochlora* x15: (a) *S. provocans*; (b) *S. tenebrosa*.

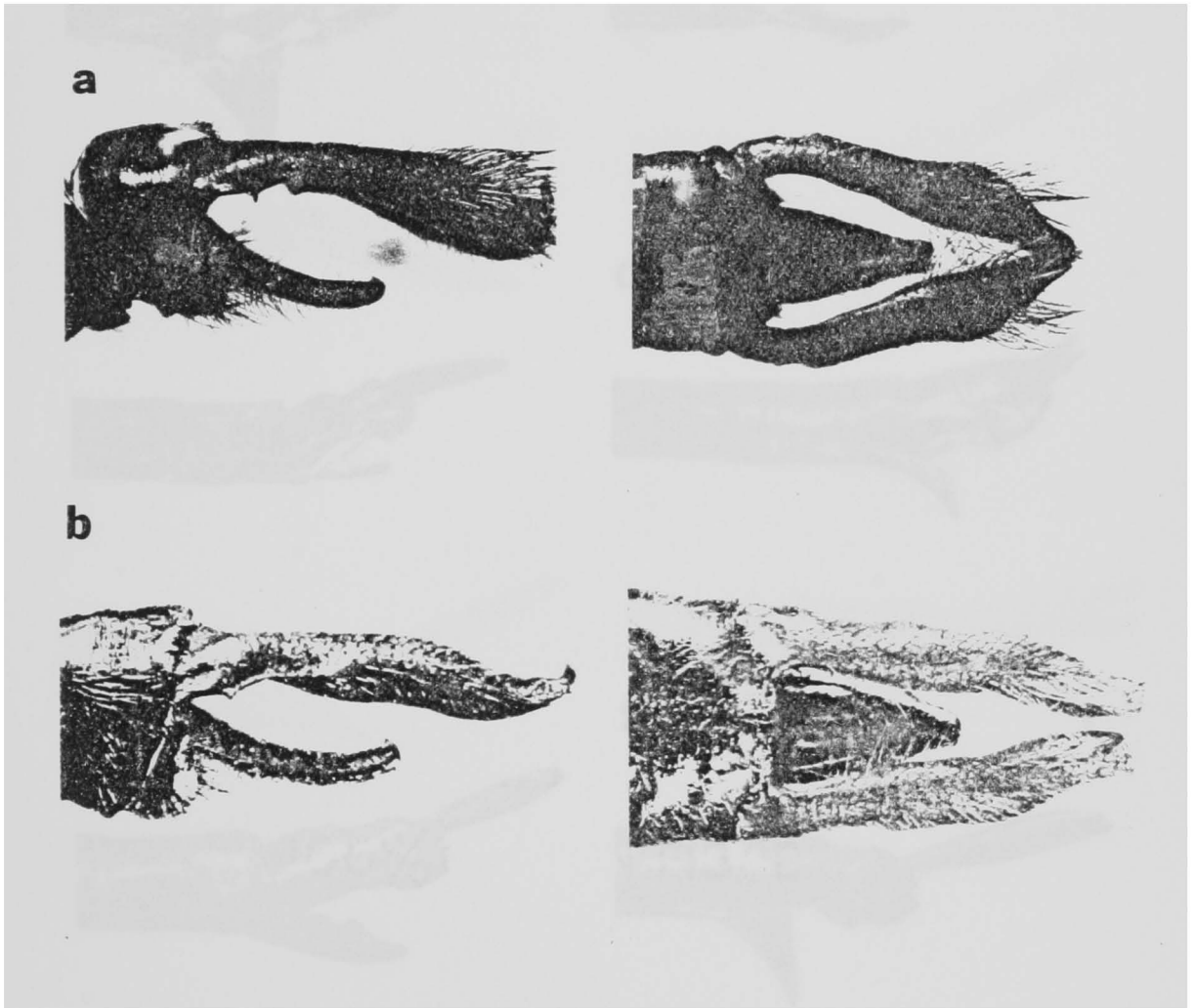


Figure 141. Male terminalia in lateral and dorsal view of *Somatochlora* x15: (a) *S. walshii*; (b) *S. williamsoni*.

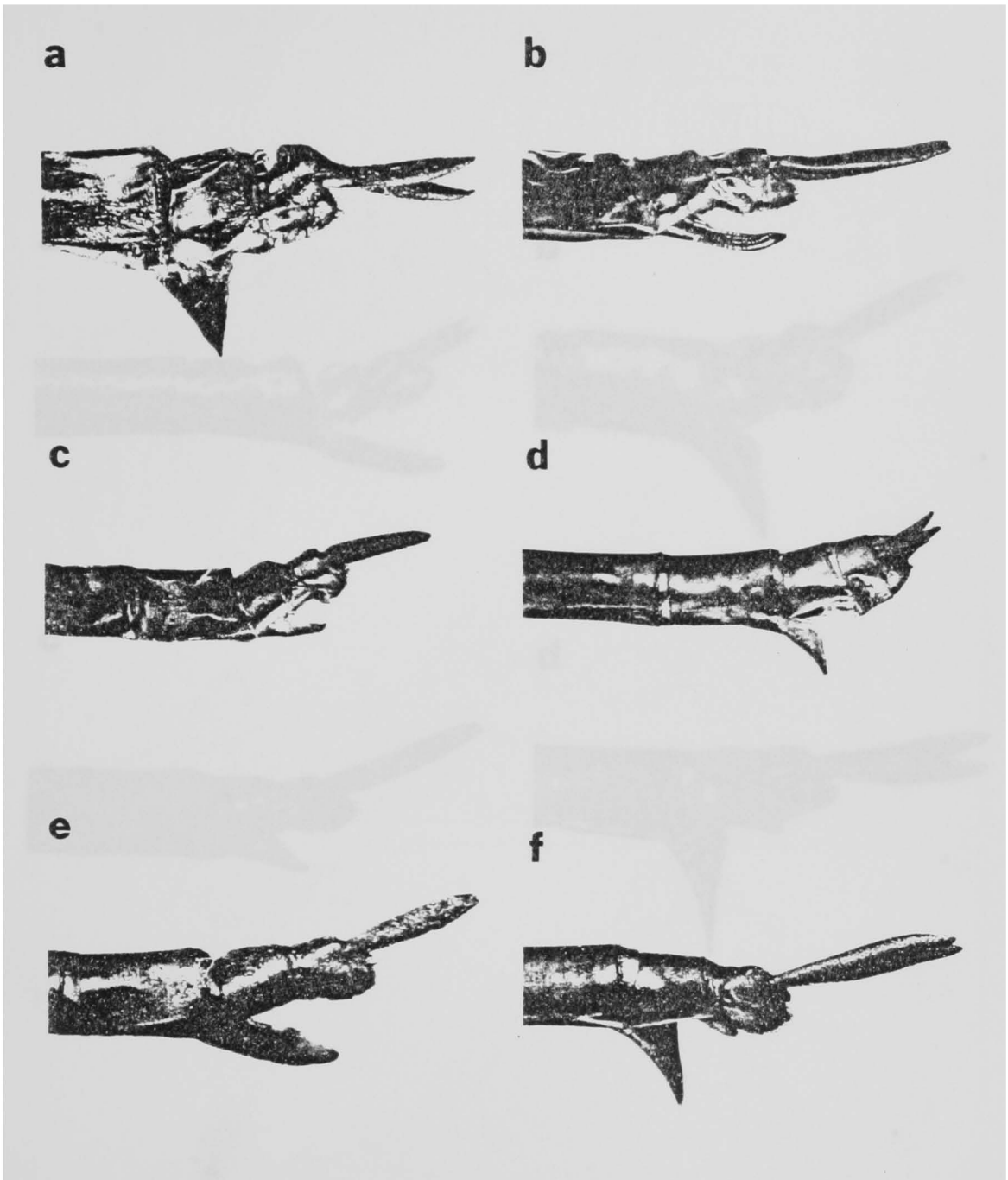


Figure 142. Female abdominal apex in lateral view of *Somatochlora* x6:
 (a) *S. elongata*; (b) *S. filosa*; (c) *S. forcipata*;
 (d) *S. georgiana*; (e) *S. incurvata*; (f) *S. linearis*.

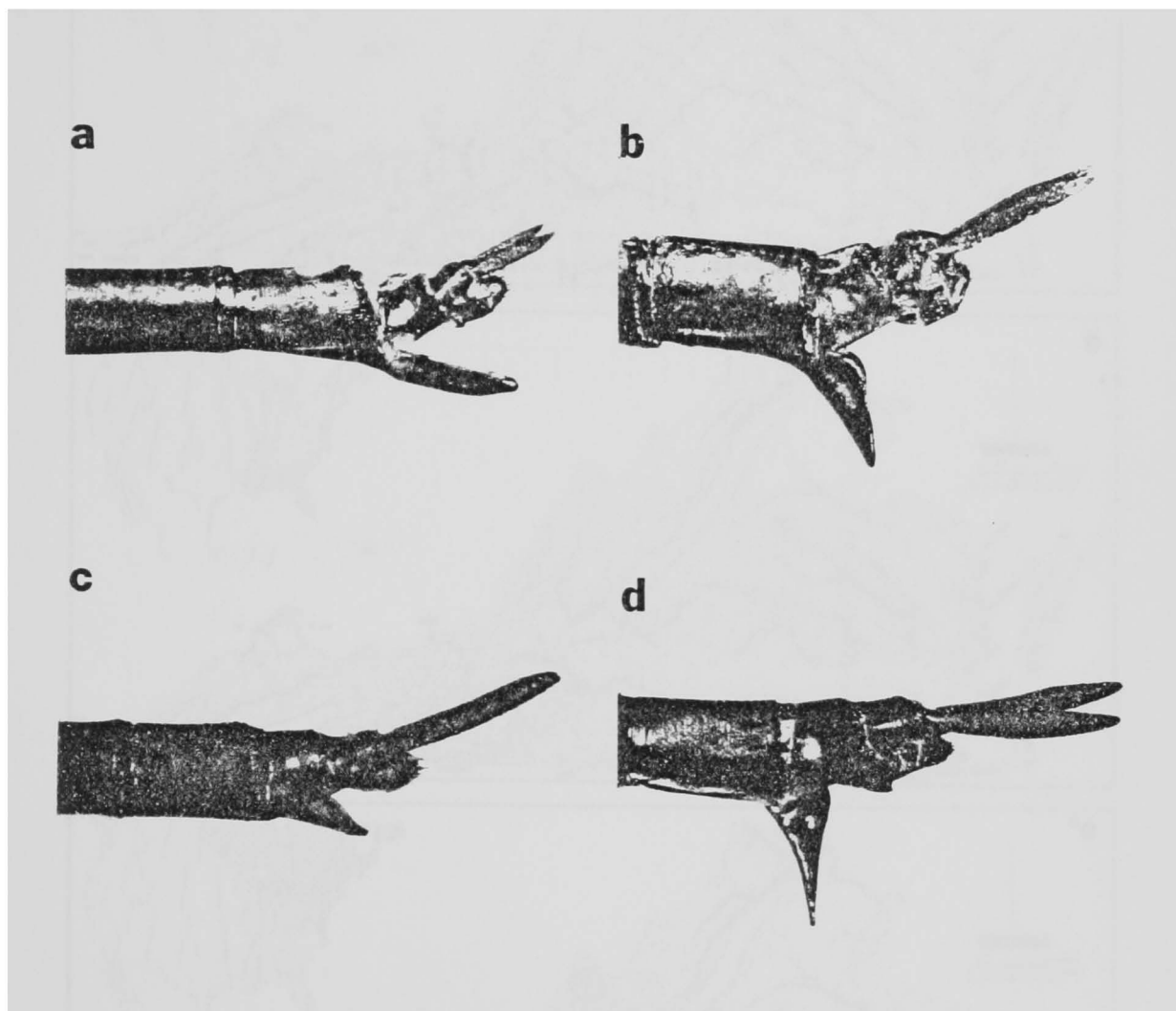


Figure 143. Female abdominal apex in lateral view of *Somatochlora* x6:
(a) *S. provocans*; (b) *S. tenebrosa*; (c) *S. walshii*;
(d) *S. williamsoni*.

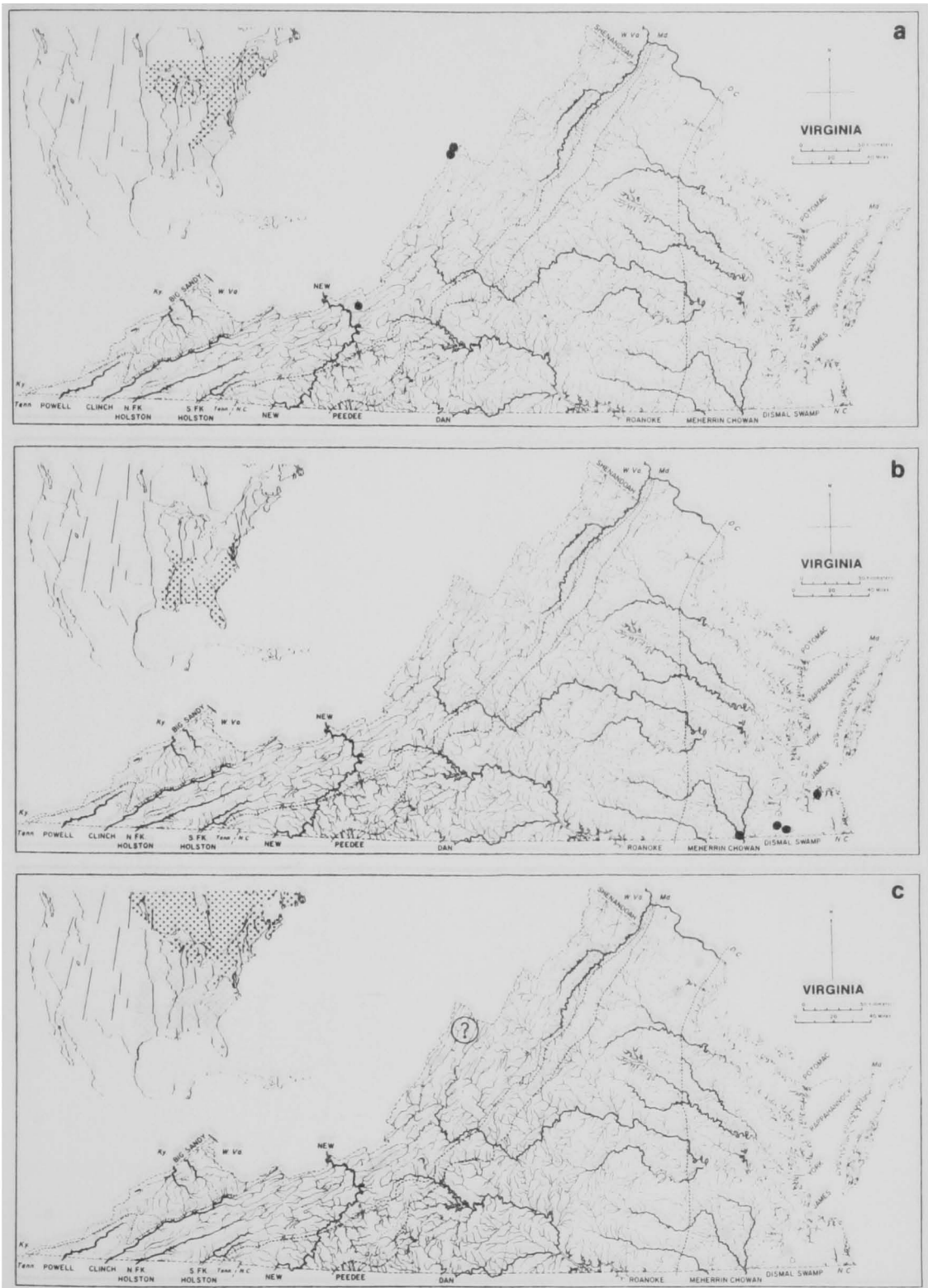


Figure 144. Geographic distribution of *Somatochlora*: (a) *S. elongata*; (b) *S. filosa*; (c) *S. foreipata*.

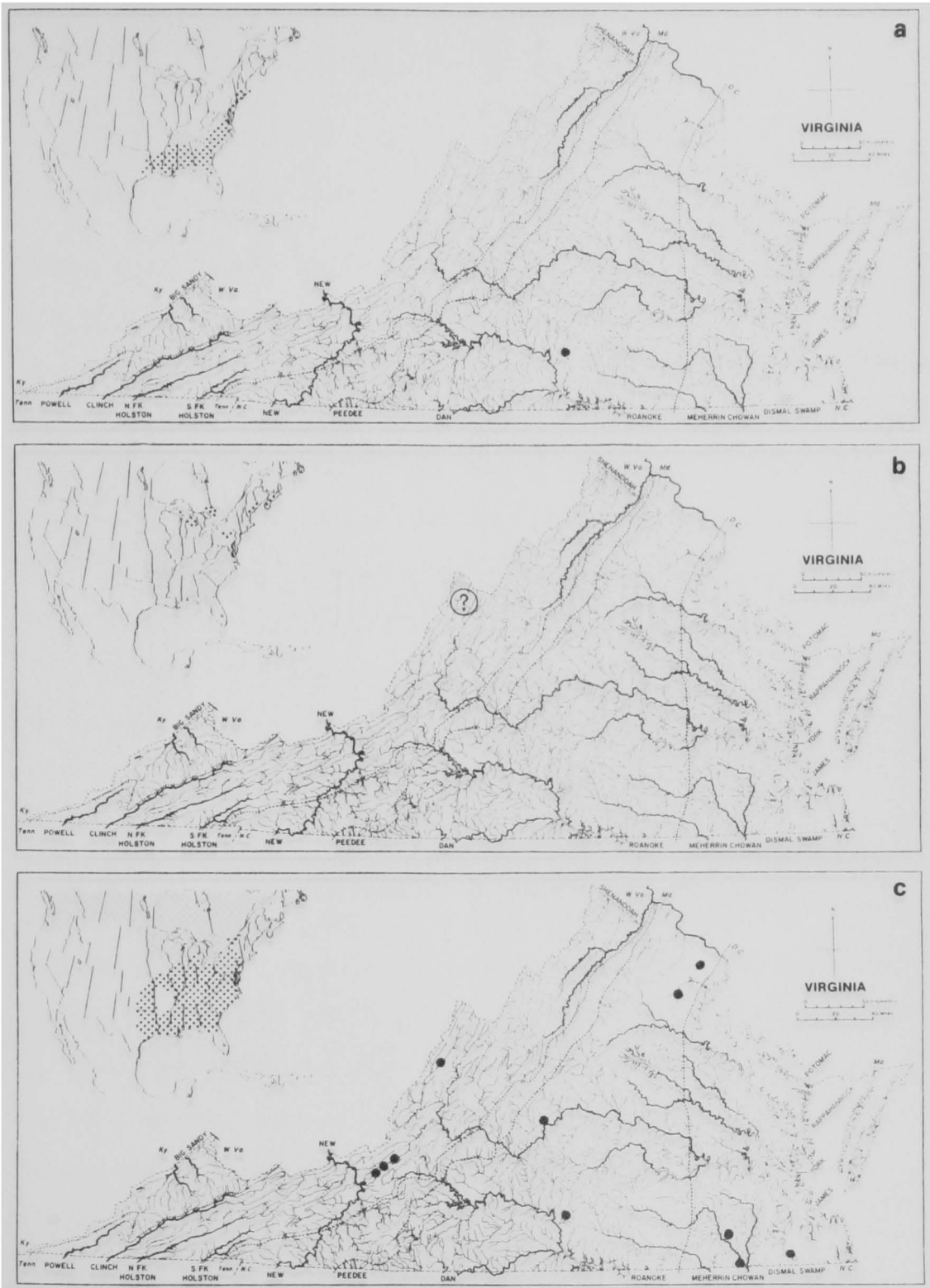


Figure 145. Geographic distribution of *Somatochlora*: (a) *S. georgiana*; (b) *S. incurvata*; (c) *S. linearis*.

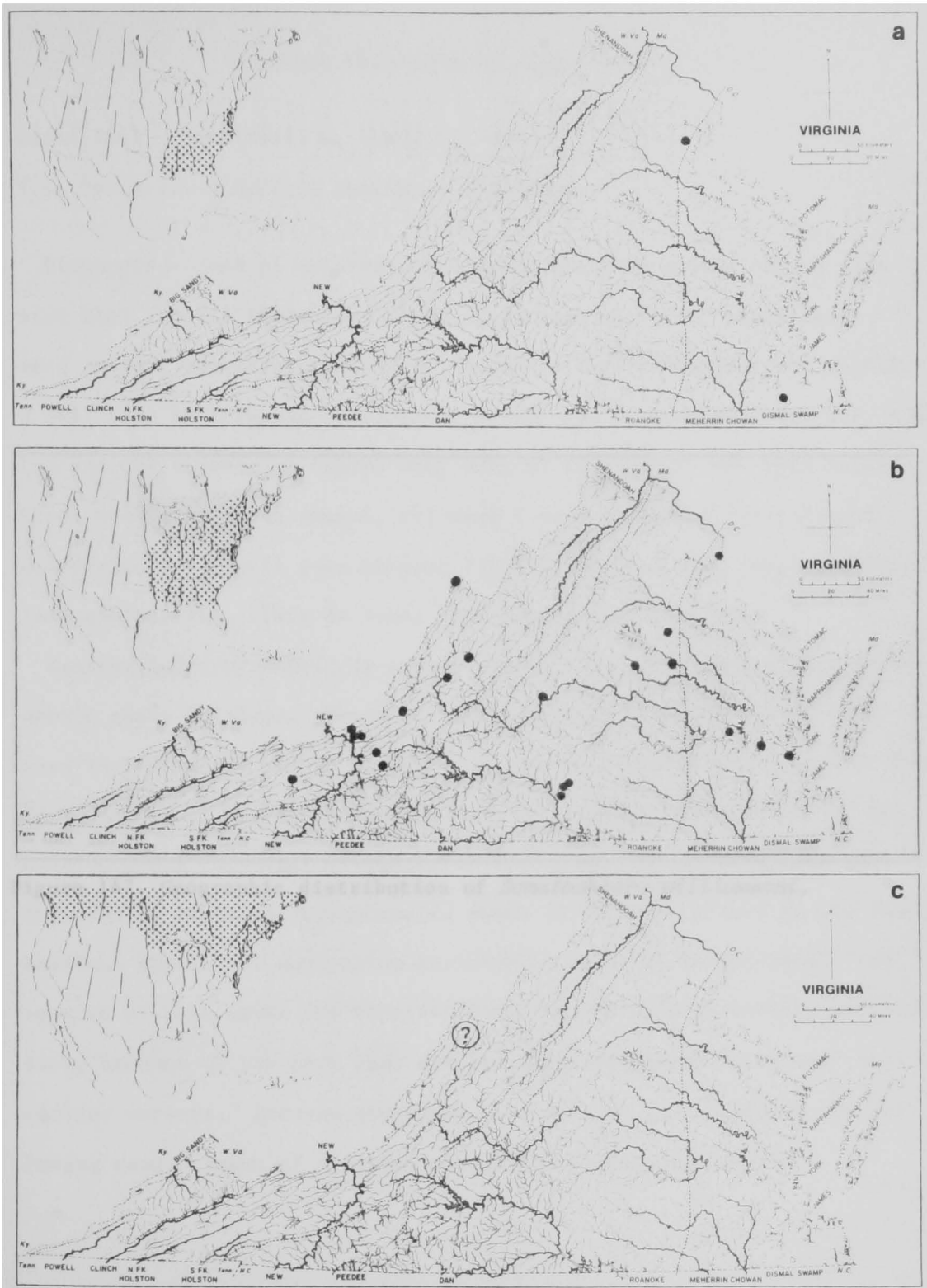


Figure 146. Geographic distribution of *Somatochlora*: (a) *S. provocans*; (b) *S. tenebrosa*; (c) *S. walshii*.

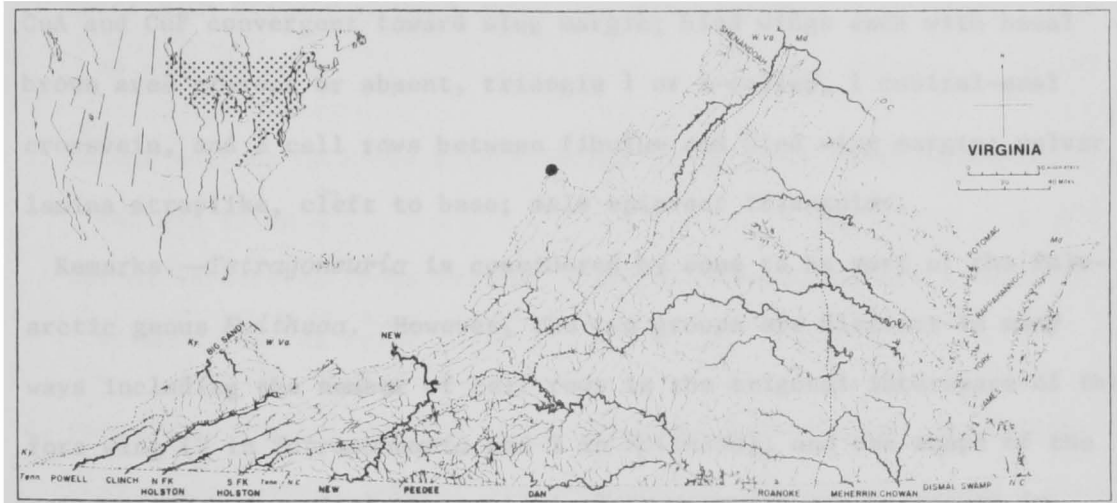


Figure 147. Geographic distribution of *Somatochlora williamsoni*.

Genus *Tetragoneuria* Hagen 1861

Hagen 1861. Syn. Neur. N. Amer., p. 140.

Type Species.--*Libellula semiaquea* Burmeister.

Diagnosis.--General coloration nonmetallic; male middle tibiae each with keel $2/5$ - $3/5$ length of tibia; fore wings each with basal brown area absent, subtriangle 3-celled, triangle 2- (occasionally 1) celled, 2 cell rows in trigonal interspace, 1 cell row between Cu_{1P} and Cu_P , and Cu_A and Cu_P convergent toward wing margin; hind wings each with basal brown area present or absent, triangle 1 or 2-celled, 1 cubital-anal crossvein, and 3 cell rows between fibulum and hind wing margin; vulvar lamina straplike, cleft to base; male epiproct triangular.

Remarks.--*Tetragoneuria* is considered by some to be part of the Palearctic genus *Epitheca*. However, the two groups are distinct in many ways including the number of cell rows in the trigonal interspace of the fore wing (2 in *Tetragoneuria* and 3 in *Epitheca*), and the shape of the male epiproct (acuminate-truncate in *Tetragoneuria* and bifurcate in *Epitheca*). Actually *Tetragoneuria* seems as closely related to the South American *Ryalla* and Australian *Procordulia* as it is to *Epitheca*. The species of this genus are very difficult to identify correctly, particularly because of the very poor species descriptions of Muttkowski and earlier workers. Because the types have not yet been studied, the following readjustment of synonyms should not be regarded as final.

Species Key to Adult Male *Tetragoneuria* of Virginia

1. Cerci each with apices directed posteroventrally and with dorsal spine 2
 Cerci each with apices directed posteriorly and without dorsal spine 3
2. Cerci each with ventral tubercle; second penile segment ca. $3/8$ as wide as long *T. canis* p. 648
 Cerci each without ventral tubercle; second penile segment ca. $1/2$ as wide as long *T. spinosa* p. 661
3. Dorsal surface of frons with T-shaped brown spot; cerci each with ventral spine *T. spinigera* p. 659
 Dorsal surface of frons without T-shaped brown spot; cerci each without ventral spine 4
4. Cerci each without ventral carina extended beyond basal angulation; distance between lateral and ventromedial carinae of tergum 5 less than $1/3$ length of lateral carinae *T. costalis* p. 649
 Cerci each with ventral carina extended beyond basal angulation; distance between lateral and ventromedial carinae of tergum 5 more than $3/8$ length of lateral carinae 5

5. Distance between lateral and ventromedial carinae of terga 5 and 6
 ca. $\frac{2}{5}$ length of lateral carinae; hind wings each with brown
 basal spot not extended to nodus *T. cynosura* p. 651
- Distance between lateral and ventromedial carinae of terga 5 and 6
 ca. $\frac{1}{2}$ length of lateral carinae; hind wings each with brown
 basal spot extended to nodus *T. semiaquea* p. 658

Species Key to Adult Female *Tetragoneuria* of Virginia

1. Vulvar lamina shorter than sternum 9, medial margins of lateral
 lobes convex apically *T. canis* p. 648
- Vulvar lamina longer than sternum 9, medial margins of lateral lobes
 concave apically 2
2. Cerci longer than vulvar lamina; distance between lateral and
 ventromedial carinae of tergum 6 less than $\frac{3}{8}$ length of lateral
 carinae 3
- Cerci shorter than vulvar lamina; distance between lateral and
 ventromedial carinae of tergum 6 more than $\frac{3}{8}$ length of lateral
 carinae 4
3. Dorsal surface of frons without T-shaped brown spot; distance be-
 tween lateral and ventromedial carinae of tergum 6 less than $\frac{3}{10}$
 length of lateral carinae *T. costalis* p. 649
- Dorsal surface of frons with T-shaped brown spot; distance between
 lateral and ventromedial carinae of tergum 6 more than $\frac{1}{3}$ length
 of lateral carinae *T. spinigera* p. 659

4. Cerci not acuminate; abdomen 9/10 length of hind wings; vulvar lamina not extended to apex of abdominal segment 10
 *T. spinosa* p. 661
- Cerci acuminate; abdomen as long as hind wings; vulvar lamina extended to apex of abdominal segment 10 5
5. Distance between lateral and ventromedial carinae of terga 5 and 6 ca. 2/5 length of lateral carinae; hind wings each with brown basal spot not extended to nodus *T. cynosura* p. 651
- Distance between lateral and ventromedial carinae of terga 5 and 6 ca. 1/2 length of lateral carinae; hind wings each with brown basal spot extended to nodus *T. semiaquea* p. 658

Tetragoneuria canis McLachlan

(Figures 149a, 151a, 154a)

McLachlan 1886. Entomol. Mon. Mag. 23:104.

Length 42-50 mm; abdomen 31-39 mm; hind wings 28-32 mm.

Diagnosis.--Dorsal surface of frons without well developed T-shaped brown spot; fore wings each with 7-9 antenodals, and 5 or 6 postnodals; hind wings each with basal spot generally extended to near first antenodal crossvein, 5-7 antenodals, and 6-8 postnodals; second penile segment 0.36-0.38 as wide as long; distance between lateral and ventromedial carinae of tergum 6 0.31-0.35 length of lateral carinae; vulvar lamina extended nearly to apex of sternum 9, longer than cerci with medial margin of lateral lobes convex subapically; male cerci each with

apices directed posteroventrally, with dorsal spine, with ventral tubercle, and ventral carinae extended beyond basal tubercle; female cerci 2.3-2.7 mm long, slightly longer than abdominal segment 9.

Distribution.--Known from the states of CA, CT, ME, MD, MI, NH, NY, OR, PA, VT, VA, WA, WV, and WI, and the provinces of B.C., N.B., N.S., Ont., P.E.I., Que., and Sask. Known from the Virginia county of Highland. Known distribution among the counties of neighboring states include: Maryland- Garrett; Pennsylvania- Centre, Columbia, Clinton, Crawford, Elk, Huntingdon, Luzerne, Mercer, Northampton, Sullivan, Warren, and Wayne; West Virginia- Tucker.

Virginia Records.--Highland Co.; Buck Run beaver ponds, 10 June 1979, 1 male, BCK; Buck Run beaver ponds, 18 June 1978, 2 males, FLC.

Flight Season.--May 7 (Que.) to Aug. 2 (NY); in Virginia- June 10 to 18. Known season in neighboring states are: Maryland- June 8; Pennsylvania- May 8 to June 31; West Virginia- July 1.

Biology.--*Tetragoneuria canis* inhabits boggy ponds. Adult males patrol over emergent vegetation at from 0.5-1.0 m above water. Adults feed in open areas at from 2-10 m. Oviposition is accomplished by draping egg strings over floating vegetation.

Remarks.--The Highland county records for this species are the southernmost for eastern North America.

Tetragoneuria costalis (Selys)

Syn.: *basiguttata* Selys new comb., *williamsoni* Muttkowski new comb.

(Figures 148, 151b,c, 154b)

Selys 1871. Bull. Acad. Belg. 31:271 (in *Cordulia*).

Length 36-46 mm; abdomen 25-34 mm; hind wings 28-31 mm.

Diagnosis.--Dorsal surface of frons without well-developed T-shaped brown spot; fore wings each with 6 or 7 antenodals, and 4 postnodals; hind wings each with basal spot generally extended to near first antenodal crossvein (occasionally to pterostigmata in female), 5-7 antenodals, and 5-7 postnodals; second penile segment 0.39-0.43 as wide as long; distance between lateral and ventromedian carinae of tergum 6 0.27-0.30 length of lateral carinae; vulvar lamina extended to midlength of sternum 10, longer than cerci with medial margin of lateral lobes concave subapically; male cerci each with apices directed posteriorly, without dorsal spine, with ventral angulation, and ventral carinae not extended beyond ventral angulation; female cerci 2.0-3.1 mm long, longer than abdominal segments 9 and 10.

Distribution.--Known from the states of AL, FL, LA, MD, MS, NC, OK, PA, SC, TN, TX, and VA. Known from the Virginia county of Fairfax and the cities of Suffolk and Virginia Beach. Known distribution among the counties of neighboring states include: North Carolina- Henderson, Moore, and Washington; Pennsylvania- Delaware.

Virginia Records.--Fairfax Co.; Great Falls, 21 May 1914, 1 male, RPC, USNM; Great Falls, 2 June 1914, 1 male, RPC, USNM. City of Suffolk; Jericho Lane in Dismal Swamp Wildlife Refuge, 21 May 1977, 1 male, FLC. City of Virginia Beach; White Lake at Seaside St. Park, 22 May 1977, 1 male, FLC.

Flight Season.--Apr. 1 (AL) to June 17 (NC); in Virginia May 21 to

June 2. Known season in neighboring states are: North Carolina- May 6 to June 17; Pennsylvania- May 24 to June 23.

Biology.--*Tetragoneuria costalis* inhabits ponds and lakes. Adult males patrol near shore at ca. 1 m (observed at one locality only). Adults feed in open areas at from 1-10 m. Oviposition is accomplished by draping egg strings over floating vegetation.

Remarks.--This species is probably more common in Virginia than previous records indicate. Northern specimens (Maryland to South Carolina) have shorter cerci than typical specimens and have been previously referred to as *T. williamsoni* Muttkowski. However, the types of *T. williamsoni* are similar to the type of *T. costalis* which Muttkowski had not studied. In addition *T. basiguttata* Selys may have been described from the male of this species; if this is the case than *T. basiguttata* has page priority over *T. costalis*.

Tetragoneuria cynosura (Say)

Syn.: *calverti* Muttlowksi, *diffinis* Selys, *lateralis* Burmeister,
morio Muttkowski, *simulans* Muttkowski

(Figures 149b,c, 152a,b, 154c)

Say 1839. J. Acad. Phila. 8:30 (in *Libellula*).

Length 38-44 mm; abdomen 25-34 mm; hind wings 26-31 mm.

Diagnosis.--Dorsal surface of frons without well-developed T-shaped brown spot; fore wings each with 6-8 antenodals, and 5-7 postnodals; hind wings each with basal spot generally extended to near first antenodal crossveins (occasionally extended to nodus), 4 or 5 antenodals,

and 5-7 postnodals; second penile segment 0.40-0.43 as wide as long; distance between lateral and ventromedian carinae of tergum 6 0.39-0.42 length of lateral carinae; vulvar lamina extended to near apex of sternum 10, longer than cerci with medial margin of lateral lobes concave subapically; male cerci each with apices directed posteriorly, without dorsal spine, with ventral angulation, and ventral carinae extended beyond basal angulation; female cerci 1.5-1.8 mm long, ca. as long as abdominal segment 9.

Distribution.--Known from the states of AL, AR, CT, DC, FL, GA, IL, IN, IA, KS, KY, LA, ME, MD, MA, MI, MN, MS, MO, NB, NH, NJ, NY, NC, OH, OK, PA, SC, TN, TX, VT, VA, WV, and WI, and the provinces of N.B., N.S., Ont., and Que. Known from the Virginia counties of Albermarle, Alleghany, Bath, Bedford, Brunswick, Campbell, Charles City, Charlotte, Craig, Cumberland, Dickenson, Dinwiddie, Fairfax, Franklin, Giles, Halifax, Hanover, Highland, Isle of Wight, James City, Lee, Montgomery, Nelson, New Kent, Nottoway, Patrick, Powhatan, Prince Edward, Roanoke, Rockingham, Russell, Southampton, Spotsylvania, Tazewell, Warren, Washington, Wise, and York, and the cities of Newport News, Suffolk, and Virginia Beach. Known distribution among the counties of neighboring states include: Kentucky- Adair, Allen, Anderson, Barren, Bell, Breckinridge, Bullitt, Butler, Carter, Christian, Cumberland, Edmonson, Fayette, Floyd, Fulton, Grayson, Green, Hardin, Harrison, Hart, Henderson, Jefferson, Kenton, Letcher, Logan, Marion, McCreary, Meade, Metcalfe, Monroe, Muhlenberg, Nelson, Ohio, Oldham, Pike, Pulaski, Robertson, Russell, Taylor, Todd, Trigg, Union, Warren, Washington, and Whitley; Maryland- Cecil; North Carolina- Guilford, McDowell, Robeson, and Wake;

Pennsylvania- Allegheny, Beaver, Bedford, Blair, Bucks, Butler, Cambria, Centre, Chester, Clearfield, Clinton, Columbia, Crawford, Dauphin, Delaware, Elk, Erie, Fayette, Forest, Franklin, Fulton, Greene, Huntingdon, Indiana, Juniata, Lackawanna, Luzerne, Mercer, Monroe, Montgomery, Northampton, Perry, Philadelphia, Pike, Potter, Somerset, Sullivan, Union, Venango, Warren, Washington, Wayne, Westmoreland, and York; Tennessee- Coffee, Cumberland, Fentress, Johnson, Knox, Overton, and Sullivan; West Virginia- Pendleton, Pocahontas, Raleigh, Ritchie, Upshur and Taylor.

Virginia Records.--Albemarle Co.; Charlottesville, 10 May 1978, 1 female, K. Quinn, FLC Collection. Alleghany Co.; Pond at Selma, 24 May 1950, 2 males, R. L. Hoffman, (Det. LKG); Jackson R. at Lowmoor, 29 May 1977, 2 males, FLC; Powell Farm on Big Ridge Mtn. at Rt. 602, 10 June 1978, P. K. Powell, FLC Collection; Griffith, 16 June 1951, 1 male, R. L. Hoffman, (Det. LKG). Bath Co.; Coursey Springs, 30 May 1977, 1 male, FLC; Douthat Lk., 18 June 1978, 1 male, FLC; Beaver pond along Rt. 600, 18 June 1978, 3 males, FLC; Douthat Lk. at Rt. 629, 27 June 1973, SWD. Bedford Co.; Preston Pd. at Rt. 627, 17 May 1978, 1 male, 1 female, J. Bragg, VPI&SU; Peaks of Otter Lake, 22 July 1978, 1 male, FLC. Brunswick Co.; Rt. 634 at Rt. 726, 15 Apr. 1978, 2 males, SWB, FLC Collection; Waqua Cr. at Rt. 1, 15 Apr. 1978, 1 male, 1 female, FLC. Campbell Co.; Pond at Rt. 646, 2 May 1980, 2 males (teneral), BCK. Charles City Co.; Berkeley Hills, 19 Apr. 1938, 2 males, MED and D. T. R., (Det. MED, MDR notes); Herring Cr. Pd. on Rt. 5, 19 Apr. 1938, 2 males, 1 pair, MED, (Det. MED, MDR notes). Charlotte Co.; Twittys Cr., 23 Apr. 1976, 1 male, M. Mauney, VPI&SU; Twittys Cr. Reservoir, 18 May 1978, 5 males, 2 females, FLC; Spring Cr. at Rt. 654, 18 May 1978, 2 males, 1 female,

BCK; Spring Cr. at Rt. 654, 23 May 1977, 1 male, 6 females, FLC; Twittys Cr. 1 mile upstream from Drakes Branch, 23 May 1977, 2 males, 1 female, FLC; Twittys Cr. at Rt. 642, 23 May 1977, 1 male, FLC; Twittys Cr. Dam, 10 June 1975, 1 male, FLC; Twittys Cr. Dam, 18 June 1975, 1 male, FLC. Craig Co.; Cold Spring Branch at Rt. 611, 28 May 1977, 1 male, FLC; Johns Cr. at Rt. 311, 28 May 1977, 1 male, FLC; Small marsh nr. Rt. 635 2 miles S. of Paintbank, 7 June 1974, 1 male, FLC; Cold Spring seepage area at Rt. 611, 17 June 1978, 1 male, FLC. Cumberland Co.; Bear Cr. Lk., 23 May 1977, 3 males, 43 nymphal exuviae, FLC. Dickenson Co.; Laurel Lk. at Breaks Interstate Park, 13 June 1979, 5 males, JRV, VPI&SU; Small lake at Breaks Interstate Park below dam, 14 June 1979, 1 female, JRV, VPI&SU; Laurel Lk. and Laurel Br. below dam at Breaks Interstate Park, 14 June 1979, 2 males, JRV, VPI&SU; John W. Flannagan Reservoir at Rt. 755, 12 July 1980, 1 male, FLC. Dinwiddie Co.; Sappony Cr. at Rt. 40, 16 Apr. 1978 (emerged 24 Apr. 1978), 1 male, FLC. Fairfax Co.; Pond behind Mallory House at George Mason U., 24 Apr. 1973, 1 male, C. R. Parker, VPI&SU; Great Falls, 2 May 1917, 1 female, W. L. McAltee, USNM; Burke Lake Park, 18 May 1965, 4 males, OSF, USNM; Great Falls, 21 May 1914, 4 males, RPC, USNM; Great Falls, 2 June 1914, 1 male, RPC, USNM. Franklin Co.; Burnt Chimney, 22 Apr. 1976, 1 male, R. Booth, VPI&SU. Giles Co.; Farrier Farm at Newport, 7 May 1938, 1 male, MED, (Det. MED, MDR notes); Sinking Cr. at Rt. 42, 28 May 1977, 1 male, FLC; Mtn. Lk. at Pond Drain Cr., 5 July 1973, 2 males, FLC. Halifax Co.; Rt. 306, 8 June 1978, 1 male, 1 female, BCK. Hanover Co.; Lukart's Farm, 12 Apr. 1975, 1 male, T. Kline, VCU. Henrico Co.; Richmond, 12 June 1974, 1 male, G. Cotron, VCU; Richmond, 12 June 1974, 1 male,

M. Driscoll, VCU; Richmond, 19 June 1974, 1 male, M. Driscoll, VCU.
 Highland Co.; Bullpasture R. at head of gorge, 30 May 1977, 1 male,
 FLC; Small pond on Rt. 250 E. of Monterey, 23 June 1978, 3 males, FLC.
 Isle of Wight, locality unknown, 5 Jan. 1976 (emerged 26 Mar. 1976), 1
 male, J. O'Hop, ODU; Blackwater R. above Franklin, 10 Apr. 1976, 1 fe-
 male, J. O'Hop, ODU. James City Co.; Lk. Matoaka at Williamsburg, 14
 Apr. 1938, 1 male, MED and D. T. R., (Det. MED, MDR notes); Williamsburg,
 27 Apr. 1938, 1 female, collector unknown, (Det. MED), W&M; Williamsburg,
 2 May 1937, 1 male, collector unknown, (Det. MED, MDR notes); Lk. Mato-
 aka, 4 May 1938, 2 males, T. D. M., (Det. T. D. M., MDR notes); Lk.
 Matoaka, 4 May 1938, 7 males, MED, (Det. MED, MDR notes); Williamsburg,
 9 May 1937, 1 male, collector unknown, (Det. MED, MDR notes); Lk. Mato-
 aka, 10 May 1938, 1 male, MED and T. D. M., (Det. MED, MDR notes); Wil-
 liamsburg, 11 May 1937, 2 males, collector unknown, (Det. MED), W&M;
 Williamsburg, 17 May 1937, 1 male, MED, (Det. MED, MDR notes); Jollys
 Pd., 17 May 1966, 6 males, MDR, VPI&SU; Williamsburg, 18 May 1937, 1
 male, collector unknown, (Det. MED, MDR notes); Lake Matoaka at Williams-
 burg, 18 May 1966, 3 males, MDR, VPI&SU; Tutters Neck Pd., 18 May 1966,
 2 males, MDR, VPI&SU; Williamsburg, 20 May 1937, 4 males, collector un-
 known, (Det. MED, MDR notes); Williamsburg, 23 May 1938, 1 male, col-
 lector unknown, (Det. MED), W&M; Rt. 611, 24 May 1966, 1 male, 1 female,
 MDR, VPI&SU; Pond nr. Long Hill Swamp, 24 May 1966, 1 male, MDR, VPI&SU.
 Lee Co.; Small marsh nr. Rt. 606, 3 July 1977, 1 male, FLC; Keokee Lk.,
 3 July 1977, 4 males, FLC. Montgomery Co.; Blacksburg, 14 Apr. 1958,
 1 male, N. T. Gardner, VPI&SU; Blacksburg, 15 Apr. 1948, 1 male, Cock-
 rell, VPI&SU; Pandapas Pd., 16 Apr. 1977 (emerged 27 Apr. 1977), 1 female,

M. Meschter, VPI&SU; Pond nr. Toms Cr., 19 Apr. 1977 (emerged 22 Apr. to 12 May 1977), Dr. Voshell's class, VPI&SU; Pond nr. Toms Cr., 19 Apr. 1977, 1 male, S. Mudre, VPI&SU; Pond nr. Toms Cr., 2 May 1978 (emerged 2 to 5 May 1978), B. Rinker, VPI&SU; Pond on Rt. 655, 2 May 1978, 1 female (teneral), K. Loyd, VPI&SU; Blacksburg, 15 May 1948, 1 male, E. C. Cockrell, VPI&SU; Blacksburg, 16 May 1953, 1 male, F. S. Tulloss, VPI&SU; locality unknown, 17 May 1976, 1 male, H. Matthews, VPI&SU; Craig Cr. beaver pd., 17 May 1977, 1 male, J. Schmidt, VPI&SU; Blacksburg, 23 May 1960, 1 male, W. M. Thornton, 23 May 1960, 1 male, VPI&SU; Pandapas Pd., 24 May 1973, 2 males, FLC; Blacksburg, 27 May 1957, 1 male, W. B. H., VPI&SU; Poverty Cr. at Rt. 621, 27 May 1962, 3 males, D. Innes, VPI&SU; Pandapas Pd., 7 June 1976, 3 males, 1 female, Hammond; Issaic Walton Pd., 10 June 1978, 1 male, FLC; Issaic Walton Pd., 10 June 1978, 1 male, BCK, VPI&SU; Pandapas Pd., 14 June 1974, 1 male, FLC; Pandapas Pd., 27 June 1975, 1 male, 1 female, SWB, VPI&SU; Pandapas Pd., 5 July 1973, 1 male, FLC, VPI&SU; Blacksburg, 10 July 1948, 2 males, G. M. Boush, VPI&SU. Nelson Co.; Private campground at Montebello Pd. at Rt. 56, 19 July 1978, 6 males, JRV and TJV, VPI&SU. New Kent Co.; Plum Point, 30 Apr. 1970, 2 males, C. Shiffer. Nottoway Co.; Nottoway R. at The Falls, 15 Apr. 1978, 1 female (teneral), FLC. Patrick Co.; Seepage area along Rock Castle Cr. at Rt. 605, 11 June 1978, 1 male, FLC. Powhatan Co.; locality unknown, 14 Apr. 1974, 1 male, J. L. Kopsch, VCU. Prince Edward Co.; locality unknown, 16 Apr. 1977, 1 male, Keil and Cannon, VPI&SU. Roanoke Co.; Roanoke R. at Blue Ridge Parkway, 20 May 1977, 4 males, FLC. Rockingham Co.; Hone Quarry Lk. and stream, 1 July 1973, 1 male, SWD. Russell Co.; Laurel Bed Lk., 4 July 1977, 2 males, 2 nymphal exu-

viae, FLC. Southampton Co.; Nottoway R. at Rt. 653, 16 Apr. 1978, 1 male (teneral), FLC; Delzell Farm 9 miles N.W. of Windsor off Rt. 635, 5 May 1979, 2 females, J. Clark, VPI&SU. Spotsylvania Co.; Small tributary of Matta R. at Rt. 617, 29 May 1978, 1 male, FLC. Tazewell Co.; Rt. 666 at Goses Mill, 10 June 1978, 2 males, FLC. Warren Co.; Surber's Pd. at Rt. 634, 6 June 1977, 1 male, FLC. Washington Co.; Small pond along Rt. 663, 15 June 1980, 1 male, FLC. Wise Co.; North Fork Reservoir at Phillips Cr. Recreation Area at Rt. 834, 12 July 1980, 1 male, FLC. York Co.; Seepage below Waller Mill Reservoir, 19 May 1966, 1 male, MDR, VPI&SU. City of Newport News; locality unknown, 10 May 1966, 1 male, J. McKey, ODU. City of Suffolk; Dismal Swamp Wildlife Refuge, 10 Feb. 1975, 1 female (reared); J. Hancock, ODU; Blackwater R. at Rt. 189 below Franklin, 11 Apr. 1976, 1 male, J. O'Hop, ODU; Jericho Lane in Dismal Swamp Wildlife Refuge, 16 Apr. 1978, 1 male, SWB, FLC Collection; Badger Ditch in Dismal Swamp Wildlife Refuge, 17 Apr. 1978, 5 males, 4 females (teneral), 20 nymphal exuviae, FLC; Dismal Swamp Wildlife Refuge, 22 Apr. 1974, 5 males, 2 females, J. Hancock, ODU; Dismal Swamp Wildlife Refuge, 25 Apr. 1970, 1 female, H. F. P., ODU; Dismal Swamp Wildlife Refuge, 25 Apr. 1970, 1 female, JFM, ODU; Dismal Swamp Wildlife Refuge, 6 May 1970, 1 male, JFM, ODU; Dismal Swamp Wildlife Refuge, 9 May 1970, 1 male, M. Burckett, ODU; locality unknown, 14 May 1964, 1 female, collector unknown, ODU; Washington Ditch in Dismal Swamp Wildlife Refuge, 21 May 1977, 1 female, FLC; Jericho Lane in Dismal Swamp Wildlife Refuge, 21 May 1977, 5 males, 11 females, FLC. City of Virginia Beach; 17 Apr. 1976, 1 male, J. O'Hop, ODU; White Lk. at Seaside State Park, 22 May 1977, 4 males, FLC.

Flight Season.--Year-round (FL); in Virginia Apr. 10 to July 22.

Known season in neighboring states are: Kentucky- Apr. 10 to July 5; Maryland- June 20; North Carolina- Mar. to Sept.; Pennsylvania- May 16 to Aug. 15; Tennessee- May 1 to Aug. 16; West Virginia- June 1 to July 11.

Biology.--*Tetragoneuria cynosura* inhabits ponds and lakes. Adult males patrol near shore during daylight at from 40-80 cm above water. Adults generally feed in openings near shore. Oviposition is accomplished by draping egg strings over floating vegetation.

Remarks.--This is the most common species of *Tetragoneuria*. Northern populations may represent a distinct species to which the names *T. diffinis*, *T. simulans*, and *T. morio* may apply. The northern form has been collected in Giles county, Virginia at an elevation of 1180 m.

Tetragoneuria semiaquea (Burmeister)

Syn.: *complanata* Rambur

(Figures 150a, 152c, 155a)

Burmeister 1839. Handb. 2:858 (in *Libellula*).

Length 34-36 mm; abdomen 24-26 mm; hind wings 23-26 mm.

Diagnosis.--Dorsal surface of frons without well-developed T-shaped brown spot; fore wings each with 6 or 7 antenodals, and 4-6 postnodals; hind wings each with basal spot generally extended to nodus, 4 antenodals, and 5-7 postnodals; second penile segment 0.41-0.44 as wide as long; distance between lateral and ventromedian carinae of tergum 6 0.46-0.48 length of lateral carinae; vulvar lamina extended to near apex of sternum 10, longer than cerci with medial margin of lateral lobes concave

subapically; male cerci each with apices directed posteriorly, without dorsal spine, with ventral angulation, and ventral carinae extended beyond ventral angulation; female cerci 1.2-1.5 mm long, slightly longer than abdominal segment 9.

Distribution.--Known from the states of FL, GA, MD, MA, NJ, NY, NC, SC, and VA. Known from the Virginia county of Southampton. Known distribution among the counties of neighboring states include: North Carolina- Bladen, Craven, Duplin, Gates, Lee, Moore, New Hanover, Robeson, Scotland, and Wake.

Virginia Records.--Southampton Co.; Blackwater R. at Rt. 258 nr. Franklin, 20 May 1977, 1 male, 1 female (in tandem), FLC.

Flight Season.--Jan. 8 (FL) to Aug. 30 (SC); in Virginia May 20. Known season in neighboring states are: North Carolina- Mar. 27 to May 9.

Biology.--*Tetragoneuria semiaquea* inhabits boggy ponds. Adult males patrol near shore in shade or at dusk at from 20-60 cm above water. Adults feed along road cuts and in forest openings at from 1-10 cm. Oviposition is accomplished by draping egg strings over floating vegetation.

Remarks.--This is the smallest species of *Tetragoneuria*. The wing markings are characteristically lighter toward the center of cells. Northern populations (New Jersey to Nova Scotia) may represent a distinct subspecies.

Tetragoneuria spinigera Selys

Syn.: *indistincta* Morse; var. *suffusa* Davis

(Figures 150b, 153a, 155b)

Selys 1871. Bull. Acad. Belg. 31:269.

Length 42-53 mm; abdomen 30-38 mm; hind wings 29-37 mm.

Diagnosis.--Dorsal surface of frons with well-developed T-shaped brown spot; fore wings each with 6-8 antenodals, and 6-8 postnodals; hind wings each with basal spot generally extended to near first antenodal cross-vein (occasionally halfway to nodus in female), 4 or 5 antenodals, and 5-8 postnodals; second penile segment 0.42-0.45 as wide as long; distance between lateral and ventromedian carinae of tergum 6 0.34-0.36 length of lateral carinae; vulvar lamina extended to midlength of sternum 10, shorter than cerci with medial margin of lateral lobes concave subapically; male cerci each with apices directed posteriorly, without dorsal spine, with ventral spine, and ventral carinae vestigial; female cerci 3.0-3.5 mm long, longer than abdominal segments 9 and 10.

Distribution.--Known from the states of CA, CT, IN, KY, ME, MA, MI, MN, MT, NH, NJ, NY, PA, VT, WA, WV, and WI, and the provinces of Alta., B.C., Man., N.B., N.S., Ont., Que., and Sask. Known distribution among the counties of neighboring states include: Kentucky- Union; Pennsylvania- Bradford and Lycoming.

Flight Season.--May 17 (MI) to Sept. (NY). Known season in neighboring states are: Kentucky- June; Pennsylvania- June 16 to July 7.

Biology.--*Tetragoneuria spinigera* inhabits ponds and lakes with tree fragments covering the bottom. Adult males patrol near shore at from 20-40 cm. Adults feed near shore and in forest openings at from 1-10 m. Oviposition is accomplished by draping egg strings over floating vegetation. This species is perhaps the most wary species of *Tetragon-*

euria.

Remarks.--Although not previously reported from Virginia this species probably occurs in the upland ponds of western Virginia.

Tetragoneuria spinosa (Hagen)

(Figures 150c, 153b, 155c)

Hagen 1878. In Selys, Bull. Acad. Belg. 45:188 (in *Cordulia*).

Length 43-49 mm; abdomen 29-35 mm; hind wings 28-34mm.

Diagnosis.--Dorsal surface of frons without well-developed T-shaped brown spot; fore wings each with 6-9 antenodals, and 5-8 postnodals; hind wings each with basal spot generally extended to near first antenodal crossvein, 4-6 antenodals, and 5-8 postnodals; second penile segment 0.47-0.50 as wide as long; distance between lateral and ventromedian carinae of tergum 6 0.44-0.46 length of lateral carinae; vulvar lamina extended slightly beyond apex of sternum 9, longer than cerci with medial margin of lateral lobes concave subapically; male cerci each with apices directed posteroventrally, with dorsal spine, with slight ventral angulation, and ventral carinae absent; female cerci 1.9-2.3 mm long, ca. as long as abdominal segment 9.

Distribution.--Known from the states of AL, DE, FL, GA, MD, NJ, NC, OK(?), SC, and VA. Known from the Virginia county of Southampton and the city of Suffolk. Known distribution among the counties of neighboring states include: North Carolina- Durham, Northampton, and Wake.

Virginia Records.--Southampton Co.; Nottoway R. at Rt. 653, 16 Apr. 1978, 3 males, 1 female, FLC; Nottoway R. at Rt. 653, 16 Apr. 1978, 1

female, SWB, FLC Collection; 16 miles E. of Emporia, 18 Apr. 1951, 1 male, R. L. Hoffman, (Det. LKG). City of Suffolk, Badger Ditch at Dis- male Swamp Wildlife Refuge, 17 Apr. 1978, 34 males (2 teneral), 1 female, 13 nymphal exuviae, FLC and SWB, FLC Collection.

Flight Season.--Apr. 2 (NC) to June 6 (NJ): in Virginia Apr. 16 to 18. Known season in neighboring states are: North Carolina- Apr. 2 to 19.

Biology.--*Tetragoneuria spinosa* inhabits ponds and lakes. Adult males have not been observed patrolling near shore. Adults feed in open areas at from 1-5 m. Oviposition is probably accomplished by draping egg strings over floating vegetation near shore.

Remarks.--This species is more common on the Virginia coastal plain than previous records indicate.

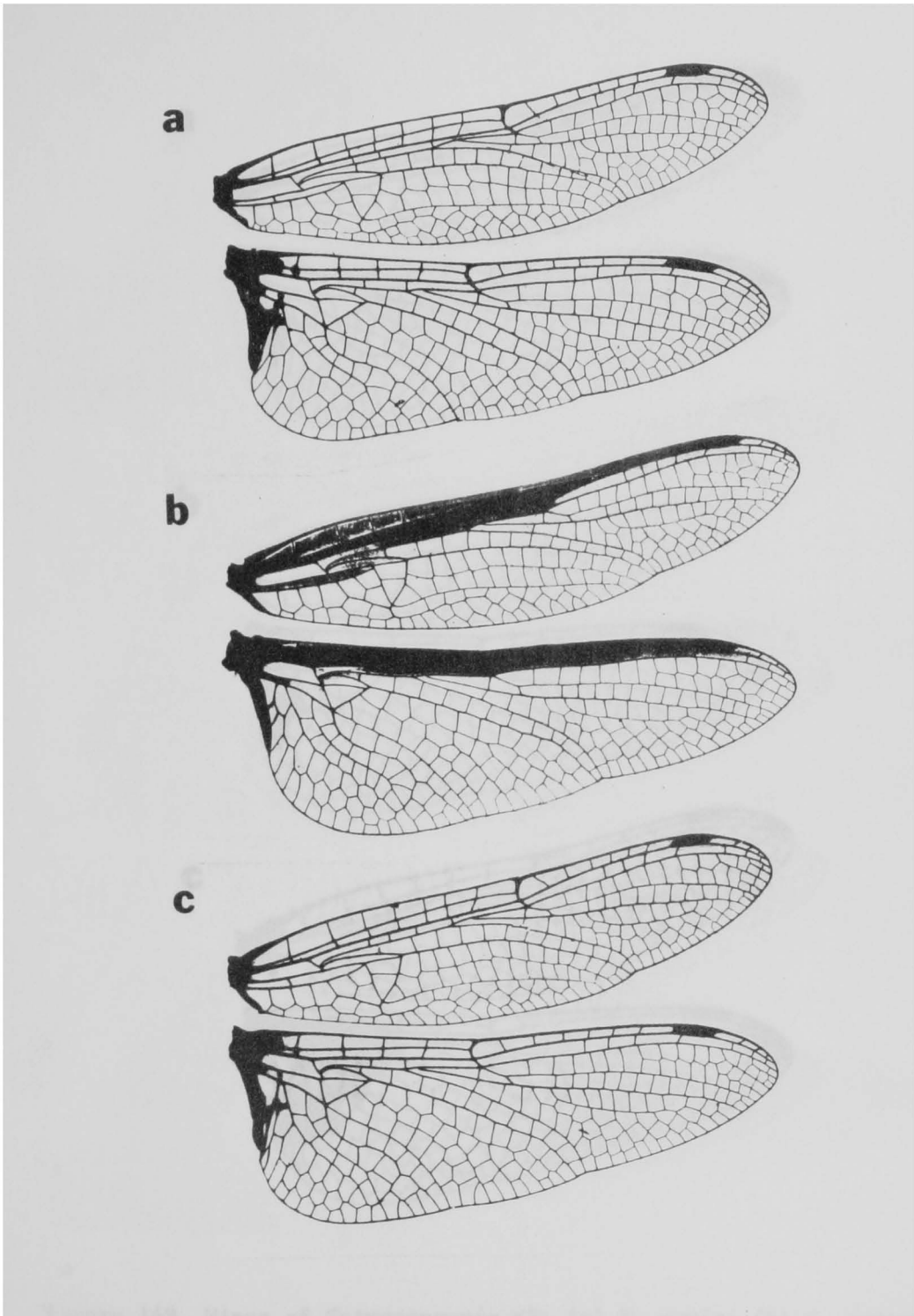


Figure 148. Wings of *Tetrhoneuria costalis* x3: (a) male (FL); (b) female (FL); (c) male (VA).

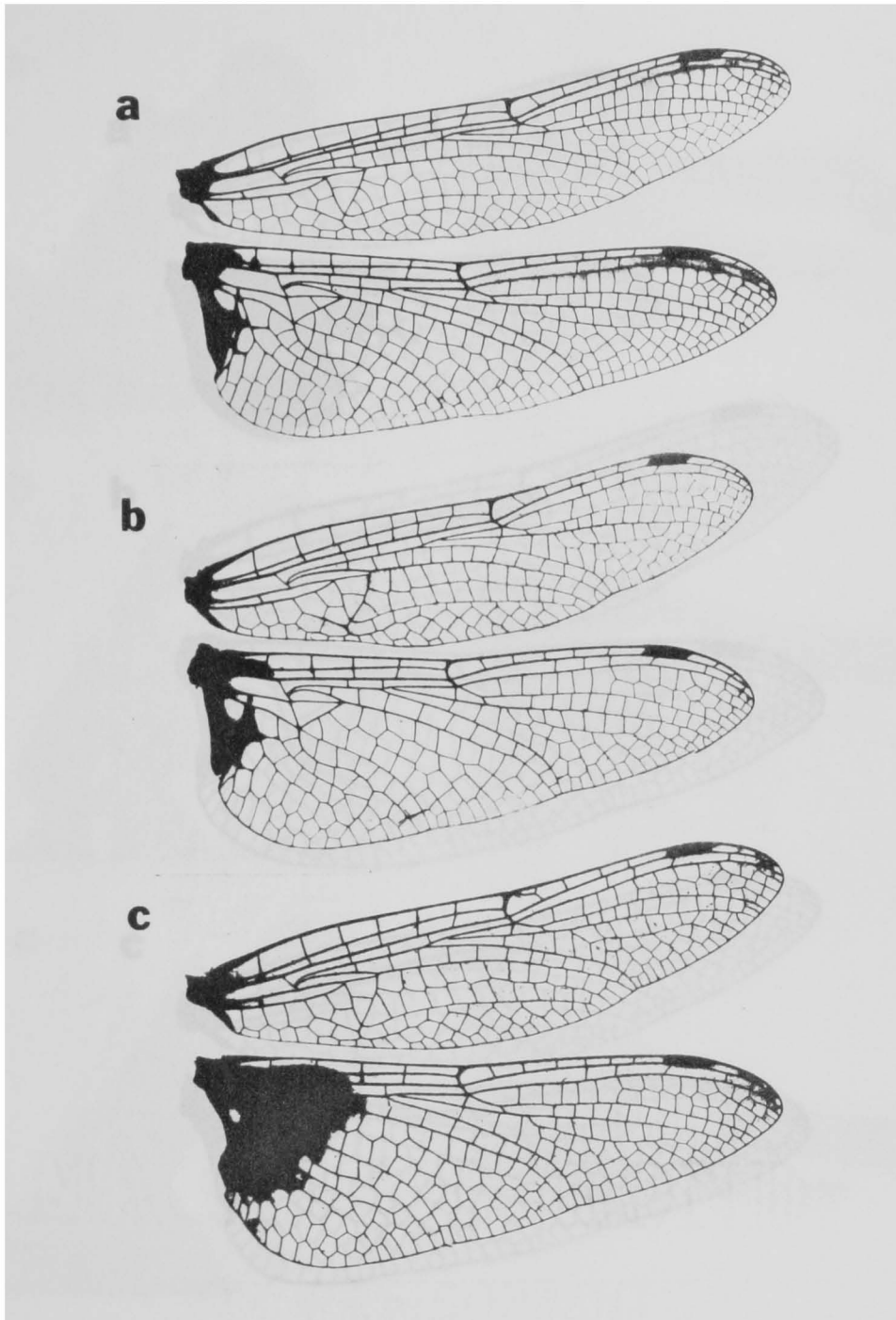


Figure 149. Wings of *Tetragoneuria* x3: (a) *T. canis*; (b) *T. cynosura*; (c) *T. cynosura* (Mtn. Lk., VA).

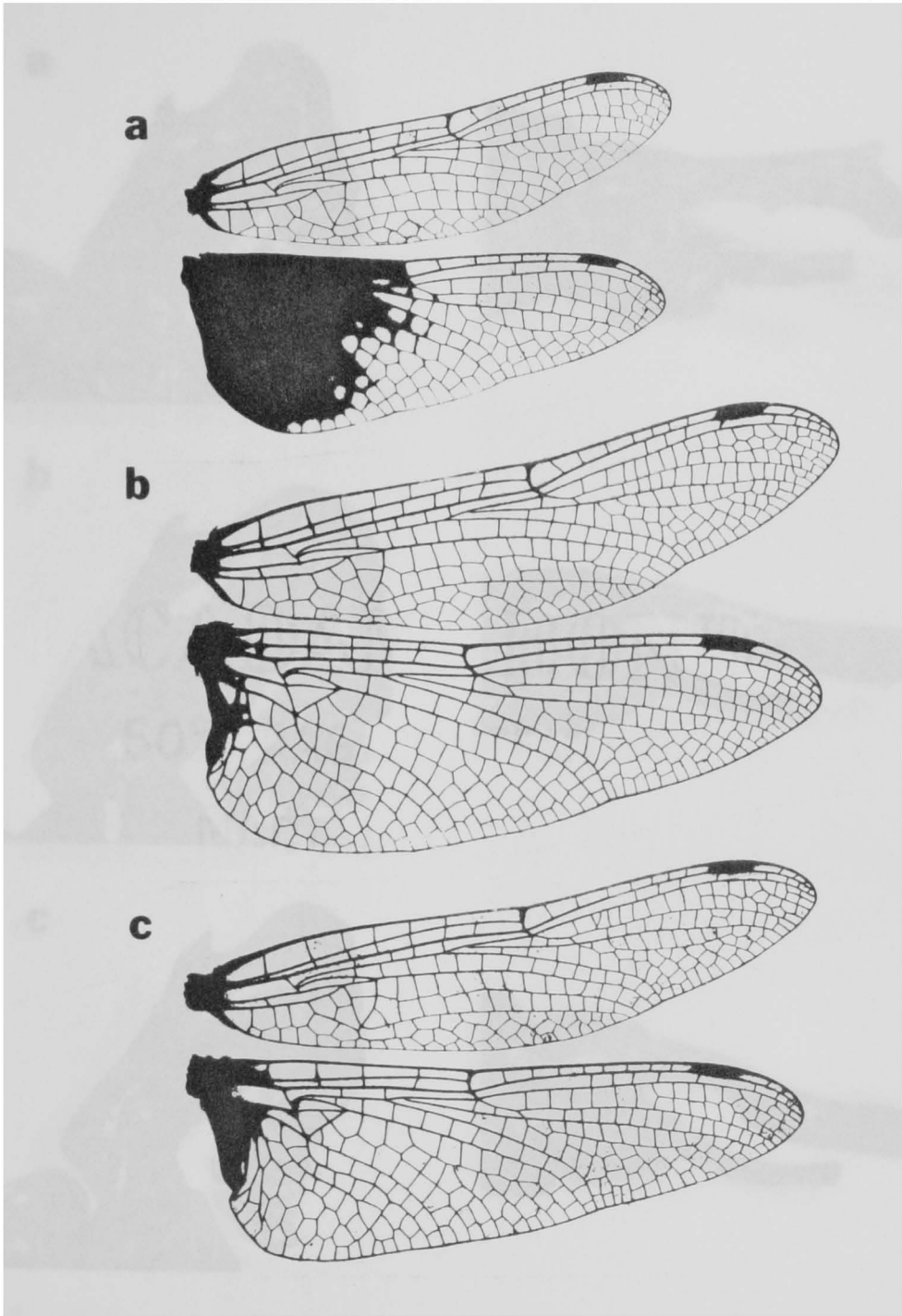


Figure 150. Wings of *Tetragoneuria* x3: (a) *T. semiaqua*;
(b) *T. spinigera*; (c) *T. spinosa*.

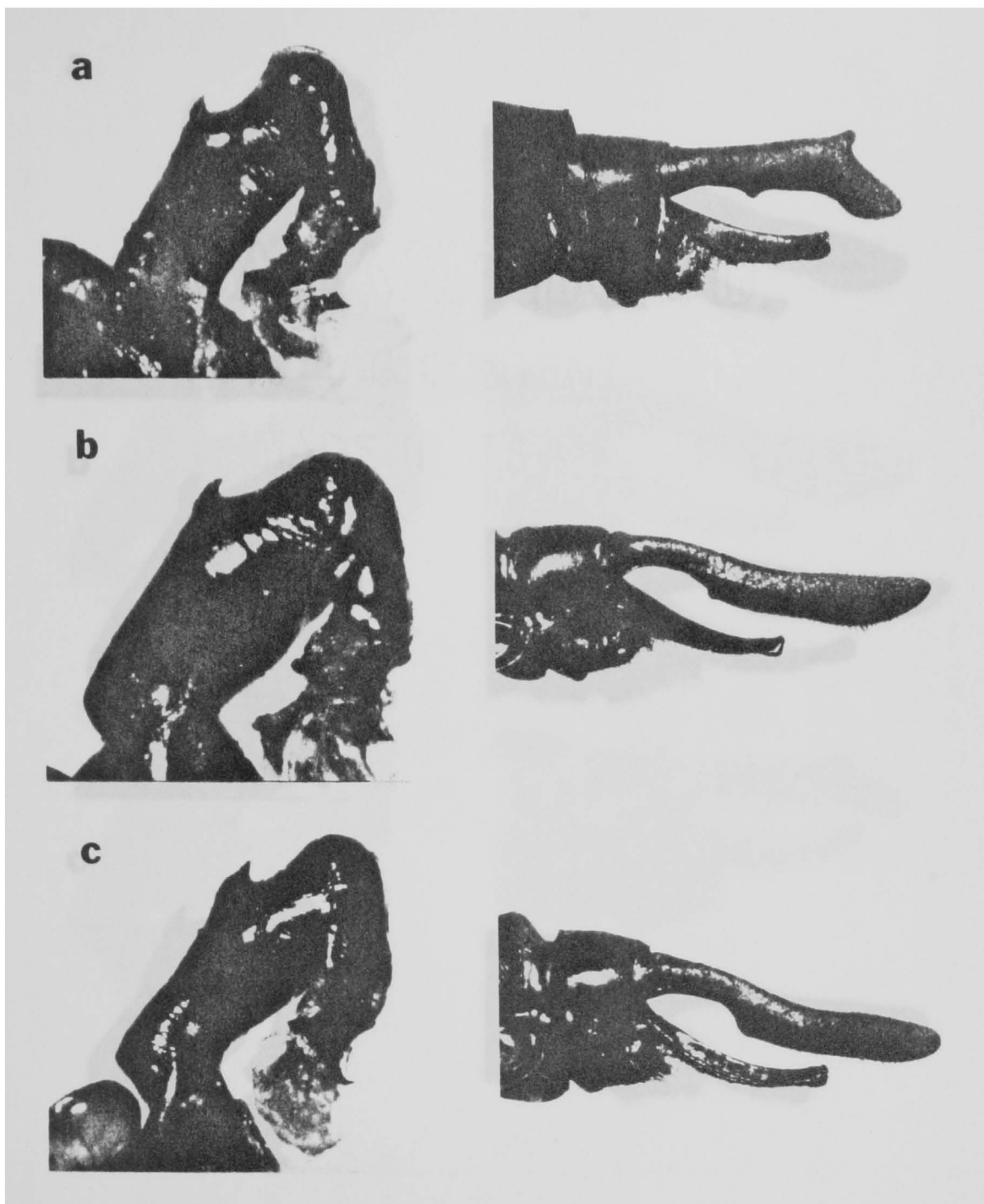


Figure 151. Male penis x40 and terminalia x17 in lateral view of *Tetragoneuria*: (a) *T. cunis*; (b) *T. costalis* (FL); (c) *T. costalis* (VA).

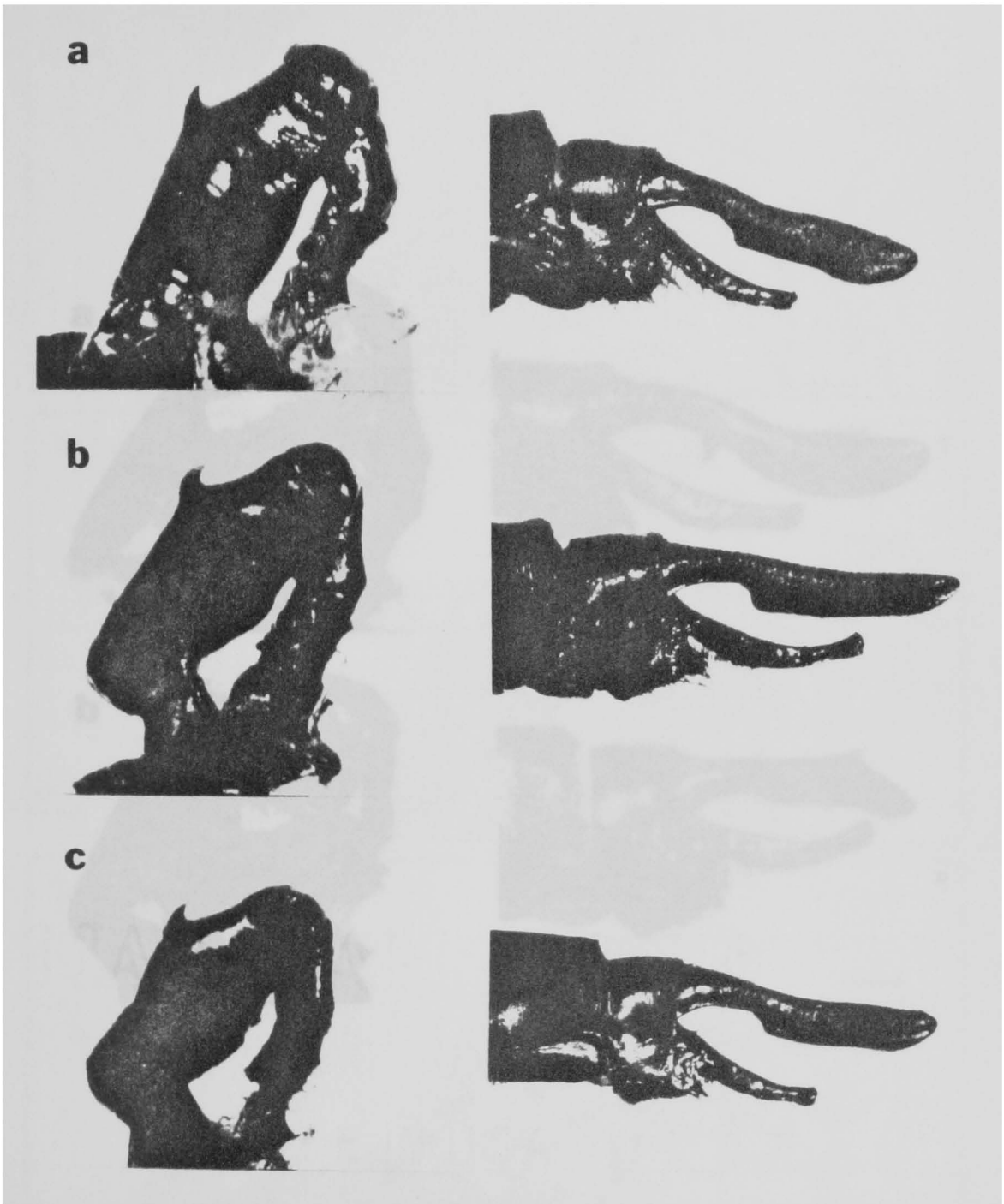


Figure 152. Male penis x40 and terminalia x17 in lateral view of *Tetragoneuria*: (a) *T. cynosura*; (b) *T. cynosura* (Mtn. Lk., VA); (c) *T. semiaqua*.

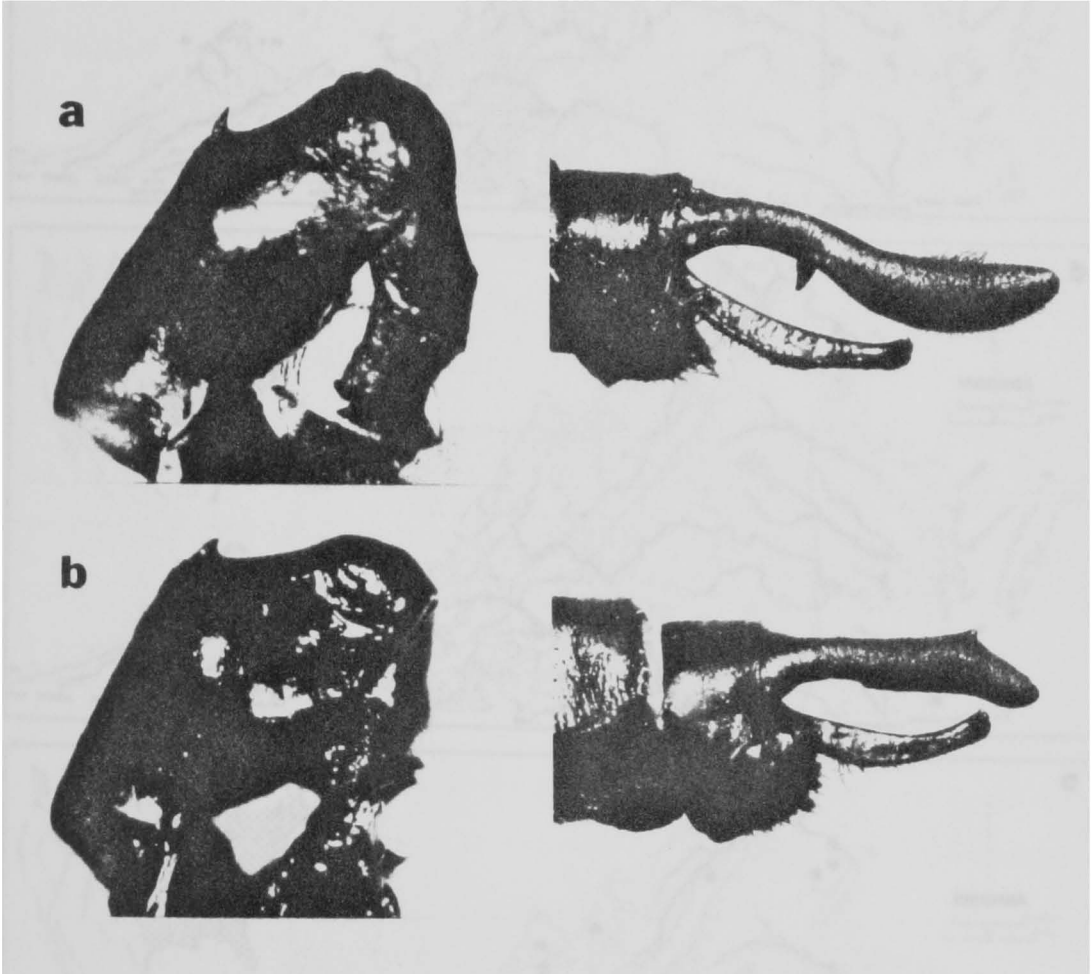


Figure 153. Male penis x40 and terminalia x17 in lateral view of *Tetragoncuria*: (a) *T. spinigera*; (b) *T. spinosa*.

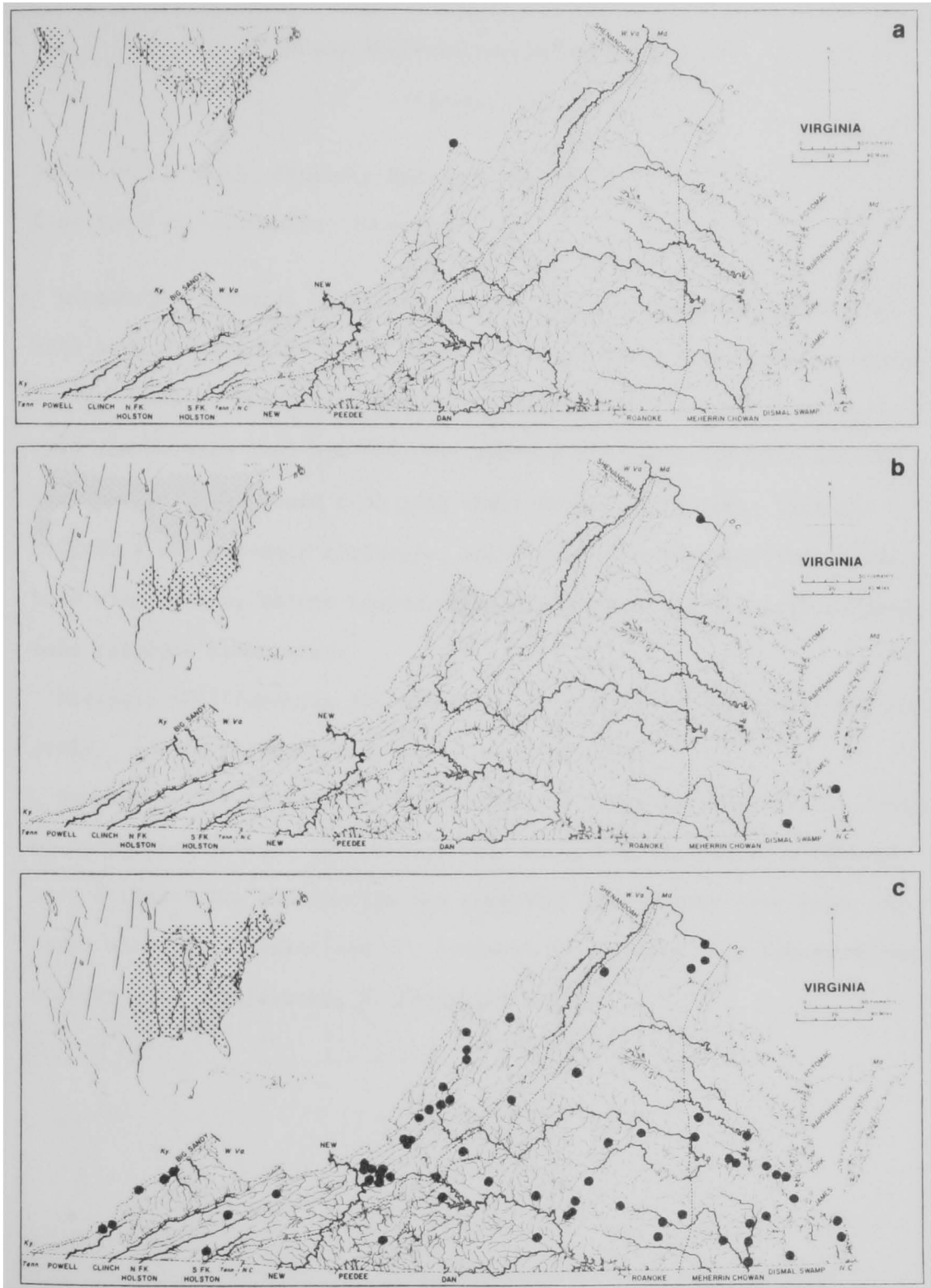


Figure 154. Geographic distribution of *Tetragoneuria*: (a) *T. canis*; (b) *T. costalis*; (c) *T. cynosura*.

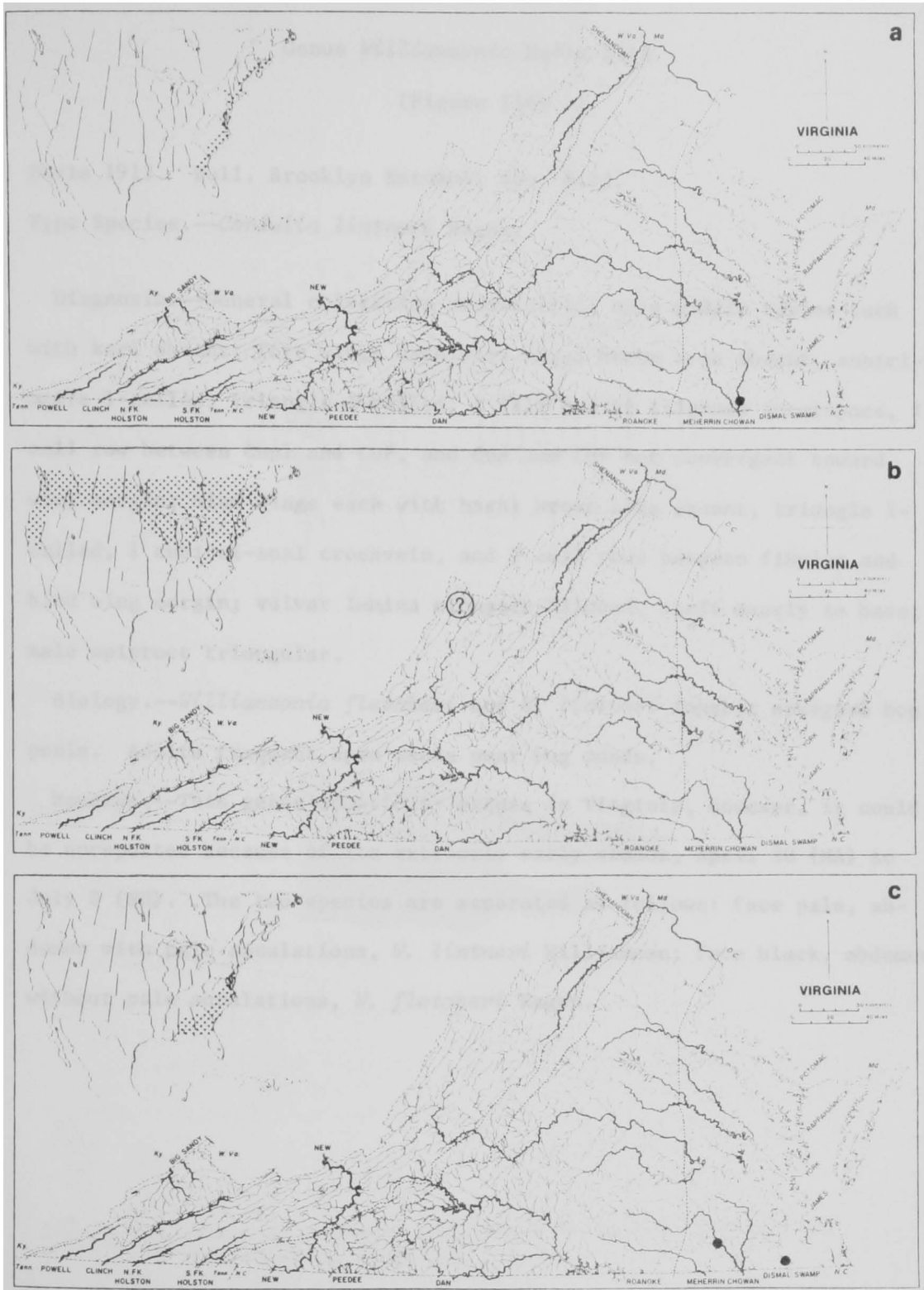


Figure 155. Geographic distribution of *Tetragoneuria*: (a) *T. semiaquea*; (b) *T. spinigera*; (c) *T. spinosa*.

Genus *Williamsonia* Davis 1913

(Figure 156)

Davis 1913. Bull. Brooklyn Entomol. Soc. 8:93.

Type Species.--*Cordulia lintneri* Hagen.

Diagnosis.--General coloration nonmetallic; male middle tibiae each with keel absent; fore wings each with basal brown area absent, subtriangle 1-celled, triangle 1-celled, 1 cell row in trigonal interspace, 1 cell row between Cu_{1P} and Cu_P , and CuA and Cu_P not convergent toward wing margin; hind wings each with basal brown area absent, triangle 1-celled, 1 cubital-anal crossvein, and 2 cell rows between fibulum and hind wing margin; vulvar lamina elongate-bilobed, cleft nearly to base; male epiproct triangular.

Biology.--*Williamsonia fletcheri* and *W. lintneri* inhabit sphagnum bog pools. Adults frequent open woods near bog ponds.

Remarks.--This genus doubtfully occurs in Virginia, however, it could be unreported because of its extremely early season, April 30 (MA) to July 8 (NH). The two species are separated as follows: face pale, abdomen with pale annulations, *W. lintneri* Williamson; face black, abdomen without pale annulations, *W. fletcheri* Hagen.

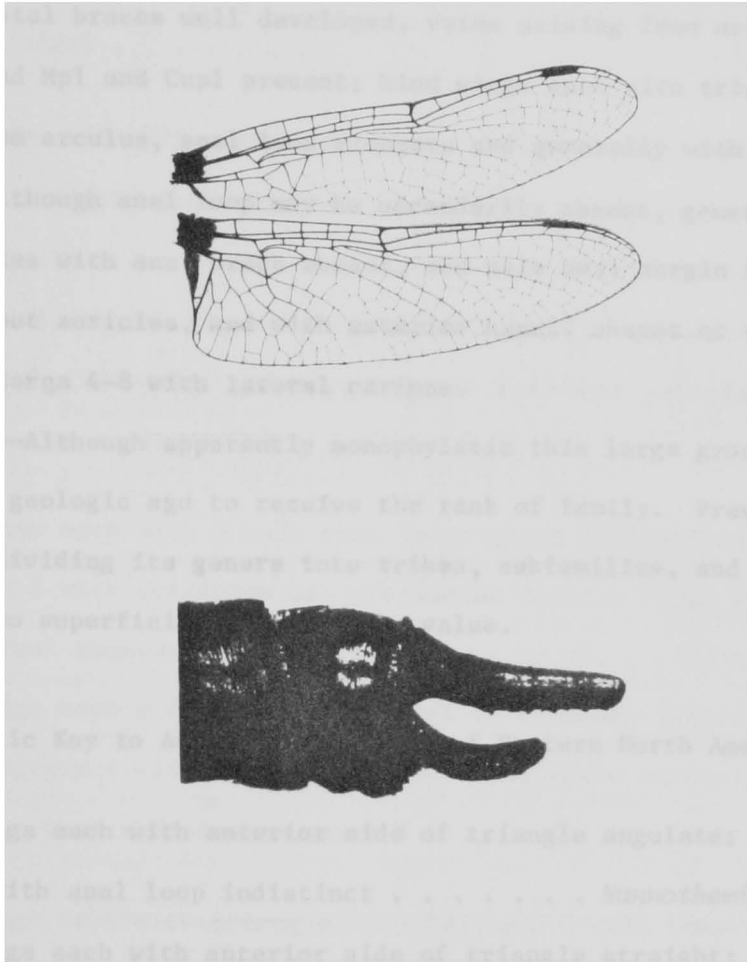


Figure 156. Wings x3 and male terminalia in lateral view x17 of *Williamsonia lintneri*.

Subfamily Libellulinae Selys

Diagnosis.--Hind margin of compound eyes sinuate or level laterally; mesopleural sulci sinuate or level; males without tibial keels; hooks of tarsal claws unequal or subequal in length; wings each with supplementary costal braces well developed, veins arising from arculus fused basally, and Mpl and Cupl present; hind wings each with triangle not distant from arculus, anal loop elongate and generally with well-developed toe although anal loop may be secondarily absent, generally with midrib, males with anal brace absent, and male anal margin rounded; males without auricles, and with anterior hamuli absent or vestigial; abdominal terga 4-8 with lateral carinae.

Remarks.--Although apparently monophyletic this large group is not of sufficient geologic age to receive the rank of family. Previous work variously dividing its genera into tribes, subfamilies, and families has been too superficial to be of any value.

Generic Key to Adult Libellulinae of Eastern North America

1. Fore wings each with anterior side of triangle angulate; hind wings each with anal loop indistinct *Nannothemis* p. 837
 Fore wings each with anterior side of triangle straight; hind wings each with anal loop distinct 2

2. Wings each with proximal and distal margins of pterostigma divergent anteriorly, proximal side nearly perpendicular to main veins, pterostigma trapezoidal 3
- Wings each with proximal and distal margins of pterostigma parallel, proximal side nearly oblique to main veins, pterostigma not trapezoidal 7
3. Wings each with RP₂ and MA undulate; hind wings each with 2 cubital-anal crossveins; abdominal tergum 5 with supplementary transverse carina *Pantala* p. 858
- Wings each without RP₂ and MA undulate; hind wings each with 1 cubital-anal crossvein; abdominal tergum 5 without supplementary transverse carina 4
4. Fore wings each with 4 cell rows in trigonal interspace; abdominal tergum 4 with supplementary transverse carina; cerci longer than abdominal segment 8 *Tramea* p. 927
- Fore wings each with 2 or 3 cell rows in trigonal interspace; abdominal tergum 4 without supplementary transverse carina; cerci shorter than abdominal segment 8 5
5. Fore wings each with triangle 2-celled, and 3 cell rows in trigonal interspace; hind wings each with 3 paranal cells within anal loop *Tauriphila* p. 924
- Fore wings each with triangle 1-celled, and 2 cell rows in trigonal interspace; hind wings each with 2 paranal cells within anal loop 6

6. Wings each without Rpl; fore wings each with 3 postmedian crossveins;
 hind wings each with 5 or 6 postnodal crossveins
 *Macrodiplox* p. 830
- Wings each with Rpl; fore wings each with 5 postmedian crossveins;
 hind wings each with 8-10 postnodal crossveins
 *Miathyria* p. 834
7. Wings each with RP_2 strongly undulate; posterior margin of pronotum
 evenly convex, without medial indentation 8
- Wings each with RP_2 not strongly undulate; posterior margin of
 pronotum not evenly convex, with medial indentation 12
8. Fore wings each with 2 or 3 cell rows subtended by Cup1 9
- Fore wings each with 1 cell row subtended by Cup1 10
9. Male abdominal sternum 1 without paired ventral processes, anterior
 lamina not directed anteriorly to engage base of penile segment 3;
 female abdominal segment 9 without lateral carinae, vulvar lamina
 directed ventrally *Libellula* p. 766
- Male abdominal sternum 1 with paired ventral processes, anterior
 lamina directed anteriorly to engage base of penile segment 3;
 female abdominal segment 9 with lateral carinae, vulvar lamina
 directed posteriorly *Plathemis* p. 875

10. Wings each with 2-4 bridge crossveins, and basal brown area extended to first antenodal crossvein *Isodon* p. 738
 Wings each with 1 bridge crossvein, and basal brown area not extended to first antenodal crossvein 11
11. Wings each with 2 or 3 crossveins between pterostigma and RP_1 ; hind wings each with 2 or 3 cell rows between fibulum and wing margin *Dythemis* p. 712
 Wings each with 4-7 crossveins between pterostigma and RP_1 ; hind wings each with 4 or 5 cell rows between fibulum and wing margin *Orthemis* p. 842
12. Hind wings each with midvein of anal loop angulated less than 20° at ankle 13
 Hind wings each with midvein of anal loop angulated more than 20° at ankle ~~14~~ 15
13. Fore wings each with anterior side of triangle nearly as long as proximal side; hind wings each with 2 paranal cells proximal to anal loop; abdominal terga 3 and 9 with lateral carinae, and tergum 4 with supplementary transverse carina *Perithemis* p. 865
 Fore wings each with anterior side of triangle ca. 1/2 as long as proximal side; hind wings each with 3 paranal cells proximal to anal loop; abdominal terga 3 and 9 without lateral carinae, and tergum 4 without supplementary transverse carina 14

14. Fore wings each with triangles 2-5-celled; fore wings each with
 nodus located at ca. middle of wing *Celithemis* p. 683
 Fore wings each with triangles 1-celled; fore wings each with
 nodus located beyond middle of wing *Idiataphe* p. 736
15. Fore wings each with 6 or 7 paranal cells proximal to subtriangle;
 middle and hind tibiae each with apical 3 or 4 spines of outer
 spine row greatly lengthened 16
 Fore wings each with 5 paranal cells proximal to subtriangle;
 middle and hind tibiae each with apical 3 or 4 spines of outer
 spine row not greatly lengthened 17
16. Wings each with 1 cell row subtended by Mpl; hind wings each with
 3 or 4 postmedian crossveins; abdominal tergum 4 with postero-
 dorsal carinae more than 1/3 length of dorsomedial carina
 *Erythemis* p. 716
 Wings each with 2 cell rows subtended by Mpl; hind wings each with
 5 postmedian crossveins; abdominal tergum 4 with posterodorsal
 carinae less than 1/4 length of dorsomedial carina
 *Leptthemis* p. 747
17. Hind wings each with 2 paranal cells proximal to fibulum, and 2 or
 3 cell rows subtended by Rpl for distance of 5-7 cells proximal
 to IRP₁ *brachymesia* p. 679
 Hind wings each with 3 paranal cells proximal to fibulum, and 2 or
 3 cell rows subtended by Rpl for distance of 1-3 cells proximal
 to IRP₁ 18

18. Fore wings each with CuA and CuP divergent to wing margin; hind wings each with basal black triangular area posterior to CuP; abdominal tergum 4 without lateral carinae
. *Leucorrhinia* p. 750
- Fore wings each with CuA and CuP convergent to wing margin; hind wings each without basal black triangular area posterior to CuP; abdominal tergum 4 with lateral carinae 19
19. Abdominal tergum 4 with supplementary transverse carina; fore wings each with 2 cell rows subtended by Mpl for distance of 4 or 5 cells *Tarnetrum* p. 920
- Abdominal tergum 4 without supplementary transverse carina; fore wings each without 2 cell rows subtended by Mpl for distance of 4 or 5 cells 20
20. Abdominal terga 3 and generally 9 without well-developed lateral carinae; posterior margin of pronotum directed dorsally with deep medial "V"-shaped notch *Synpctrum* p. 889
- Abdominal terga 3 and 9 with well-developed lateral carinae; posterior margin of pronotum directed posterodorsally with shallow medial "U"-shaped notch 21
21. Wings each with 2 or 3 crossveins between pterostigma and RP₁; posterior hamuli longer than wide; vulvar lamina not bilobate
. *Erythrodiplax* p. 727
- Wings each without or with 1 crossvein between pterostigma and RP₁; posterior hamuli wider than long; vulvar lamina bilobate
. *Pachydiplax* p. 846

Genus *Brachymesia* Kirby 1889Syn.: *Cannaeria* Kirby

Kirby 1889. Ann. Nat. Hist. 14:262.

Type Species.--*Erythemis furcata* Hagen.

Diagnosis.--Posterior margin of pronotum directed dorsally with small medial notch; apical 3 or 4 spines of outer spine row of hind femora not greatly lengthened; wings each with proximal and distal margins of pterostigma not divergent anteriorly, 2 or 3 crossveins between pterostigma and RP_1 , 1 or 2 bridge crossveins, RP_2 not undulate, 2 cell rows subtended by Mpl , 1 or 2 cell rows subtended by $Cupl$, and 1 cubital anal crossvein; wings each with large brown area distal to nodus (vestigial in female); fore wings each with triangle 2-celled, subtriangle 3-celled, 3 cell rows in trigonal interspace, CuA and CuP subparallel to wing margin, and 5 paranal cells proximal to subtriangle; hind wings each with triangle 1-celled, CuP arising at posterior angle of triangle, 2 paranal cells proximal to fibulum, 3 paranal cells distal to fibulum, anal loop well developed, and midrib angulated at ca. 40° at ankle; abdominal sternum of male without paired processes; abdominal tergum 3 with well-developed lateral carinae; abdominal tergum 4 without supplementary transverse carinae at antecostal suture; abdominal tergum 9 with well-developed lateral carinae.

Brachymesia gravida (Calvert)

(Figures 157, 158)

Calvert 1890. Trans. Amer. Entomol. Soc. 17:35 (in *Leptemis*).

Length 46-54 mm; abdomen 32-40 mm; hind wings 35-42 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AL, FL, GA, LA, MD, MS, NE, NC, OK, SC, TN, TX, and VA. Known from the Virginia county of Lancaster, and the city of Virginia Beach. Known distribution among the counties of neighboring states include: North Carolina- Dare and Pamlico.

Virginia Records.--Lancaster Co.; locality unknown, 7 July 1957, 1 male, J. P. E. Morrison, USNM. City of Virginia Beach; Seaside State Park, 12 June 1975, 1 male, 3 females, FLC; Back Bay Refuge, 27 June 1973, 1 female, JFM, ODU; Back Bay Refuge, 12 July 1975, 2 males, J. O'Hop, ODU; Back Bay Refuge, 14 July 1974, 3 males, FLC; locality unknown, 8 Sept. 1973, 1 male, A. C., ODU; Back Bay Refuge, 21 Sept. 1974, 1 female, Leggett, ODU.

Flight Season.--Mar. 29 (FL) to Dec. 31 (FL); in Virginia June 12 to Sept. 21. Known season in neighboring states are: North Carolina- July to Sept. 2.

Biology.--*Brachymesia gravida* inhabits edges of salt marshes and lakes of the coastal plain.

Remarks.--In Virginia this species has been collected only in slightly brackish water. It is generally found in association with *Erythrodiplax berenice* and *Libellula needhami*.

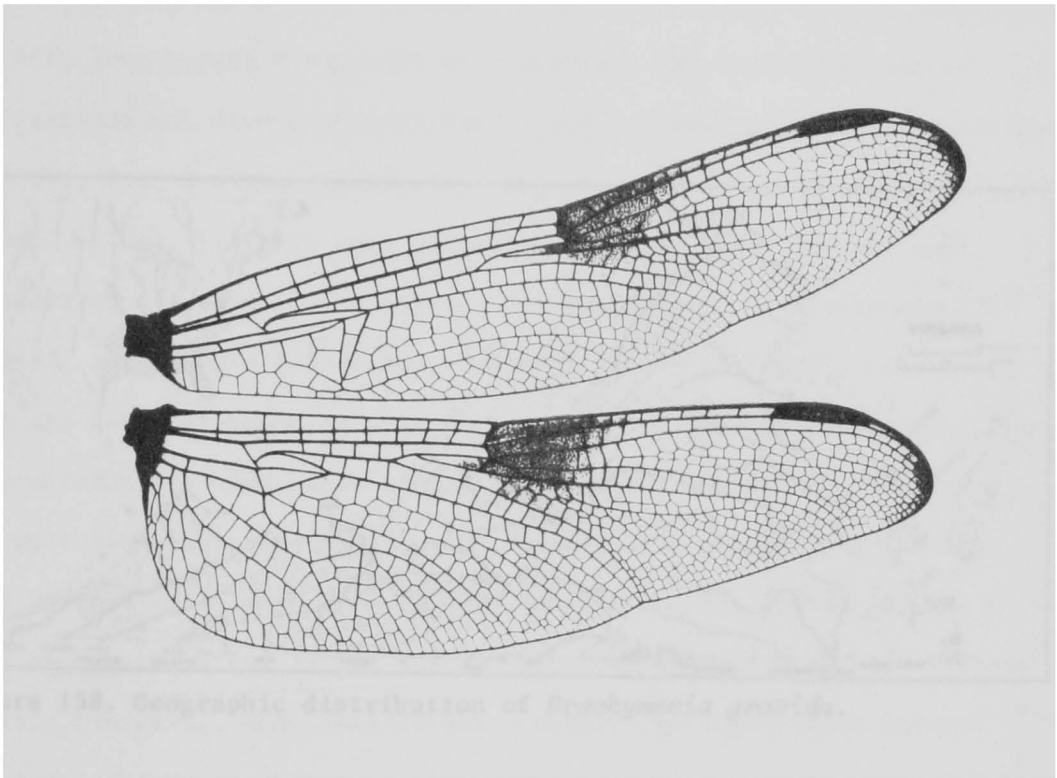


Figure 157. Wings of *Brachymesia gravida* x3.

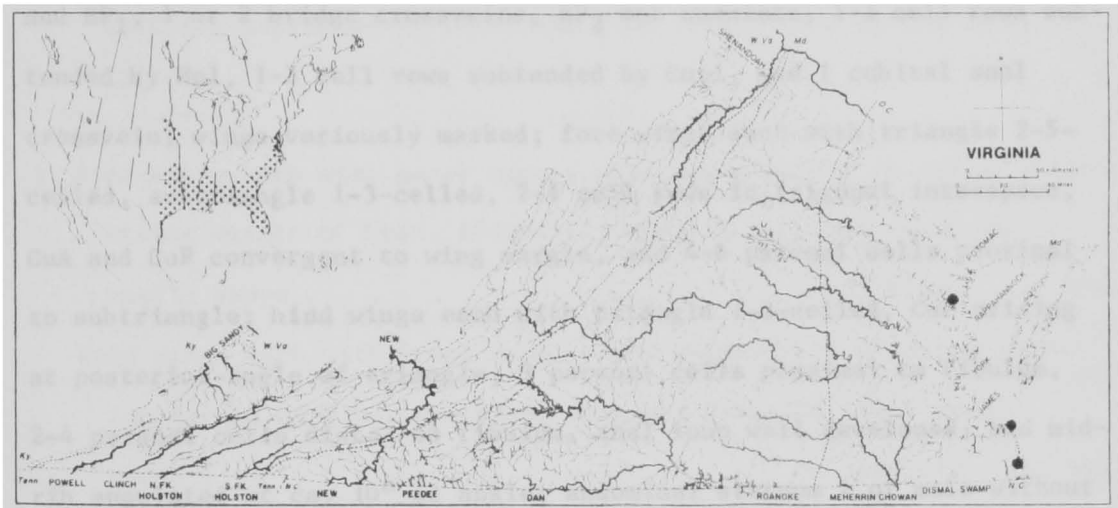


Figure 158. Geographic distribution of *Brachymenia grivida*.

Genus *Celithemis* Hagen 1861

Hagen 1861. Syn. Neur. N. Amer., p. 147.

Type Species.--*Libellula eponina* Drury.

Diagnosis.--Posterior margin of pronotum directed dorsally with small medial notch; apical 3 or 4 spines of outer spine row of hind femora not greatly lengthened; wings each with proximal and distal margins of pterostigma not divergent anteriorly, 1-4 crossveins between pterostigma and RP_1 , 1 or 2 bridge crossveins, RP_2 not undulate, 1-3 cell rows subtended by Mpl , 1-3 cell rows subtended by $Cupl$, and 1 cubital anal crossvein; wings variously marked; fore wings each with triangle 2-5-celled, subtriangle 1-3-celled, 2-4 cell rows in trigonal interspace, CuA and CuP convergent to wing margin, and 4-6 paranal cells proximal to subtriangle; hind wings each with triangle 1-3-celled, CuP arising at posterior angle of triangle, 3 paranal cells proximal to fibulum, 2-4 paranal cells distal to fibulum, anal loop well developed, and midrib angulated at ca. 10° at ankle; abdominal sternum 1 of male without paired processes; abdominal tergum 3 without well-developed lateral carinae; abdominal tergum 4 without supplementary transverse carina at antecostal suture; abdominal tergum 9 without well-developed lateral carinae.

Species Key to Adult *Celithemis*

1. Wings each with opaque spots between nodus and pterostigma 2
 Wings each without opaque spots between nodus and pterostigma . . . 4
2. Wings each with membrane transparent saffron between postnodal
 opaque spots; 2 or 3 cell rows subtended by Cup1, and 4 or 5 cell
 rows subtended by Rpl *C. eponina* p. 693
 Wings each with membrane hyaline between postnodal opaque spots; 1
 cell row subtended by Cup1, and 2 or 3 cell rows subtended by
 Rpl 3
3. Hind wings each with basal opaque spot not extended to nodus; post-
 ocular margin of head, abdominal segments 2-4, and cerci not
 mostly brown *C. elisa* p. 688
 Hind wings each with basal opaque spot extended to nodus; postocu-
 lar margin of head, abdominal segments 2-4, and cerci mostly
 brown *C. fuscata* p. 696
4. Fore wings each with 1 cell row between Cup1 and CuP; wings each
 with Rpl not well developed; without squarish dark spot above each
 metathoracic spiracle; male epiproct with apical cleft apparent
 in ventral view 5
 Fore wings each with 2 cell rows between Cup1 and CuP; wings each
 with Rpl well developed; with squarish dark spot above each meta-
 thoracic spiracle; male epiproct with apical cleft not apparent in
 ventral view 6

5. Wings each with pterostigma shorter than cell immediately proximal to it; hind wings each without basal antenodal spot; cerci yellow dorsally *C. amanda* p. 685
- Wings each with pterostigma longer than cell immediately proximal to it; hind wings each with basal antenodal opaque spot; cerci brown dorsally *C. martha* p. 700
6. Mesanepisternal pale stripes not continuous; abdominal segments 5-7 without dorsal spots; wings each with 2 cell rows subtended by Mpl *C. verna* p. 703
- Mesanepisternal pale stripes continuous; abdominal segments 5-7 with dorsal spots; wings each with 1 cell row subtended by Mpl 7
7. Metanepisternal pale stripes continuous; abdominal segment 4 with wide lateral pale area; male wing veins red proximally
. *C. berthii* p. 687
- Metanepisternal pale stripes not continuous; abdominal segment 4 without wide lateral pale area; male wing veins black proximally .
. *C. ornata* p. 702

Celithemis amanda (Hagen)

Syn.: *pulchella* Burmeister

(Figures 159a, 163a)

Hagen 1861. Syn. Neur. N. Amer., p. 183 (in *Diplax*).

Length 24-31 mm; abdomen 15-22 mm; hind wings 22-26 mm.

Diagnosis.--Thoracic pale areas obscure in mature males; mesanepi-

sternal pale stripes wide, confluent with mesanepimeral pale stripes ventrad; thorax without large dark area above each metathoracic spiracle; mesanepimeral pale stripes confluent with metanepisternal pale stripes; metanepisternal pale stripes confluent with metanepimeral pale stripes ventrad; wings each with pterostigma shorter than cell immediately proximal to it, 1 crossvein between pterostigma and RP_1 , 1 cell row subtended by R_{pl} , 1 cell row subtended by M_{pl} , and 1 cell row subtended by Cu_{pl} ; fore wings each with opaque spots absent, wing membrane hyaline, transparent saffron at base, triangle 2-celled, and with 1 cell row between Cu_{pl} and Cu_P ; hind wings each with basal, discal, and anal opaque areas, antenodal opaque spots absent, wing membrane transparent saffron between basal opaque areas, 5 antenodal crossveins (yellow in male), triangle 1-celled, and anal loop with 0-3 ankle cells; abdominal segments 5-7 with dorsal red or yellow spots; cerci mostly yellow or orange dorsally; male cerci each with well-developed ventral angulation; apex of male epiproct with cleft apparent in ventral view.

Distribution.--Known from the states of AL, FL, GA, LA, MS, NC, and SC. Known distribution among the counties of neighboring states include: North Carolina-- Bladen, Cumberland, Edgecombe, Johnston, Moore, Onslow, Pamlico, and Pender.

Flight Season.--Apr. 2 (MS) to Nov. (FL). Known season in neighboring states are: North Carolina-- June to Oct. 15.

Biology.--*Celithemis amanda* inhabits marshy borders of ponds and lakes, Adult males perch at the apices of emergent vegetation near shore.

Remarks.--Although this species is previously unreported from Virginia it probably occurs in ponds of the coastal plain.

Celithemis berthia WilliamsonSyn.: *leonora* Westfall

(Figures 159b, 163b)

Williamson 1922. Occ. Pap. Mus. Zool. Univ. Mich. 108:8.

Length 25-36 mm; abdomen 17-24 mm; hind wings 22-28 mm.

Diagnosis.--Thoracic pale areas well defined in mature males; mesanepisternal pale stripes wide, narrowly separated from mesanepimeral pale stripes at midlength; thorax with large dark area above each metathoracic spiracle; mesanepimeral pale stripes confluent with metanepisternal pale stripes dorsad; metanepisternal pale stripes not confluent with metanepimeral pale stripes; wings each with pterostigma longer than cell immediately proximal to it, 1 or 2 crossveins between pterostigma and RP_1 , 2 cell rows subtended by R_{pl} , 1 cell row subtended by M_{pl} , and 1 cell row subtended by Cu_{pl} ; fore wings each with opaque spots absent (apical spots occasionally present), wing membrane hyaline, triangle 2-celled, and with 2 (occasionally 1) cell rows between Cu_{pl} and Cu_P ; hind wings each with basal and anal opaque areas present or absent (apical spots occasionally present), wing membrane hyaline (transparent saffron between basal opaque areas when spots developed), 5 antenodal crossveins (red in male), triangle 1-celled, and anal loop with 1 (occasionally absent) ankle cell; abdominal segments 5-7 with dorsal red or yellow spots; cerci mostly brown; male cerci each with well-developed ventral angulation; apex of male epiproct without cleft apparent in ventral view.

Distribution.--Known from the states of FL, GA, NC, and SC. Known distribution among the counties of neighboring states include: North

Carolina- Bertie, Franklin, Granville, Harnett, Moore, Onslow, and Wayne.

Flight Season.--Mar. 31 to Dec. 20 (FL). Known season in neighboring states are: North Carolina- June 17 to Sept. 26.

Biology.--*Celithemis bertha* inhabits marsh-bordered ponds and lakes. Adult males perch on the apices of emergent vegetation away from shore.

Remarks.--This species has not been previously reported from Virginia but it probably occurs in marshy ponds of the coastal plain. Although *C. leonora* (distinguished by the apical wing spots) is generally considered a synonym of this species it may represent a distinct species.

Celithemis elisa (Hagen)

(Figures 160a, 163c)

Hagen 1861. Syn. Neur. N. Amer., p. 182 (in *Diplax*).

Length 28-34 mm; abdomen 18-22 mm; hind wings 24-28 mm.

Diagnosis.--Thoracic pale areas well defined in mature males; mesanepisternal pale stripes wide, not confluent in male, confluent ventrad in female with mesanepimeral pale stripes; thorax with large dark area above each metathoracic spiracle; mesanepimeral pale stripes confluent with metanepisternal pale stripes, latter stripes often divided; metanepisternal pale stripes confluent with metanepimeral pale stripes ventrad; wings each with pterostigma longer than cell immediately proximal to it, 2 or 3 crossveins between pterostigma and RP_1 , 2 (occasionally 3) cell rows subtended by R_{p1} , 2 cell rows subtended by M_{p1} , and 1 cell row subtended by Cu_{p1} ; fore wings each with opaque areas present at triangle, between nodus and pterostigma, and at apex, wing membrane

hyaline, transparent saffron basally, triangle 2 or 3-celled, and with 2 cell rows between Cu_{1l} and Cu_P ; hind wings each with basal, anal, postnodal, and apical opaque areas present (antenodal opaque spots restricted to crossveins), wing membrane hyaline, transparent saffron basally, 5 or 6 antenodal crossveins (orange in male), triangle 1 or 2-celled, and anal loop with 3-7 ankle cells; abdominal segments 5-7 with dorsal red or yellow spots; cerci mostly orange or yellow; male cerci each with well-developed ventral angulation; apex of male epiproct with small cleft apparent in ventral view.

Distribution.--Known from the states of AL, AR, CT, FL, GA, IL, IN, IA, KS, KY, LA, ME, MD, MA, MI, MN, MS, MO, NH, NJ, NY, NC, OH, OK, PA, RI, SC, TN, TX, VT, VA, WV, and WI, and the provinces of N.B., N.S., Ont., and Que. Known from the Virginia counties of Augusta, Bath, Charles City, Charlotte, Chesterfield, Dickenson, Fairfax, Giles, Goochland, Hanover, James City, King and Queen, Lee, Mecklenburg, Montgomery, Nelson, Page, Powhatan, Pulaski, Roanoke, Russell, Spotsylvania, and Wythe, and the cities of Chesapeake, Norfolk, Suffolk, and Virginia Beach. Known distribution among the counties of neighboring states include: Kentucky- Adair, Allen, Breckinridge, Bullitt, Butler, Edmonson, Fayette, Grayson, Green, Hart, Henderson, Jefferson, Marion, McCreary, Meade, Obion, Oldham, Pulaski, Russell, Taylor, Union, Warren, and Washington; Maryland- Prince Georges; North Carolina- Cumberland, McDowell, Mecklenburg, Moore, Rowan, and Wake; Pennsylvania- Allegheny, Beaver, Berks, Bucks, Centre, Clearfield, Delaware, Fayette, Franklin, Greene, Huntingdon, Indiana, Jefferson, Lancaster, Lawrence, Lebanon, Lehigh, Monroe, Montgomery, Northampton, Philadelphia, Pike, Schuylkill, Sulli-

van, Wayne, Westmoreland, Wyoming, and York; Tennessee- Blount, Claiborne, Cocke, Cumberland, Davidson, Dickson, Knox, Madison, Monroe, Overton, and Sullivan; West Virginia- Lincoln, Mason, Nicholas, Raleigh, Ritchie, Summers, and Taylor.

Virginia Records.--Augusta Co.; Shenandoah Pd., 13 June 1980, 1 male (teneral), FLC; Shenandoah Pd., 17 July 1980, 1 male, BCK. Bath Co.; Douthat Lk., 18 June 1978, 1 male, FLC. Charles City Co.; Marl pit on Rt. 5, 23 May 1938, 2 males, MED, VPI&SU; Federal Fish Hatchery, 28 May 1967, 2 males, MDR, VPI&SU; Harrison Lk. at Roxbury, 1 June 1938, 1 female, R. Hess, (Det. A. D. Hess), A. D. Hess Collection; Harrison Lk. at Roxbury, 12 June 1938, 2 males, 1 female, R. Hess, (Det. A. D. Hess), A. D. Hess Collection; Harrison Lk. at Roxbury, 13 June 1938, 1 male, R. Hess, (Det. A. D. Hess), A. D. Hess Collection; Marl pit on Rt. 5, 18 June 1938, 4 males, V. M. D. and MED, VPI&SU; Marl pit on Rt. 5, 3 Aug. 1938, (observation), MDR notes. Charlotte Co.; Twittys Cr. Dam, 18 June 1975, 4 males (2 teneral), FLC; Gee's Pd. at Keysville, 23 June 1938, 3 males, J. T. Baldwin, VPI&SU; Keysville Pd., 24 Aug. 1938, 2 males, MED, VPI&SU; Keysville Pd., 24 Aug. 1938, 1 male, MED, (Det. MED, MDR notes). Chesterfield Co.; Chester, 8 July 1976, 1 female, G. Steiner, VCU; Meadowdale Apartments, 7 Aug. 1969, 1 female, J. Marsh, VCU. Dickenson Co.; Breaks Interstate Park below dam, 14 June 1979, 1 male, JRV, VPI&SU. Fairfax Co.; Great Falls, 4 July 1899, 2 males, 2 females, W. R. Maxon and G. N. Collins, USNM; Great Falls, 27 July 1907, 2 males, RPC, USNM. Giles Co.; Mtn. Lk., 20 June 1948, 1 male, G. M. Boush, VPI&SU; Mtn. Lk., 26 June 1975, 1 male, FLC; Mtn. Lk., 30 June 1946, 1 female, T. H. Hubble, (Det. T. H. Hubble, MDR notes); Mtn. Lk. at Pond

Drain Cr., 5 July 1973, 1 male, FLC; Mtn. Lk., 11 July 1948, 1 female, C. L. Perkins, VPI&SU; Mtn. Lk. Bio. Sta., 20 July 1977, 2 males, P. K. Powell, FLC Collection; Mtn. Lk., 30 July 1949, 1 male, C. F. Byers, (Det. C. F. Byers, Byers 1951); Mtn. Lk., 11 Aug. 1949, 1 male, C. F. Byers, (Det. C. F. Byers, Byers 1951). Goochland Co.; 2 miles S. of Foxhead Inn on Rt. 676, 28 July 1969, 2 males, A. E. Pyles, VCU. Hanover Co.; Ashland, 21 June 1975, 1 female, C. Strange, VCU. James City Co.; Indian Field Cr., 15 July 1938, 1 male, MED, VPI&SU. King and Queen Co.; Rt. 14 at Walkerton, 1 male, L. Luestermann, (Det. P. Thomas) P. Thomas Collection. Lee Co.; Keokee Lk., 3 July 1977, 3 males, FLC, Small marsh nr. Rt. 606, 1 male, FLC. Mecklenburg Co.; Farm pd. at Rt. 697. 1 June 1980, 2 males, BCK. Montgomery Co.; Pond on Toms Cr. at Rt. 655, 2 May 1978, 1 male nymph, K. Kelly, VPI&SU; Private pd. at Rt. 655, 2 May 1978 (emerged 15 May 1978), 1 female, M. T. Mengak, VPI&SU; Private pd. at Rt. 655, 2 May 1978 (emerged 24, 26 May 1978), 1 male nymph, 1 female nymph, K. Loyd, VPI&SU; Pandapas Pd., 14 June 1974, 5 males (1 teneral), FLC; locality unknown, 15 June 1974, 1 male, A. Buckman, VPI&SU; Blacksburg, 25 June 1960, 2 females, R. R. Mills, VCU; Pandapas Pd., 29 June 1977, 1 female, FLC; Blacksburg, 3 July 1960, 1 male, 1 female, R. R. Mills, VCU; Pandapas Pd., 10 July 1977, 1 male, BCK; Pandapas Pd., 20 July 1973, 1 male, FLC, VPI&SU; Pandapas Pd., 28 July 1973, 1 male, FLC; Heath Pd. off Rt. 685 nr. Blacksburg, 1 Aug. 1977, 1 male, FLC; Pandapas Pd., 15 Aug. 1978, 1 male, FLC; locality unknown, 23 Aug. 1976, 1 male, T. Bailey, VPI&SU. Nelson Co.; Afton Mtn., 1 Aug. 1973, 1 male, W. Smith, VCU. Page Co.; L. Jackson, 15 Aug. 1980, 2 males, BCK. Powhatan Co.; locality unknown, 27 June 1975, 1

male, R. H. Nugent, VCU. Pulaski Co.; Gatewood Reservoir, 29 June 1973, 1 female, FLC. Roanoke Co.; Hope Rd., 2 June 1969, 1 male, SWB, VPI&SU. Russell Co.; Laurel Bed Lk., 4 July 1977, 1 female, FLC. Spotsylvania Co.; locality unknown, 3 July 1889, 1 male, W. D. Richardson, (Det. P. P. Calvert, Calvert 1890). Wythe Co.; Wytheville, 28 June 1935, 6 males, CA, (Det. CA); E. M. Chitwood Pd. on Pine Ridge Rd., 30 June 1970, 1 male, VPI&SU. City of Chesapeake; locality unknown, 13 May 1970, 1 male, 1 female, Donaldson, ODU. City of Norfolk; locality unknown, 7 July 1974, 2 males, 1 female, J. Hancock, ODU; locality unknown, 9 July 1974, 6 males, JFM, ODU; locality unknown, 11 July 1973, 1 male, D. Laist, ODU. City of Richmond; James R. Park, 15 June, 1972, 1 male, M. Harntson, VCU. City of Suffolk; Dismal Swamp Wildlife Refuge, 19 Aug. 1974, 1 male, J. Hancock, ODU. City of Virginia Beach; Back Bay Refuge, 31 May 1975, 1 male, J. O'Hop, ODU; Cape Henry, 2 July 1962, 1 male, A. B. Gurney and OSF, USNM; Cape Henry, 9 July 1962, 1 male, A. B. Gurney and OSF, USNM.

Flight Season.--Apr. 4 (MS) to Oct. 7 (SC); in Virginia May 13 to Aug. 24. Known season in neighboring states are: Kentucky- Apr. 14 to Aug. 24; Maryland- June 3 to 10; North Carolina- May to Aug. 6; Pennsylvania- May 24 to Sept. 15; Tennessee- May 12 to Oct. 2; West Virginia- June 14 to Aug. 20.

Biology.--*Celithemis elisa* inhabits ponds and marsh-bordered lakes. Adult males perch at the apices of emergent vegetation near shore. Oviposition occurs in tandem with the male.

Remarks.--This is the most widespread species of *Celithemis* in Virginia.

Celithemis eponina (Drury)Syn.: *camilla* Rambur, *lucilla* Rambur

(Figures 160b, 164a)

Drury 1773. Ill. Exot. Ins. 2:86 (in *Libellula*).

Length 33-42 mm; abdomen 22-28 mm; hind wings 30-34 mm.

Diagnosis.--Thoracic pale areas well defined in mature males; mesanepisternal pale stripes wide, not confluent (occasionally confluent) with mesanepimeral pale stripes; thorax with large dark area above each metathoracic spiracle; mesanepimeral pale stripes confluent with metanepisternal pale stripes dorsad; metanepisternal pale stripes not confluent (occasionally confluent ventrad) with metanepimeral pale stripes; wings each with pterostigma longer than cell immediately proximal to it, 2 or 3 crossveins between pterostigma and RP_1 , 4 or 5 cell rows subtended by R_{pl} , 2 or 3 cell rows subtended by M_{pl} , and 2 or 3 cell rows subtended by Cu_{pl} ; fore wings each with opaque areas at triangle, nodus, before pterostigma, and at apex, wing membrane transparent saffron between opaque areas, triangle 3-5-celled, and with 3 cell rows between Cu_{pl} and Cu_P ; hind wings each with antenodal opaque areas extended to nodus, and with anal, postnodal, and apical opaque areas present (apical areas frequently faint), wing membrane transparent saffron between opaque areas, 6 antenodal crossveins (yellow in male), triangle 2 or 3-celled, and anal loop with 3-12 ankle cells; abdominal segments 5-7 with dorsal red or yellow spots; cerci mostly brown or yellow; male cerci each with well-developed ventral angulation; apex of male epiproct without cleft apparent in ventral view.

Distribution.--Known from the states of AL, AR, CT, DC, DE, FL, GA, IL, IN, IA, KS, KY, LA, ME, MD, MA, MI, MN, MS, MO, NE, NH, NJ, NY, NC, OH, OK, PA, RI, SC, TN, TX, VT, VA, WV, and WI, and the province of Ont., and also known from Cuba. Known from the Virginia counties of Accomack, Charles City, Charlotte, Essex, Fairfax, James City, Lancaster, Montgomery, Northampton, Prince William, Westmoreland, and York, and the cities of Chesapeake, Newport News, Norfolk, and Virginia Beach. Known distribution among the counties of neighboring states include: Kentucky- Adair, Allen, Breckinridge, Bullitt, Edmonson, Fayette, Fulton, Grayson, Green, Hart, Hickman, Hopkins, Jefferson, Letcher, Marion, Meade, Metcalfe, Ohio, Russell, Shelby, Taylor, Trigg, Union, Warren, and Washington; Maryland- Alleghany; North Carolina- Dare, Durham, Lee, Nash, New Hanover, Onslow, Orange, Rockingham, Tyrrell, Wayne, and Wilson; Pennsylvania- Bucks, Chester, Crawford, Delaware, Erie, Lackawanna, Lawrence, Lebanon, Northampton, Philadelphia, Pike, Union, Venango, Wayne, Westmoreland, and York; Tennessee- Blount, Cumberland, Fentress, Hamblen, Knox, Monroe, and Obion; West Virginia- Mason and Mineral.

Virginia Records.--Accomack Co.; Chincoteague Island, 31 Aug. 1891, 1 male, P. P. Calvert, (Det. P. P. Calvert, Ries 1912). Charles City Co.; Harrison Lk. at Roxbury, 12 June 1938, 1 male, 1 female, R. Hess, (Det. A. D. Hess). A. D. Hess Collection; Harrison Lk. at Roxbury, 21 Sept. 1966, 1 male, MED, VPI&SU. Charlotte Co.; Twittys Cr. Dam, 10 June 1975, 2 females, FLC; Twittys Cr. at Rt. 642, 14 June 1975, 4 males, 1 female, FLC; Twittys Cr. Dam, 18 June 1975, 1 male, 2 females, FLC. Essex Co.; Dunbrooke, 28 July 1899, 1 female, RPC, USNM. Fairfax Co.; Great Falls, 10 July 1914, 1 male, RPC, USNM; Mt. Vernon, 1 Aug. 1915,

1 male, 1 female, W. L. McAtee, USNM. James City Co.; Williamsburg, 6 June 1936, 1 female, collector unknown, (Det. MDR), W&M; Barretts Ferry, 18 June 1938, 1 male, 1 female, MED, VPI&SU; Williamsburg, 22 June 1937, 2 females, collector unknown, VPI&SU; Williamsburg, 24 June 1937, 1 male, 2 females, collector unknown, VPI&SU; Williamsburg, 25 June 1937, 1 female, CC, (Det. CC), CC Collection; Williamsburg, 26 June 1937, 2 females, collector unknown, VPI&SU; Reservoir nr. Fort Eustis, 29 June 1938, 2 males, 1 female, MED, VPI&SU; Jamestown Rd. at Lk. Matoaka, 1 July 1937, 1 male, CC, (Det. CC), CC Collection; Rt. 5 at Rt. 602, 5 July 1938, 1 female, MED, VPI&SU; Reservoir nr. Fort Eustis, 7 July 1938, 1 male, MED and T. D. M., VPI&SU; Williamsburg, 7 July 1936, 1 female, collector unknown, VPI&SU; Williamsburg, 10 July 1937, 1 male, collector unknown, VPI&SU; Pd. on Jamestown Island, 19 July 1938, 1 male, MED, VPI&SU; Lk. Powell at Williamsburg, 6 Aug. 1937, 1 male, V. M. D. and MED, VPI&SU; Williamsburg, 15 Sept. 1929, 2 males, MED, VPI&SU; Riverview Pd., 18 Sept. 1966, 1 male, MDR, VPI&SU. Lancaster Co.; Whitestone, 15 June 1974, 1 male, W. C. Rothery, VCU. Montgomery Co.; Pd. on Shadow Lk. Rd. in Blacksburg, 18 July 1977, 2 males, S. Mudre, VPI&SU. Northampton Co.; Curtis Pd. at Savage Neck, 1 June 1937, 1 male, F. M. Jones, VPI&SU. Prince William Co.; Youngs Br. at Rts. 29 and 211, "June 27 to July 28", (Donnelly 1961). Westmoreland Co.; Coles Point, 27 June 1917, 2 males, 2 females, J. E. Benedict, USNM. York Co.; Ballard Cr., 29 July 1938, 1 male, MED, W&M; Brachens Pd. on Colonial Parkway, 16 Sept. 1966, 1 male, MDR, VPI&SU. City of Chesapeake; locality unknown, 8 Sept. 1973, 1 male, P. W. Larkins, VPI&SU. City of Newport News; Marsh at Denbigh, 30 July 1938, 1 male, 1 female,

MED, VPI&SU. City of Norfolk; locality unknown, 11 June 1973, 1 male, 3 females, JFM, ODU; locality unknown, 9 July 1927, 1 female, F. W. Poos, USNM. City of Virginia Beach; Back Bay Refuge, 8 June 1975, 1 male, 1 female, J. O'Hop, ODU; Seaside State Park, 12 June 1975, 1 female, FLC; locality unknown, 21 June 1973, 1 male, D. Simonet, VPI&SU; Back Bay Refuge, 26 June 1973, 3 males, 4 females, JFM, ODU; Back Bay Refuge, 14 July 1974, 1 male, FLC; Cape Henry, Aug. 1916, 1 male, M. Carmody, USNM.

Flight Season.--Year-round (FL); in Virginia June 1 to Sept. 21.

Known season in neighboring states are: District of Columbia- June 28 to July 8; Kentucky- June to Aug. 22; Maryland- Sept. 1; North Carolina- June 18 to Sept. 4; Pennsylvania- June 1 to Sept. 15; Tennessee- June 17 to Aug. 15; West Virginia- July 7 to Aug. 20.

Biology.--*Celithemis eponina* inhabits ponds and lakes. Adult males frequently perch at the apices of emergent vegetation near shore. Oviposition occurs in tandem with the male.

Remarks.--This is the largest and most common species of *Celithemis* and is easily distinguished by the transparent saffron wing membrane.

Celithemis fasciata Kirby

Syn.: *monomelaena* Williamson

(Figures 161, 164b)

Kirby 1889. Trans. Zool. Soc. London 12:326.

Length 30-38 mm; abdomen 19-26 mm; hind wings 25-32 mm.

Diagnosis.--Thoracic pale areas obscure in mature males; mesanepi-

sternal pale stripes narrow, constricted dorsad, not confluent with mesanepimeral pale stripes; thorax with large dark area above each metathoracic spiracle; mesanepimeral pale stripes confluent with metanepisternal pale stripes dorsad, latter stripes often divided; metanepisternal pale stripes not confluent with mesanepimeral pale stripes; wings each with pterostigma longer than cell immediately proximal to it, 2 crossveins between pterostigma and RP_1 , 2 or 3 cell rows subtended by R_{1+2} , 2 cell rows subtended by M_{1+2} , and 1 cell row subtended by Cu_{1+2} ; fore wings each with antenodal opaque areas extended to nodus, postnodal and apical opaque areas present, wing membrane hyaline, or transparent saffron basally, triangle 2 or 3-celled, and with 2 or 3 cell rows between Cu_{1+2} and CuP ; hind wings each with basal opaque area extended to nodus, and with anal postnodal and apical opaque areas present, wing membrane hyaline, or transparent saffron basally, 5 or 6 antenodal crossveins (brown in male), triangle 1-celled (occasionally 2-celled), and anal loop with 1-5 (occasionally absent) ankle cells; abdominal segments 5-7 with dorsal red or yellow spots (obscure or absent in mature males); cerci mostly brown; male cerci each with well-developed ventral angulation; apex of male epiproct without cleft apparent in ventral view.

Distribution.--Known from the states of AL, AR, CT, FL, GA, IN, KS, KY, LA, MD, MA, MI, MS, MO, NJ, NY, NC, OH, OK, SC, TN, TX, VA, WV, and WI, and the province of Ont. Known from the Virginia counties of Charles City, Charlotte, Fairfax, James City, Lunenburg, Middlesex, New Kent, Powhatan, Prince Georges, and York, and the city of Suffolk. Known distribution among the counties of neighboring states include:

Kentucky- Bullitt, Edmonson, Green, Hart, Metcalfe, Ohio, Taylor, Trigg, and Warren; Maryland- Montgomery; North Carolina- Alamance, Chatham, Cumberland, Davidson, Davie, Durham, Franklin, Henderson, Johnston, Lee, New Hanover, Orange, Pender, Transylvania, Wake, and Warren; Tennessee- Blount, Knox, Monroe, and Sullivan.

Virginia Records.--Charles City Co.; Harrison Lk. at Roxbury, 28 May 1938, 1 male, 2 females, R. Hess, (Det. MED, MDR notes); Harrison Lk. at Roxbury, 21 June 1938, 1 male, R. Hess, (Det. MED, MDR notes); Fish Hatchery, 22 June 1976, 1 male, L. Westermann, VCU. Charlotte Co.; Small pd. nr. Drakes Br., 10 June 1975, 3 males, FLC; Small pd. nr. Drakes Br., 14 June 1975, 2 males, FLC; Small pd. N. of Drakes Br., 18 June 1975, 1 male, FLC. Fairfax Co.; Great Falls, 19 June 1910, 1 male, WTD, USNM; Great Falls, 8 July 1914, 1 male, RPC, USNM; Great Falls, 8 July 1915, 1 male, 1 female (in tandem), RPC, USNM; Great Falls, 10 July 1914, 1 female, RPC, USNM; Great Falls, 28 July 1914, 1 male, H. L. Nichols, USNM. James City Co.; Ewell Pd., 5 June 1967, 1 female, MDR, VPI&SU; Riverview Plantation Rd., 5 June 1967, 2 females, MDR, VPI&SU; Reservoir nr. Fort Eustis, 29 June 1938, 1 male, MED, VPI&SU; Lees Mill Pd. at Fort Eustis, 30 July 1938, 1 male, MED, (MDR notes). Lunenburg Co.; Small pond nr. Rt. 40 at Lunenburg, 14 June 1975, 1 male, FLC. Middlesex Co.; Nimcock Pd., 15 June 1974, 1 male, 1 female, W. C. Rothery, VCU. New Kent Co.; Spillway Pd., 8 June 1967, 1 male, MDR, VPI&SU. Powhatan Co.; locality unknown, 27 June 1975, 1 male, D. Custer VCU. Prince George Co.; Hopewell, 23 July 1976, 1 male, P. Thomas, P. Thomas Collection. York Co.; Jones Pd., 9 July 1938, 1 female, MED, VPI&SU; Jones Pd., 29 July 1938, 1 male, MED, (Det. MED, MDR notes).

City of Suffolk; locality unknown, 21 June 1975, 2 males, 3 females, J. Hancock and JFM, ODU; locality unknown, 6 Aug. 1975, 1 male, J. Hancock, ODU.

Flight Season.--May 5 (FL) to Oct. 19 (FL); in Virginia May 28 to Aug. 6. Known season in neighboring states are: Kentucky- June to Aug.; Maryland- July 4 to 27; North Carolina- May 27 to Sept. 24; Tennessee- May 31 to Sept. 27.

Biology.--*Celithemis fasciata* inhabits ponds and marsh-bordered lakes. Adult males perch at apex of emergent vegetation near shore. Oviposition occurs in tandem with the male.

Remarks.--Williamson (1910) described *C. monomelaena* from Indiana stating that "unfortunately I am unable to find such [specific] characters elsewhere than in the wings". The wing characters used to distinguish the two "species" are summarized in the following key. Additional wing venation characteristics given by Williamson (1910) and some not given show a correlation with the venational characteristics included in the key.

1. Antenodal opaque area extended posteriorly beyond cubital planate;

wing membrane transparent saffron between basal opaque areas;

31-35 cells along posterior margin of wing from base to midrib .

. *C. fasciata*

Antenodal opaque area not extended posteriorly beyond cubital

planate; wing membrane hyaline between basal opaque areas; .

21-27 cells along posterior margin of wing from base to midrib .

. *C. monomelaena*

Specimens exhibiting an intermediate condition concerning wing color

patterns have been examined from Transylvania county, North Carolina, and from Charlotte and Fairfax counties in Virginia. Specimens exhibiting an intermediate condition concerning the color of the basal wing membrane have been examined from Wayne county, Georgia, Brunswick county, North Carolina, and from the city of Suffolk, Virginia. The ranges for the number of cells along the anal margin for various populations are as follows: Louisiana (31-35); Florida (31-34); eastern Georgia (28-34); eastern North Carolina (30-36); eastern Virginia (24-32), (24-30), (23-29); northeastern Virginia (22-32); central Virginia (21-29); Indiana (21-27). Because of the different break points for various characters it is doubtful if the northern form represents a distinct subspecies.

Celithemis martha Williamson

(Figures 162a, 164c)

Williamson 1922. Occ. Pap. Mus. Zool. Univ. Mich. 108:5.

Length 25-33 mm; abdomen 16-20 mm; hind wings 22-28 mm.

Diagnosis.--Thoracic pale areas absent in mature males; mesanepisternal pale stripes wide, confluent with mesanepimeral pale areas; thorax without large dark area above each metathoracic spiracle; mesanepimeral pale stripes confluent with metanepisternal pale areas; metanepisternal pale stripes confluent with metanepimeral pale stripes; wings each with pterostigma longer than cell immediately proximal to it, 1 or 2 crossveins between pterostigma and RP_1 , 1 (occasionally 2) cell rows subtended by R_{pl} , 1 cell row subtended by M_{pl} , and 1 cell row subtended by Cu_{pl} ; fore wings each with small basal antenodal spots present, wing

membrane hyaline, transparent saffron basally in female, triangle 2-celled, and with 1 cell row between CuP1 and CuP; hind wings each with basal antenodal, discal, and anal opaque areas present, wing membrane hyaline, transparent saffron between basal opaque areas (this area opaque brown in mature males), 5 antenodals (brown in male), triangle 1-celled, and anal loop with 0-3 ankle cells; abdominal segments 5-7 with dorsal red or yellow spots (absent in mature males); cerci mostly brown or light brown; male cerci each with well-developed ventral angulation; apex of male epiproct with cleft apparent in ventral view.

Distribution.--Known from the states of ME, MD, MA, NH, NJ, NY, PA, and VA, and the province of N.S. Known from the Virginia county of Fairfax. Known distribution among the counties of neighboring states include: Maryland- Prince Georges; Pennsylvania- Bucks, Delaware, and Philadelphia.

Virginia Records.--Fairfax Co.; Pond along Difficult Run at Rt. 1125, 19 Sept. 1978, 2 males, FLC.

Flight Season.--June 26 (ME) to Sept. 19 (VA); in Virginia Sept. 19. Known season in neighboring states are: Maryland- Aug. 14 to 16; Pennsylvania- July 16 to Aug. 7.

Biology.--*Celithemis martha* inhabits boggy, marsh-bordered ponds and lakes. Adult males perch on emergent vegetation away from shore. Oviposition occurs in tandem with the male.

Remarks.--This species is easily identified by the black coloration of mature males. Although Williamson (1910) considered this species closely related to *C. ornata*, it seems more closely related to *C. amanda*. The Virginia record is the most southern for the species.

Celithemis ornata (Rambur)Syn.: *pulchella* Burmeister

(Figures 162b, 165a)

Rambur 1842. Ins. Neur., p. 96 (in *Libellula*).

Length 29-35 mm; abdomen 19-25 mm; hind wings 23-28 mm.

Diagnosis.--Thoracic pale areas well defined in mature males; mesanepisternal pale stripes narrow, constricted dorsad, not confluent with mesanepimeral pale stripes; thorax with large dark area above each metathoracic spiracle; mesanepimeral pale stripes confluent with metanepisternal pale stripes dorsad, latter stripe divided; metanepisternal pale stripes not confluent with metanepimeral pale stripes; wings each with pterostigma longer than cell immediately proximal to it, 1 or 2 crossveins between pterostigma and RP_1 , 2 cell rows subtended by R_{pl} , 1 cell row subtended by M_{pl} , and 1 cell row subtended by Cu_{pl} ; fore wings each with small opaque antenodal spots present or absent, wing membrane hyaline, transparent saffron basally in female, triangle 2-celled, and with 2 cell rows between Cu_{pl} and CuP ; hind wings each with basal antenodal, discal, and anal opaque areas present, wing membrane hyaline, transparent saffron between basal opaque areas (this area occasionally opaque brown in mature males), 5 antenodal crossveins (brown in male), triangle 1-celled, and anal loop with 0-2 ankle cells; abdominal segments 5-7 with dorsal red or yellow spots; cerci mostly brown; male cerci each with well-developed ventral angulation; apex of male epiproct without cleft apparent in ventral view.

Distribution.--Known from the states of AL, FL, GA, LA, MS, NJ, NC,

SC, and VA. Known from the Virginia county of Charles City. Known distribution among the counties of neighboring states include: North Carolina- Bladen, Craven, Moore, Onslow, Pamlico, Sampson, and Scotland.

Virginia Records.--Charles City Co.; Marl pit on Rt. 5, 18 June 1938, 1 male, MED, (Det. MED, MDR notes).

Flight Season.--Jan. 24 (FL) to Sept. 27 (FL); in Virginia June 18. Known season in neighboring states are: North Carolina- Apr. 23 to Sept. 24.

Biology.--*Celithemis ornata* inhabits ponds and marsh-bordered lakes. Adult males perch at the apex of emergent vegetation near shore. Oviposition occurs in tandem with the male.

Remarks.--This species is more common in Virginia than previous records indicate.

Celithemis verma Pritchard

(Figures 162c, 165b)

Pritchard 1935. Occ. Pap. Mus. Zool. Univ. Mich. 319:6.

Length 30-35 mm; abdomen 19-23 mm; hind wings 25-28 mm.

Diagnosis.--Thoracic pale areas well defined in mature males; mesanepisternal pale stripes discontinuous dorsad, not confluent with mesanepimeral pale stripes; thorax with large dark area above each metathoracic spiracle; mesanepimeral pale stripes confluent with metanepisternal pale stripes dorsad, latter stripe divided; metanepisternal pale stripes not confluent with metanepimeral pale stripes; wings each with pterostigma longer than cell immediately proximal to it, 1 or 2 crossveins

between pterostigma and RP_1 , 2 cell rows subtended by R_{pl} , 2 cell rows subtended by M_{pl} , and 1 cell row subtended by Cu_{pl} ; fore wings each with small spots at axillary brace and at first antenodal present, wing membrane hyaline, triangle 2-celled, and with 2 cell rows between Cu_{pl} and Cu_P ; hind wings each with small basal antenodal, discal, and anal opaque areas present, wing membrane hyaline, 5 or 6 antenodal crossveins (black in male), triangle 1-celled, and anal loop with 1 or 2 ankle cells; abdominal segments 5-7 black dorsally; cerci mostly brown; male cerci each without well-developed ventral angulation; apex of male epiproct without cleft apparent in ventral view.

Distribution.--Known from the states of AL, AR, FL, GA, KY, LA, MS, MO, NC, OK, SC, TN, TX, and VA. Known from the Virginia counties of Charlotte and Cumberland. Known distribution among the counties of neighboring states include: Kentucky- Edmonson and Hart; North Carolina- Henderson, Jackson, Scotland, and Warren.

Virginia Records.--Charlotte Co.; Twittys Cr. Reservoir, 18 June 1975, 1 male, FLC. Cumberland Co.; Bear Cr. Lk., 23 May 1977, 1 nymphal exuvia, FLC.

Flight Season.--Apr. 10 (MS) to July 26 (KY); in Virginia May 23 to June 18. Known season in neighboring states are: Kentucky- May 14 to July 26; North Carolina- June 3 to July 25; Tennessee- June 22 to July 24.

Biology.--*Celithemis verna* inhabits marsh-bordered ponds and lakes. Adult males perch at the apex of emergent vegetation away from shore.

Remarks.--This species is more common in Virginia than previous records indicate; it is often not collected because of its relatively early season.

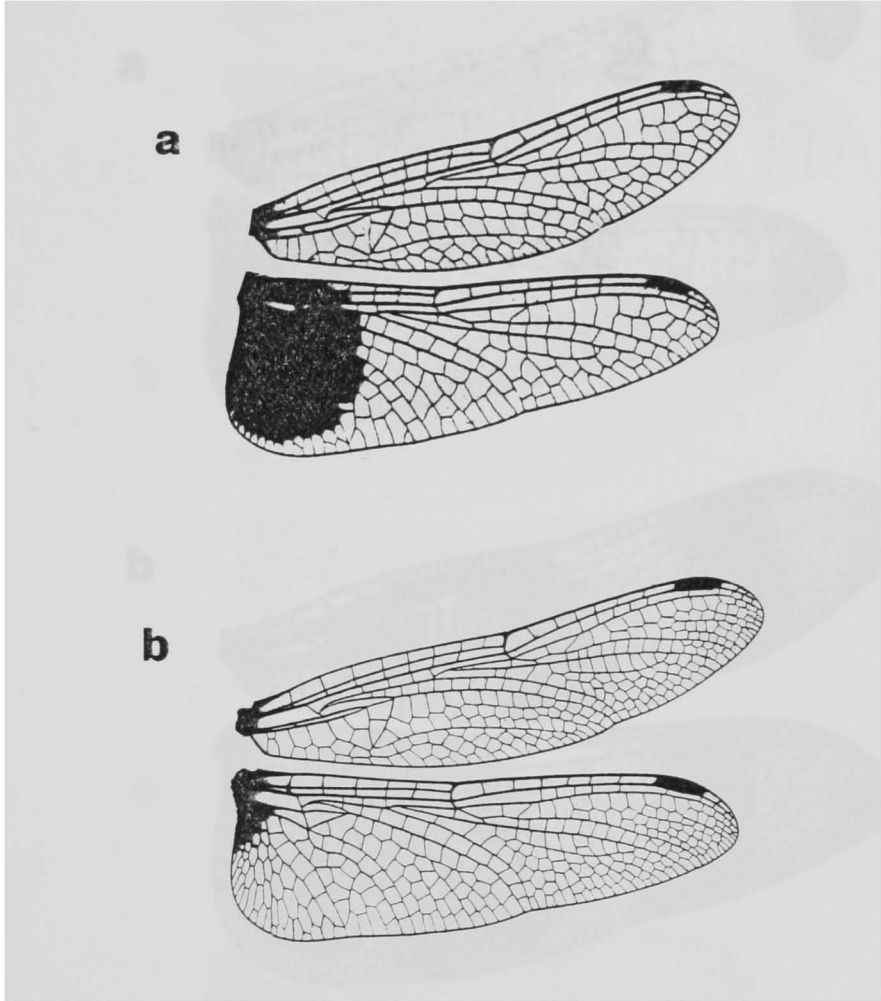


Figure 159. Wings of *Celithemis* x3: (a) *C. amanda*; (b) *C. berthae*.

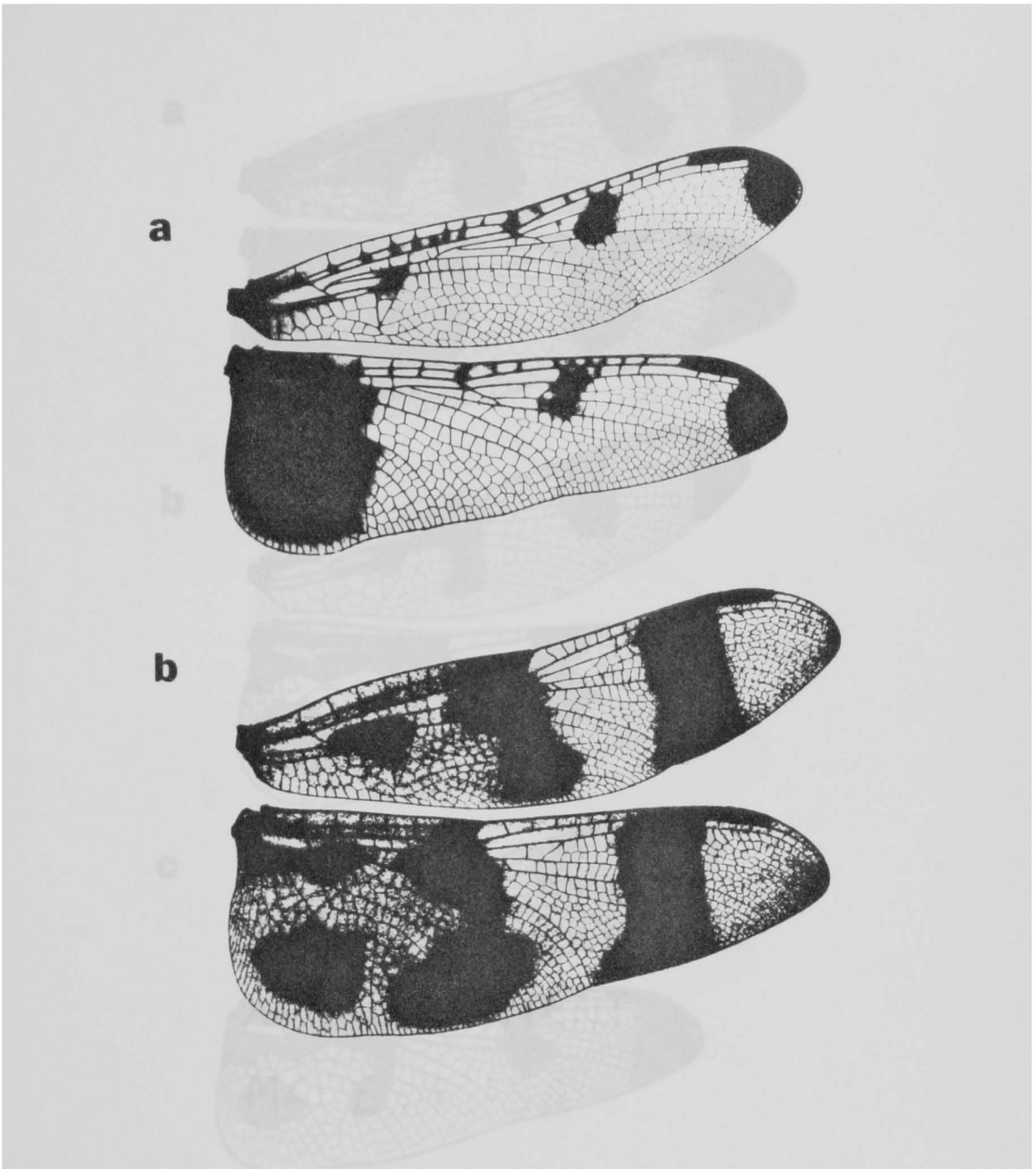


Figure 160. Wings of *Celithemis* x3: (a) *C. elisa*; (b) *C. eponina*.

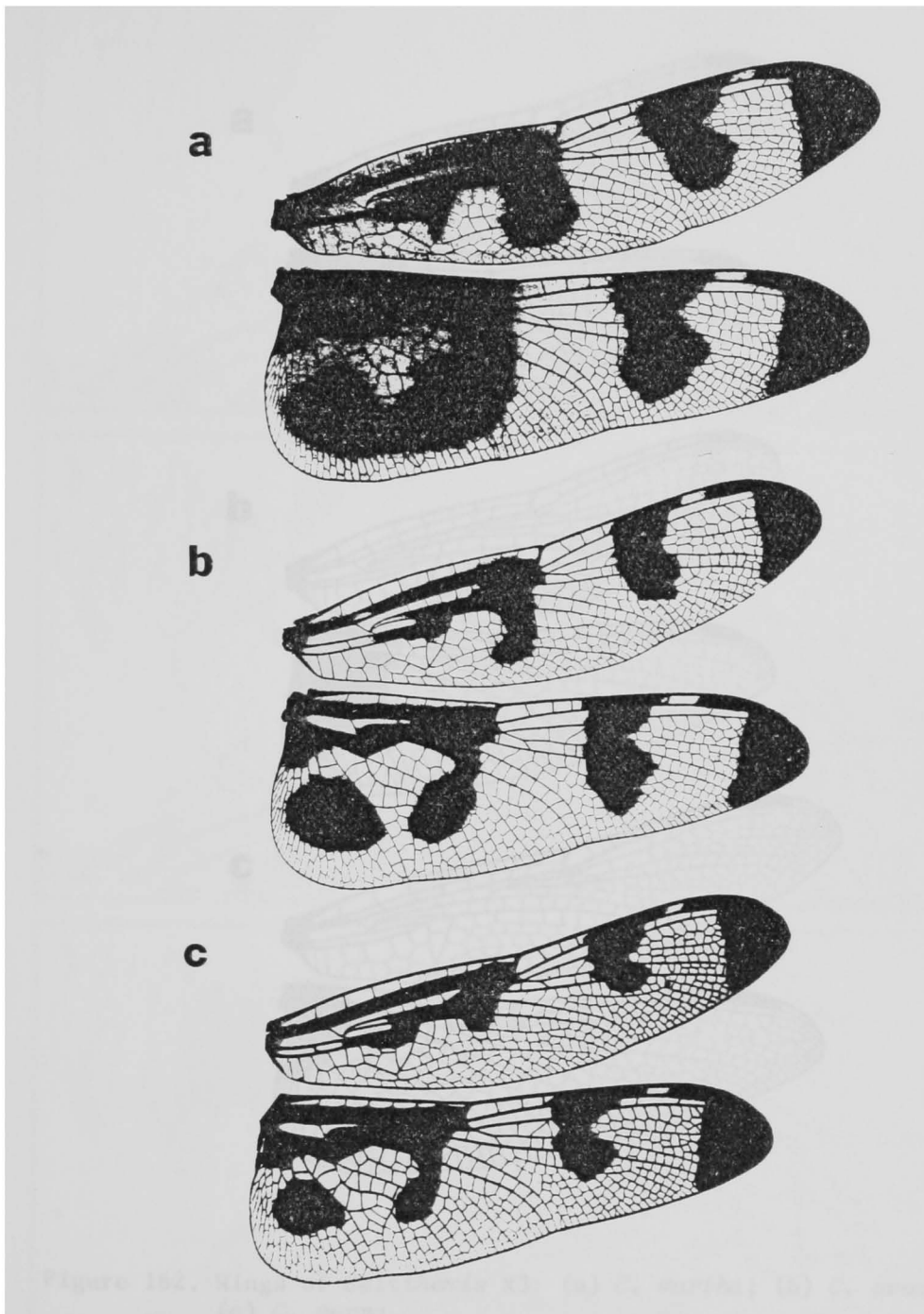


Figure 161. Wings of *Celithemis* x3: (a) *C. fasciata* (FL);
(b) *C. fasciata* (VA); (c) *C. fasciata* (IN).

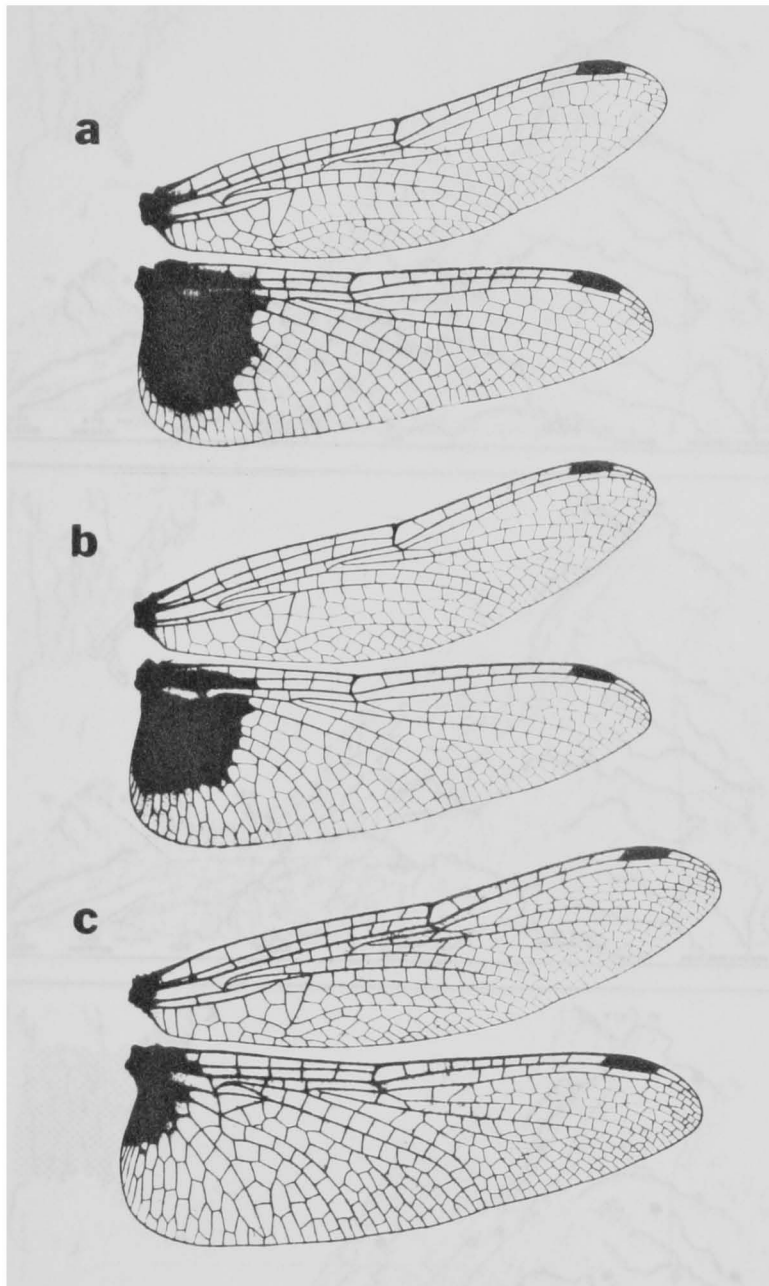


Figure 162. Wings of *Celithemis* x3: (a) *C. martha*; (b) *C. ornata*; (c) *C. verna*.

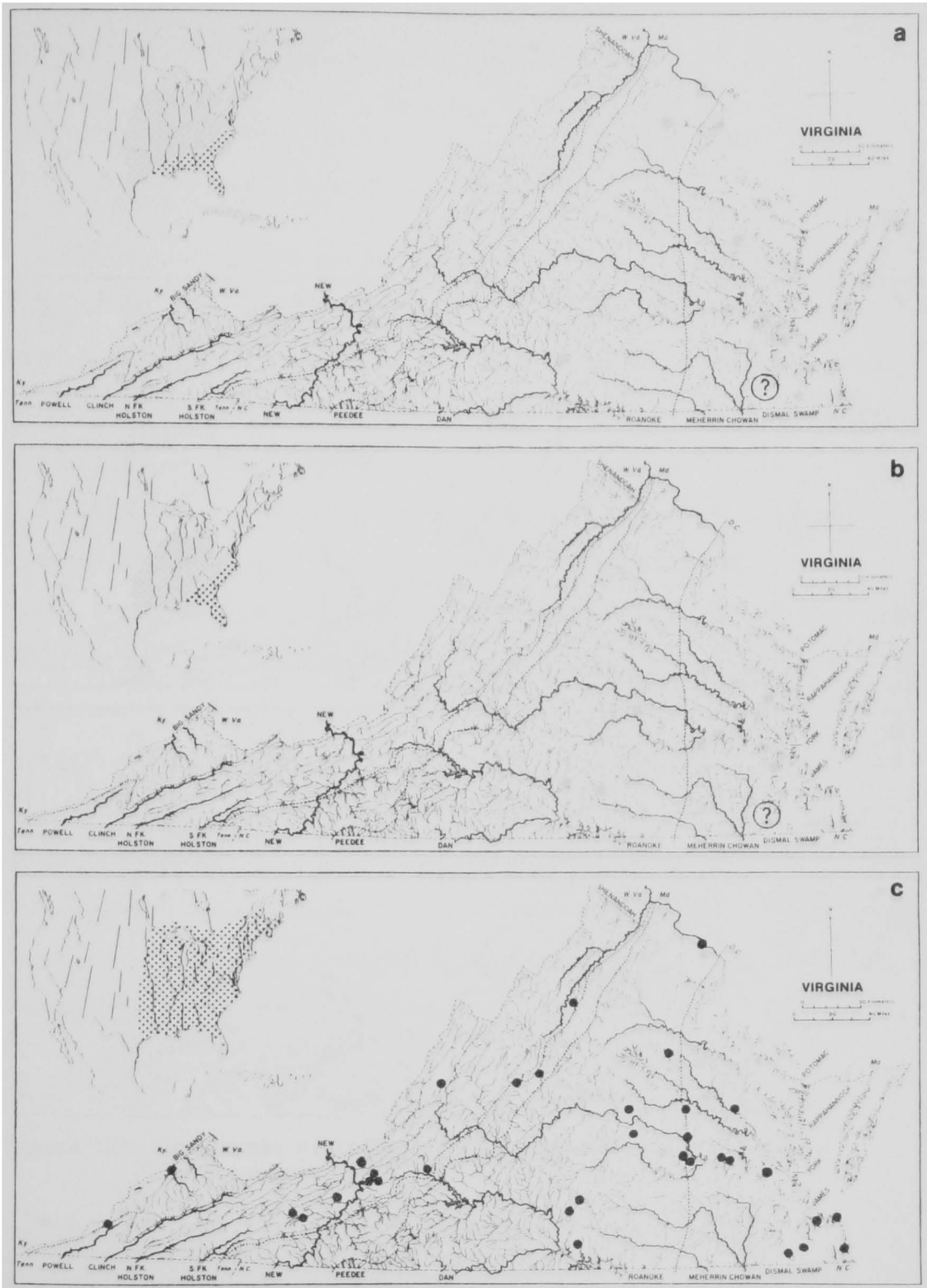


Figure 163. Geographic distribution of *Celithemis*: (a) *C. amanda*; (b) *C. bertha*; (c) *C. elisa*.

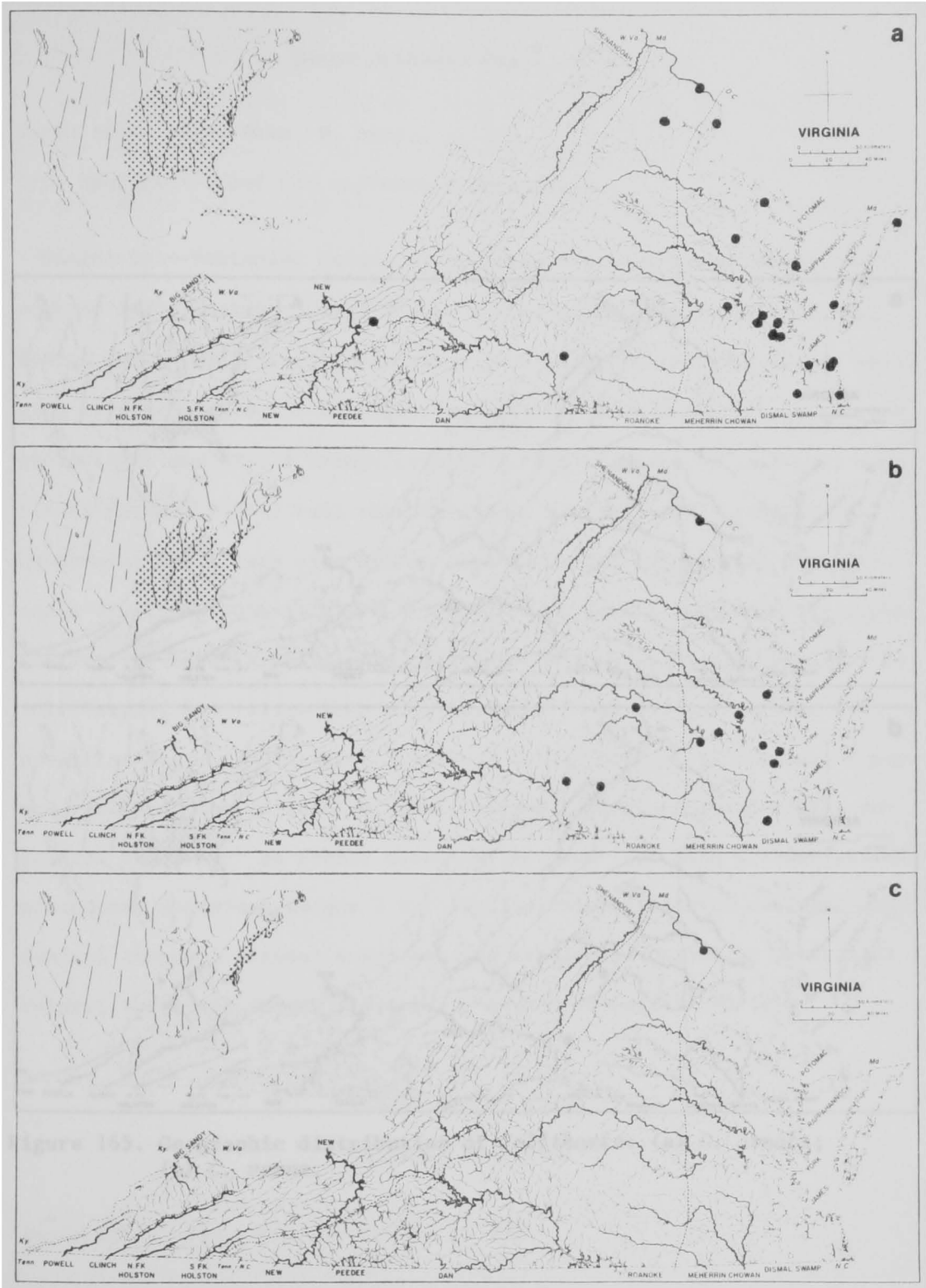


Figure 164. Geographic distribution of *Celithemis*: (a) *C. eponina*; (b) *C. fasciata*; (c) *C. martha*.

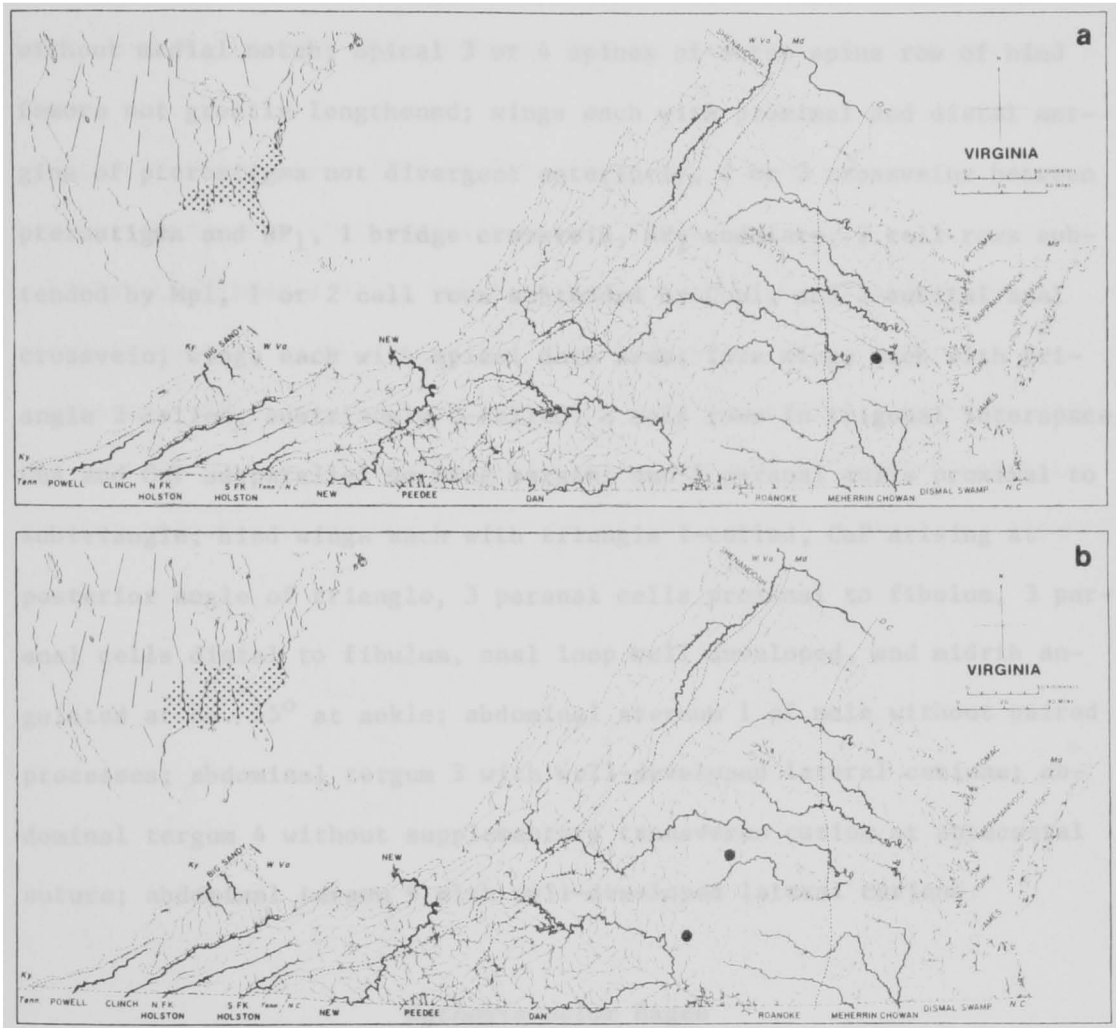


Figure 165. Geographic distribution of *Celithomis*: (a) *C. ornata*; (b) *C. verna*.

Genus *Dythemis* Hagen 1861

Hagen 1861. Syn. Neur. N. Amer., p. 162.

Type Species.--*Libellula rufinervis* Burmeister.

Diagnosis.--Posterior margin of pronotum directed posterodorsally without medial notch; apical 3 or 4 spines of outer spine row of hind femora not greatly lengthened; wings each with proximal and distal margins of pterostigma not divergent anteriorly, 2 or 3 crossveins between pterostigma and RP_1 , 1 bridge crossvein, RP_2 undulate, 2 cell rows subtended by Mp_1 , 1 or 2 cell rows subtended by Cu_1 , and 1 cubital anal crossvein; wings each with apical dark area; fore wings each with triangle 2-celled, subtriangle 3-celled, 3 cell rows in trigonal interspace, CuA and CuP subparallel to wing margin, and 5 paranal cells proximal to subtriangle; hind wings each with triangle 1-celled, CuP arising at posterior angle of triangle, 3 paranal cells proximal to fibulum, 3 paranal cells distal to fibulum, anal loop well developed, and midrib angulated at ca. 55° at ankle; abdominal sternum 1 of male without paired processes; abdominal tergum 3 with well-developed lateral carinae; abdominal tergum 4 without supplementary transverse carina at antecostal suture; abdominal tergum 9 with well-developed lateral carinae.

Dythemis velox Hagen

(Figures 166, 167)

Hagen 1861. Syn. Neur. N. Amer., p. 163.

Length 40-48 mm; abdomen 26-33 mm; hind wings 32-35 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AL, AZ, AR, CA, FL, GA, LA, MS, NM, NC, SC, and TX. Known also from Baja California, Nuevo Leon, and Tamaulipas in Mexico, and also from Cuba. Known distribution among the counties of neighboring states include: North Carolina- Caswell, Cleveland, Durham, Iredell, Mecklenburg, Person, Randolph, Rockingham, and Union.

Flight Season.--Apr. (TX) to Oct. (Baja CA). Known season in neighboring states are: North Carolina- June 23 to Sept. 16.

Biology.--*Dythemis velox* inhabits pools of sand-bottomed streams. Males frequently perch at the apex of plant stems near shore.

Remarks.--This species has apparently spread eastward from Texas over the past 30 years. Although previously unreported from Virginia, this species undoubtedly occurs in streams of the coastal plain and piedmont.

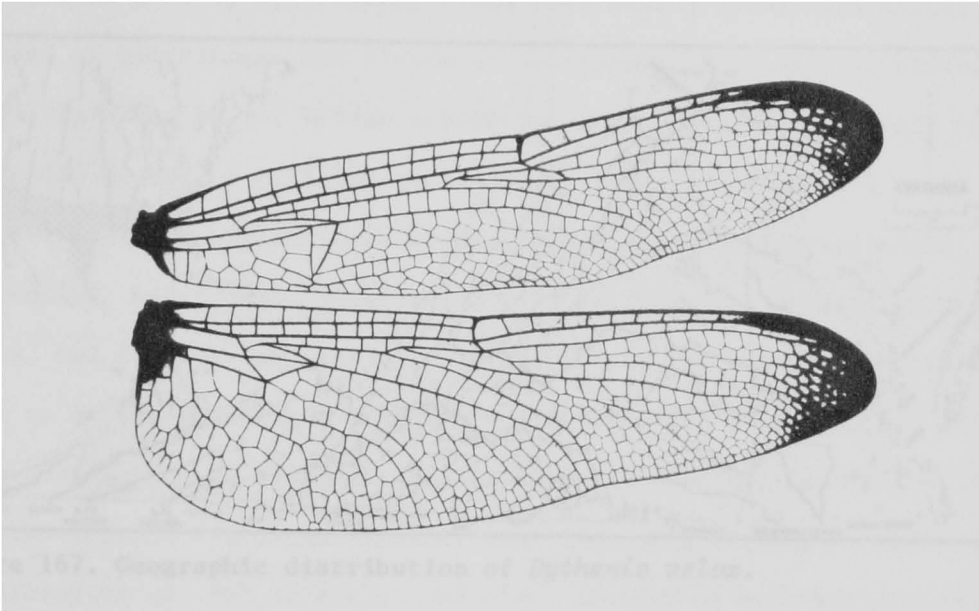


Figure 166. Wings of *Dythemis velox* x3.

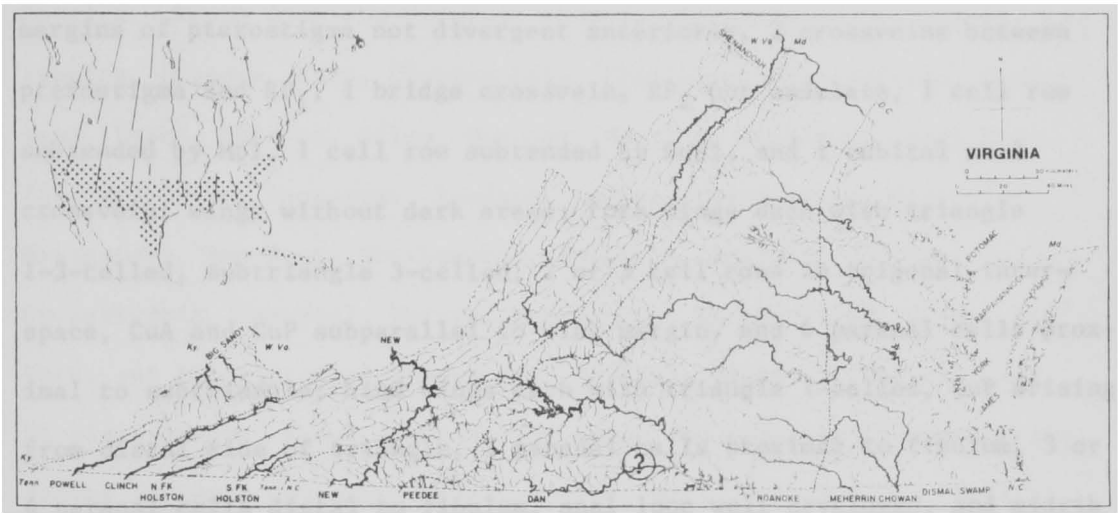


Figure 167. Geographic distribution of *Dythemis velox*.

Genus *Erythemis* Hagen 1861Syn.: *Mesothemis* Hagen

Hagen 1861. Syn. Neur. N. Amer., p. 168.

Type Species.--*Libellula peruviana* Rambur.

Diagnosis.--Posterior margin of pronotum directed posterodorsally with wide shallow medial notch; apical 3 or 4 spines of outer spine row of hind femora greatly lengthened; wings each with proximal and distal margins of pterostigma not divergent anteriorly, 2 crossveins between pterostigma and RP_1 , 1 bridge crossvein, RP_2 not undulate, 1 cell row subtended by Mpl , 1 cell row subtended by Cup_1 , and 1 cubital anal crossvein; wings without dark areas; fore wings each with triangle 1-3-celled, subtriangle 3-celled, 2 or 3 cell rows in trigonal interspace, CuA and CuP subparallel to wing margin, and 6 paranal cells proximal to subtriangle; hind wings each with triangle 1-celled, CuP arising from distal side of triangle, 3 paranal cells proximal to fibulum, 3 or 4 paranal cells distal to fibulum, anal loop well developed, and midrib angulated at ca. 40° at ankle; abdominal sternum of male without paired processes; abdominal tergum 3 with well-developed lateral carinae; abdominal tergum 4 without supplementary transverse carina at antecostal suture; abdominal tergum 9 with well-developed lateral carinae.

Erythemis simplicicollis (Say)Syn.: *caerulans* Rambur, *gundlachii* Scudder, *maculiventris* Rambur

(Figures 168, 169)

Say 1839. J. Acad. Phila., p. 28 (in *Libellula*).

Length 38-46 mm; abdomen 24-30 mm; hind wings 30-34 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AL, AR, CT, DC, DE, FL, GA, IL, IN, IA, KS, KY, LA, ME, MD, MA, MI, MN, MS, MO, NE, NH, NJ, NY, NC, OH, OK, PA, RI, SC, TN, TX, VA, WV, and WI, and the provinces of Ont. and Que. Also known from Tamaulipas, Mexico, and from Cuba, Haiti, and Jamaica. Known from the Virginia counties of Accomack, Alleghany, Arlington, Augusta, Bath, Charles City, Charlotte, Chesterfield, Cumberland, Essex, Fairfax, Giles, Hanover, Henrico, Highland, James City, King and Queen, Lancaster, Loudoun, Louisa, Mecklenburg, Middlesex, Montgomery, New Kent, Northampton, Powhatan, Russell, Southampton, Spotsylvania, Tazewell, Warren, Washington, Westmoreland, Wythe, and York, and the cities of Chesapeake, Norfolk, Richmond, Suffolk, and Virginia Beach. Known distribution among the counties of neighboring states include: Kentucky- Allen, Barren, Bell, Breckinridge, Bullitt, Carter, Cumberland, Edmonson, Fayette, Floyd, Fulton, Green, Harrison, Hart, Henderson, Hickman, Jefferson, Jessamine, Marion, Meade, Metcalfe, Oldham, Russell, Taylor, Todd, Trigg, Union, Warren, and Washington; Maryland- Wicomico and Worchester; North Carolina- Dare and Guilford; Pennsylvania- Allegheny, Beaver, Berks, Blair, Bucks, Cambria, Centre, Clearfield, Clinton, Columbia, Crawford, Delaware, Elk, Erie, Fayette, Franklin, Fulton, Greene, Huntingdon, Juniata, Lawrence, Lebanon, Luzerne, Montgomery, Perry, Philadelphia, Pike, Schuylkill, Somerset, Union, Venango, Washington, Wayne, Westmoreland, Wyoming, and York;

Tennessee-- Anderson, Bount, Campbell, Coffee, Cumberland, Davidson, Fentress, Giles, Hamblen, Hardin, Humphreys, Jackson, Knox, Madison, Monroe, Obion, Rutherford, Sevier, Shelby, Sullivan, Unicoi, and Williamson; West Virginia-- Gilmer, Lincoln, Monroe, Pendleton, Raleigh, Ritchie, and Summers.

Virginia Records.--Accomack Co.; Chincoteague National Wildlife Refuge, 26, 27 Aug. 1959, 1 female, A. B. Gurney, USNM. Alleghany Co.; Griffith, 21 June 1953, 1 female, R. L. Hoffman, (Det. LKG); 1 mile S. E. of Clifton Forge, 19 Sept. 1934, observation, LKG and J. K. Gloyd, (MDR notes). Arlington Co.; locality unknown, 8 June 1914, 1 female, A. W. J. Pomeroy, USNM. Augusta Co.; Shenandoah Pd., 17 July 1980, 1 male, BCK. Bath Co.; Beaver pd. along Rt. 600, 18 June 1978, 1 male, FLC. Charles City Co.; Harrison Lk. at Roxbury, 28 May 1938, 4 females, R. Hess, (Det. A. D. Hess), A. D. Hess Collection; Federal Fish Hatchery, 28 May 1967, 1 female, MDR, VPI&SU; Harrison Lk. at Roxbury, 3 June 1967, 2 females, MDR, VPI&SU; Harrison Lk. at Roxbury, 9 June 1967, 2 males, MDR, VPI&SU; Harrison Lk. at Roxbury, 13 June 1938, 1 male, R. Hess, (Det. A. D. Hess), A. D. Hess Collection; Marl pit, 18 June 1938, 1 male, V. M. D., (Det. MED, MDR notes); Marl pit on Rt. 5, 18 June 1938, 1 male, MED, VPI&SU; Sawmill swamp on Rt. 5, 5 July 1938, 1 male, MED, (Det. MED, MDR notes); Curles Neck Bridge, 5 July 1938, 1 male, MED, (Det. MED, MDR notes); Berkeley Mills, 5 Sept. 1937, 7 males, 1 female, MED, VPI&SU. Charlotte Co.; Twittys Cr. Dam, 18 June 1975, 1 male, 1 female, FLC; Keysville pd., 24 Aug. 1938, 2 males, J. T. Baldwin, VPI&SU; Keysville pd., 24 Aug. 1938, 1 male, 2 females, J. T. Baldwin, (Det. MED, MDR notes). Chesterfield Co.; locality unknown, 27 Apr. 1974,

1 female, J. L. Kopsch, VCU; Buckhead Springs, 11 June 1974, 1 male, J. Kittrall, VCU; Chester, 17 June 1976, 1 male, J. Steiner, VCU; Appomattox R. between Matoaca and toll booth, 19 June 1976, 1 male, P. Thomas, P. Thomas Collection; Pocahontas State Park, 20 June 1974, 1 female, J. Kittrall, VCU; Pocahontas State Park, 24 June 1968, 1 female, M. Rauscher, VCU; nr. Richmond, 25 June 1971, 1 female, R. H. Perry, VPI&SU; locality unknown, 20 July 1973, 1 female, M. Lacy, VCU; Pocahontas State Park, 27 July 1971, 1 female, B. Crickenberger, VCU; Presquile National Wildlife Refuge, 6 Aug. 1970, 1 female, JRV, VPI&SU; locality unknown, 18 Oct. 1969, 1 female, M. A. McMahon, VPI&SU. Cumberland Co.; Bear Cr. Lk., 23 May 1977, 1 male, 1 female (teneral), FLC. Essex Co.; locality unknown, 22 July 1975, 1 male, J. O'Hop, ODU. Fairfax Co.; Great Falls, 26 May 1914, 1 male (teneral), BPC, USNM; Great Falls, 2 June 1914, 2 males, 1 female, RPC, USNM; Great Falls, 17 June 1914, 3 males, 2 females, RPC, USNM; Great Falls, 25 June, G. M. Greene, USNM; Great Falls, 8 July 1914, 5 males, 6 females, RPC, USNM; Great Falls, 8 July 1914, 2 males, 2 females, V. Busck, USNM; Great Falls, 10 July 1914, 1 male, 1 female, RPC, USNM; Great Falls, 12 July 1915, 3 females, G. Chestnut, USNM; Great Falls, 12 July 1915, 1 male, 1 female, V. Busck, USNM; Great Falls, 12 July 1914, 1 female, V. Busck, USNM; Great Falls, 23 July 1914, 1 male, 1 female, BPC, USNM; Great Falls, 27 July 1914, 1 male, BPC, USNM; Bull Run Cr., 14 Aug. 1980, 1 male, 2 females, BCK; Bull Run Recreation Park, 16 Aug. 1970, 1 male, OSF, USNM; Great Falls, 24 Aug. 1915, 2 males, G. Chestnut, USNM. Giles Co.; Mtn. Lk., 7 Aug. 1949, 1 male, C. F. Byers, (Det. C. F. Byers, Byers 1951). Hanover Co.; Lukhart's Pd., 3 July 1975, 1 male, 1 female, C. Lee, VCU; locality

unknown, 3 July 1975, 1 male, N. G. Evenson, VCU; Rt. 1, 7 July 1978, 1 female, FLC; S. Anna R. at Rt. 657, 1 Sept. 1977, 1 female, BCK. Henrico Co.; Short Pump, 25 June 1975, 1 female, Y. Wallace, 1 female, VCU; locality unknown, 3 July 1975, 1 female, G. Serange, VCU. Highland Co.; Bullpasture R. at head of gorge along Rt. 678, 7 June 1975, 1 female, FLC. James City Co.; Lk. Matoaka at Williamsburg, 4 May 1938, 1 male, MED and T. D. M., VPI&SU; Jollys Pd., 24 May 1966, 3 females, MDR, VPI&SU; Jamestown Island Pd., 27 May 1938, 1 female, E. G. Fisher, (Det. E. G. Fisher), ANSP; Kingsmill Pd., 4 June 1967, 1 male, 3 females, 2 nymphal exuviae, MDR, VPI&SU; Riverview Plantation Pd., 5 June 1967, 2 females, MDR, VPI&SU; Lk. Powell, 7 June 1938, 1 male, 5 females, MED, VPI&SU; Jamestown, 9 June 1938, 2 males, 5 females, MED, VPI&SU; Reservoir nr. Fort Eustis, 29 June 1938, 1 male, 2 females, MED, VPI&SU; Lk. Powell at Williamsburg, 1 July 1937, 1 female, CC, (Det. CC), CC Collection; Jamestown Island, 4 July 1937, 1 male, CC, (Det. CC), CC Collection; Williamsburg, 23 July 1937, 1 male, 1 female, MED, VPI&SU; Williamsburg, 24 July 1937, 1 female, collector unknown, (Det. MED, MDR notes); Lk. Powell at Williamsburg, 6 Aug. 1937, 4 females, V. M. Davis and MED, VPI&SU; Williamsburg, 10 Aug. 1937, 1 female, collector unknown, VPI&SU; Lk. Matoaka at Williamsburg, 15 Aug. 1937, 1 male, MED, (Det. MED, MDR notes); Ewell, 16 Aug. 1937, 2 females, MED, VPI&SU; Riverview at Norge, 18 Sept. 1932, 5 nymphs, MED, CUC; Tutters Neck Pd., 15 Sept. 1966, 3 females, MDR, VPI&SU; Riverview Pd., 18 Sept. 1966, 2 males, MDR, VPI&SU; Kingsmill Pd., 18 Sept. 1966, 1 male, 1 female, MDR, VPI&SU; Jamestown Island pitch and tar swamp, 22 Sept. 1966, 1 female, MDR, VPI&SU; Pond at Bassett Hall in Williamsburg, 22 Sept. 1966,

2 females, MDR, VPI&SU; Toano, 8 Oct. 1937, 1 male, R. W. Menzel, (Det. MED, MDR notes). King and Queen Co.; Dragon Run Swamp at Rt. 604, 8 July 1975, 1 male, 1 female, C. R. Parker, VPI&SU. Lancaster Co.; locality unknown, 22 July 1975, 1 female, J. O'Hop, ODU. Loudoun Co.; locality unknown, 12 Aug. 1971, 1 male, 1 female, T. Muir, VPI&SU. Louisa Co.; Atkin's Pd. off Rt. 603, 31 July 1977, 1 male, S. Mudre, VPI&SU; S. Anna R. at Rt. 522, 19 Aug. 1977, 1 female, BCK; N. Anna Holiday Pd., 19 Aug. 1970, 3 males, 1 female, G. Simmons, VCU. Mecklenburg Co.; Farm pd. at Rt. 697, 1 June 1980, 1 male, BCK. Middlesex Co.; Nimcock Pd., 15 June 1974, 1 female, W. C. Rothery, VCU. Montgomery Co.; Blacksburg, 21 May 1947, 1 female, C. M. Carry, VPI&SU; Blacksburg, 2 June 1961, 1 female, A. R. Beamer, VPI&SU; Toms Cr. at Rt. 655, 12 June 1977, 1 male, R. Baer, FLC Collection; Blacksburg, 16 June 1952, 1 female, H. Jordan, VPI&SU; Poverty Hollow at Rt. 708, 2 July 1977, 1 female, BCK, VPI&SU; Blacksburg, 3 July 1960, 1 female, R. R. Mills, VCU; Oxbow of Toms Cr., 10 July 1973, 1 male, FLC, VPI&SU; Pandapas Pd., 10 July 1977, 1 male, 1 female, BCK; Pandapas Pd., 15 July 1974, 1 male, FLC; Kelly's Pd. on Shadow Lk. Rd., 18 July 1977, 1 male, S. Mudre, VPI&SU; Blacksburg, 21 July 1952, 1 male, H. Jordan, VPI&SU; Blacksburg, 22 July 1948, 7 males, 4 females, G. M. Boush, VPI&SU; Pandapas Pd., 25 July 1973, 1 female, FLC; Blacksburg, 28 July 1960, 1 female, R. R. Mills, VCU; Pandapas Pd., 28 July 1973, 1 male, FLC; Pandapas Pd., 12 Aug. 1973, 1 male, FLC. New Kent Co.; locality unknown, 27 Apr. 1974, 1 female, D. Stout, VPI&SU; Richmonds Pd. nr. Lanexa, 6 June 1967, 1 male, 1 female, MDR, VPI&SU; Jones Run and Sawmill Pd., 8 June 1967, 1 male, 1 female, MDR, VPI&SU; S. of Lanexa, 17 Aug. 1970, 1 female,

G. B. Straley, VPI&SU. Northampton Co.; Curtis Pd. at Savage Neck, 1 June 1938, 1 male, 1 female, F. M. Jones, VPI&SU. Powhatan Co.; locality unknown, 27 June 1973, 1 female, R. Kelly, VCU; locality unknown, 27 June 1975, 1 female, D. Custer, VCU; locality unknown, 27 June 1975, 1 male, R. Kelly, VCU; locality unknown, 2 July 1975, 3 males, J. A. Florence, VCU; locality unknown, 19 July 1975, 1 female, R. H. Nugent, VCU; locality unknown, 21 July, 1 female, T. Link, VCU. Russell Co.; Laurel Bed Lk., 26 Sept. 1977, 1 male, FLC. Southampton Co.; Nottoway R. at Rt. 753, 10 Oct. 1978, 1 female, FLC; Nottoway R. at Rt. 653, 10 Oct. 1978, 1 male, 1 female, FLC; 9 miles N.W. of Windsor off Rt. 635, 5 May 1979, 1 female, S. Brown, VPI&SU. Spotsylvania Co.; Rappahannock R. at Rt. 618, 16 July 1980, 2 males, BCK. Tazewell Co.; Maiden Mtn. Bog., 16 Aug. 1977, 1 male, FLC. Warren Co.; Browntown at Rt. 634, 6 July 1975, 1 female, SWB, VPI&SU; Surber's Pd. nr. Browntown, 2 Sept. 1970, 1 male, E. W. Surber, VPI&SU. Washington Co.; Small pd. along Rt. 663, 15 June 1980, 1 male, FLC; Beaver dams on Straight Branch, 14 Aug. 1979, 1 female, BCK. Westmoreland Co.; nr. Coles Point, 25 June 1917, 1 female, J. E. Benedict, USNM; nr. Coles Point, 27 June 1917, 7 males, 4 females, J. E. Benedict, USNM; nr. Coles Point, 7 Aug. 1917, 1 male, 3 females, J. E. Benedict, USNM. Wythe Co.; Wytheville, 28 June 1935, 5 males, 3 females, CA, (Det. CA), CA Collection; A. A. Campbell Pd., 3 July 1970, 1 male, W. R. Chittwood, VPI&SU; A. A. Campbell Pd., 4 July 1970, 1 male, W. R. Chittwood, VPI&SU. York Co.; Newman Pd., 5 June 1967, 3 males, 1 female, MDR, VPI&SU; Bracken Pd., 7 June 1967, 1 male, 1 female, MDR, VPI&SU; Jones Mill Pd. on Colonial Parkway, 16 Sept. 1966, 1 male, 1 female, MDR, VPI&SU; Bracken Pd. on Colonial Parkway, 16 Sept.

1966, 2 males, 2 females, MDR, VPI&SU; Newman Pd., 18 Sept. 1966, 2 males, 3 females, MDR, VPI&SU. City of Chesapeake; Stumpy Lk., 31 May 1970, 1 female, JFM, ODU; Lake Drummond, 9 June 1905, 1 female, H. S. Barber, USNM. City of Norfolk, locality unknown, 11 June 1973, 2 males, 1 female, JFM, ODU; Small pd. along Rt. 168, 13 June 1975, 2 males, FLC; locality unknown, 9 July 1974, 1 male, 1 female, JFM, ODU; locality unknown, 11 July 1973, 2 males, JFM, ODU; locality unknown, 1 Sept. 1974, 1 male, P. B. Schultz, VPI&SU; locality unknown, 8 Sept. 1973, 1 female, P. W. Larkins, VPI&SU; locality unknown, 9 Sept. 1973, 1 male, P. W. Larkins, VPI&SU. City of Richmond; locality unknown, 24 June 1968, 1 male, K. F. O'Barr, VCU; locality unknown, 26 June 1975, 1 male, Y. Wallace, VCU; Maymont Park, 13 July 1973, 1 male, W. Smith, VCU; Maymont Park, 13 July 1973, 1 male, 1 female, J. Krolak, VCU; locality unknown, 13 July 1973, 1 male, J. Verberg, VCU; locality unknown, 20 July 1973, 1 female, J. Verburg, VCU; locality unknown, 7 Aug. 1973, 1 female, K. Beck, VCU; St. Charles R., 9 Sept. 1964, 1 male, RRM, VCU. City of Suffolk; locality unknown, 20 Apr. 1975, 1 male, J. F. B., ODU; Jericho Ditch in Dismal Swamp Wildlife Refuge, 1 June 1970, 1 female, JFM, ODU; Jericho Lane in Dismal Swamp Wildlife Refuge, 22 June 1975, 1 male, 1 female, FLC; Dismal Swamp Wildlife Refuge, 2 July 1973, 3 males, 5 females, JFM, ODU; Dismal Swamp Wildlife Refuge, 20 July 1974, 2 males, 1 female, J. Hancock, ODU; Cypress Chapel, 13, 14 Sept. 1934, 1 male, 2 females, LKG, (Det. LKG, Gloyd 1951). City of Virginia Beach; Back Bay Refuge, 25 May 1975, 1 male, 1 female, J. O'Hop, ODU; locality unknown, 21 June 1973, 1 male, D. Simonet, VPI&SU; Back Bay Refuge, 26 June 1971, 3 females, JFM, ODU; Back Bay Refuge, 26 June 1973, 3 males, JFM, ODU;

Sand Bridge, 15 July 1973, 1 male, T. Slate, VCU; North Landing, 14 Aug. 1948, 2 males, 1 female, R. L. Hoffman, (Det. LKG); locality unknown, 6 Oct. 1973, 1 female, Munsen, ODU.

Flight Season.--Year-round southward; in Virginia Apr. 20 to Oct. 18. Known season in neighboring states are: Kentucky- May 7 to Sept. 10; Maryland- July 10 to Aug. 22; North Carolina- May to Sept. 4; Pennsylvania- May 24 to Sept. 15; Tennessee- Apr. 11 to Oct. 20; West Virginia- June 3 to Aug. 13.

Biology.--*Erythemis simplicicollis* inhabits pools of streams, ponds, and lakes. Adults frequently alight upon surfaces near shore.

Remarks.--This is one of the more ubiquitous species of the Libellulidae; in Virginia it has been collected from near sea level to an elevation of 1400 m. The mature males are easily distinguished by their bluish body and yellow cerci, and the immature males and females by their green bodies.

Hagen (1861) listed *E. haematogastra* Burmeister from Georgia. However, it has not been subsequently reported from the United States except for a possible observation of an individual at Cape Hatteras, North Carolina by Clark Shiffer (personal communication). This species is easily distinguished from *E. simplicicollis* by its red abdomen.

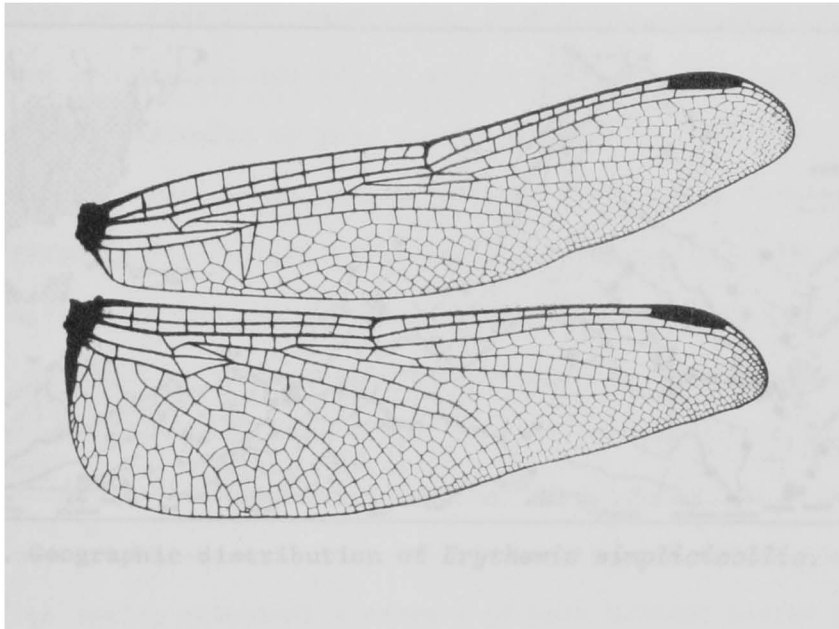


Figure 168. Wings of *Erythemis simplicicollis* x3.

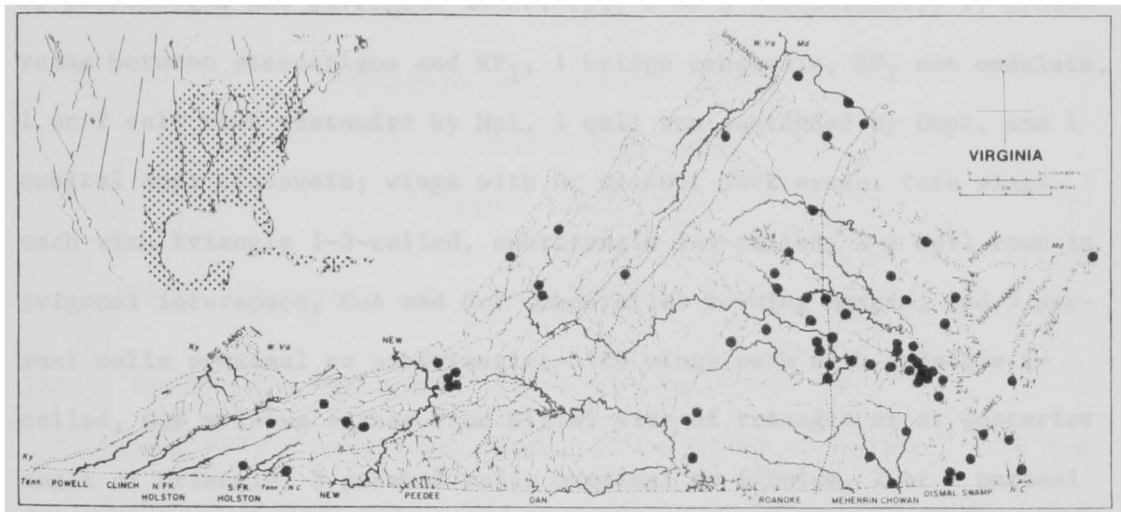


Figure 169. Geographic distribution of *Erythemis simplicicollis*.

Genus *Erythrodiplax* Brauer 1868

Brauer 1868. Verh. Zool.-Bot. Bes. Wien 18:368.

Type Species.--*Libellula fusca* Rambur.

Diagnosis.--Posterior margin of pronotum directed posterodorsally with small medial notch; apical 3 or 4 spines of outer spine row of hind femora not greatly lengthened; wings each with proximal and distal margins of pterostigma not divergent anteriorly, 2 or 3 (occasionally 1) crossveins between pterostigma and RP_1 , 1 bridge crossvein, RP_2 not undulate, 1 or 2 cell rows subtended by Mpl , 1 cell row subtended by $Cupl$, and 1 cubital anal crossvein; wings with or without dark areas; fore wings each with triangle 1-3-celled, subtriangle 1-4-celled, 2-4 cell rows in trigonal interspace, CuA and CuP subparallel to wing margin, and 5 paranal cells proximal to subtriangle; hind wings each with triangle 1-celled, CuP arising either from distal side of triangle or at posterior angle of triangle, 3 paranal cells proximal to fibulum, 2 or 3 paranal cells distal to fibulum, anal loop well developed, and midrib angulated at ca. 40° at ankle; abdominal sternum 1 of male without paired processes; abdominal tergum 3 with well-developed lateral carinae; abdominal tergum 4 without supplementary transverse carina at antecostal suture; abdominal tergum 9 with well-developed lateral carinae.

Species Key to Adult *Erythrodiplax* of Virginia

1. Hind wings each with CuP arising from distal side of triangle, and 16-25 marginal cells between RP_1 and RP_2 ; fore wings each with 3 cell rows in trigonal interspace *E. berenice* p. 728

Hind wings each with CuP arising near posterior angle of triangle, and 7-11 marginal cells between RP_1 and RP_2 ; fore wings each with 2 cell rows in trigonal interspace *E. minuscula* p. 731

Erythrodiplax berenice (Drury)

Syn.: *histris* Burmeister

(Figures 170a, 171a)

Drury 1770. Ill. Exot. Ins. 1:114 (in *Libellula*).

Length 30-36 mm; abdomen 20-25 mm; hind wings 21-27 mm.

Diagnosis.--Fore wings each with 7-12 antenodal crossveins, triangle 1 or 2-celled (generally 2-celled), 2 or 3 cell rows in trigonal interspace (generally with 3 cell rows), and subtriangle 2 or 3-celled (generally 3-celled); hind wings each with 6-8 antenodal crossveins, 16-25 marginal cells between RP_1 and RP_2 , and CuP arising from distal side of triangle; posterior hamuli with outer rami apically acuminate; vulvar lamina longer than abdominal segment 9.

Distribution.--Known from the states of AL, CT, DC, FL, GA, LA, ME, MD, MA, MS, NJ, NM(?), NY, NC, PA, RI, SC, TX, and VA, and the provinces of N.S. and Que. Known also from Baja CA, Mexico, and from the Bahamas and south to Salina Cruz, Mexico. Known from the Virginia counties of

Accomack, Buckingham, James City, Lancaster, Middlesex, New Kent, Northampton, Sussex, Westmoreland, and York, and the cities of Hampton, Newport News, Norfolk, Suffolk, and Virginia Beach. Known distribution among the counties of neighboring states include: Maryland- Anne Arundel, Calvert, Talbot, and Worchester; North Carolina- Brunswick, Carteret, Dare, Pamlico, and Pender; Pennsylvania- Bucks, Delaware, and Philadelphia.

Virginia Records.--Accomack Co.; Eastern shore opposite Parksley, 31 May 1937, 1 male, 2 females, F. M. Jones, (Det. MED, MDR notes); Cedar Island, 8 July 1914, 1 male, 1 female, H. G. Dyar, USNM; locality unknown, 21 July 1975, 1 female, J. O'Hop, ODU; locality unknown, 7 Aug. 1975, 5 females, J. O'Hop, ODU. Buckingham Co.; Arvonias, 30 June 1968, 1 male, B. Black, VCU; locality, date, and collector unknown, (Shorters 1930). James City Co.; Kings Cr. nr. Williamsburg, 24 June 1938, 1 male, MED, VPI&SU; Kings Cr. nr. Williamsburg, 24 June 1938, 10 males, 12 females, MED, (Det. MED, MDR notes); Lk. Powell at Williamsburg, 1 July 1937, 1 male, CC, (Det. CC), W&M; Riverview at Norge, 12 July 1933, 1 male, M. J. Westfall, FSCA; Williamsburg, 14 July 1937, 1 female, collector unknown, MED, W&M; Indian Field Cr., 15 July 1938, 2 females, MED, VPI&SU; Williamsburg, 23 July 1937, 2 males, 4 females, collector unknown, (Det. MED), W&M; Lees Mill Pd. at Fort Eustis, 30 July 1938, 1 male, MED, (Det. MED, MDR notes); Ballard Cr., 29 July 1938, 1 male, MED, VPI&SU; Tutters Neck Pd. on Colonial Parkway, 15 Sept. 1966, 2 males, MED, (Det. MED, MDR notes). Lancaster Co.; locality unknown, 22 July 1975, 2 males, 4 females, J. O'Hop, ODU. Middlesex Co.; Stingray Point, 20 June 1937, 1 female, CC, (Det. CC); Stingray Point, 30 June

1937, 1 male, 1 female, CC (Det. CC), CC Collection; locality unknown, 8 July, 1 male, 2 females, C. R. Parker, VPI&SU. New Kent Co.; West Point, 2 Aug. 1975, 1 male, 1 female, J. O'Hop, ODU. Northampton Co.; Silver Beach, 21 June 1975, 1 male, N. G. Evenson, VCU. Sussex Co.; locality unknown, 6 June 1975, 1 male, J. Hancock, ODU. Westmoreland Co.; nr. Coles Point, 23 June 1917, 3 males, 8 females, J. E. Benedict, USNM; nr. Coles Point, 27 June 1917, 2 males, 4 females, J. E. Benedict, USNM; nr. Coles Point, 4 Aug. 1917, 4 males, 12 females, J. E. Benedict, USNM; nr. Coles Point, 6 Aug. 1917, 1 female, J. E. Benedict, USNM. York Co.; Yorktown Cr., 10 June 1938, 1 male, 4 females, MED, VPI&SU; Yorktown Cr., 10 June 1938, 4 males, 4 females, MED, (Det. MED, MDR notes); Felgates Cr., 24 June 1938, 1 male, 3 females, MED, VPI&SU; Felgates Cr., 24 June 1938, 4 males, 13 females, MED, (Det. MED, MDR notes); Yorktown, 27 June 1948, 1 male, R. L. Hoffman, (Det. LKG); Jones Pd., 9 July 1938, 1 male, 1 female, MED, VPI&SU; Yorktown, 15 July 1937, observation, CC; Jones Pd., 29 July 1938, 1 female, MED, (Det. MED, MDR notes); Brachens Pd., 16 Sept. 1960, 1 male, MED, (Det. MED, MDR notes). City of Hampton, Hampton Roads, 16 Jan. 1973, 1 female, D. Simonet, VPI&SU; locality unknown, 9 June 1973, 1 male, D. Simonet, VPI&SU; locality unknown, 13 July 1973, 1 female, D. Simonet, VPI&SU. City of Newport News; Marsh at Denbigh, 30 July 1938, 1 male, MED, VPI&SU; Marsh at Denbigh, 30 July 1938, 1 female, MED, (Det. MED, MDR notes); Warwick R. at Denbigh, 13 Aug. 1937, 2 males, MED, (Det. MED, MDR notes); Warwick R. at Denbigh, 20 Sept. 1937, 1 female, MED, (Det. MED, MDR notes). City of Norfolk, 11 June 1973, 1 male, JFM, ODU; Ocean View, 9 Aug., 3 females, A. N. Caudell, USNM. City of Suffolk; Dismal Swamp Wildlife

Refuge, 24 July 1974, 1 male, J. Hancock, ODU. City of Virginia Beach; White L. at Seaside State Park, 22 May 1977, 3 males, 3 females (teneral), FLC; locality unknown, 29, 30 May 1900, 2 males, 4 females, C. L. Pol- lard and W. K. Maxon, USNM; locality unknown, 9 June 1948, 5 males, 3 females, G. M. Boush, VPI&SU; locality unknown, 1 Aug. 1928, 2 males, 2 females, collector unknown, (Det. MED), U. of Wisconsin; locality unknown, 5 Aug., 1 male, F. C. Pratt, USNM; locality unknown, 9 Aug. 1937, 1 male, F. C. Pratt, (Det. MED), USNM; Seaside State Park, 6 Sept. 1973, 1 female, A.C., ODU.

Flight Season.--Year-round (FL); in Virginia Jan. 16 to Sept. 20.

Known season in neighboring states are: District of Columbia- July 2 to Sept. 2; Maryland- June 18 to Sept. 5; North Carolina- June 20 to Oct. 15; Pennsylvania- June 24 to Aug. 7.

Biology.--*Erythrodiplax berenice* inhabits brackish coastal marshes. The nymphs are the most halophilic of Virginia dragonflies. This species is commonly associated with *Libellula needhami* and *Brachymesia gravida*.

Remarks.--*Erythrodiplax berenice* was the first dragonfly species to be reported from Virginia.

Erythrodiplax minuscula (Rambur)

(Figures 170b, 171b)

Rambur 1842. Ins. Neur., p. 115 (in *Libellula*).

Length 23-27 mm; abdomen 14-17 mm; hind wings 17-21 mm.

Diagnosis.--Fore wings each with 6-9 antenodal crossveins, triangle

1 or 2-celled (generally 1-celled), 2 cell rows in trigonal interspace, and subtriangle 2 or 3-celled (generally 2-celled); hind wings each with 5-7 antenodal crossveins, 7-11 marginal cells between RP_1 and RP_2 , and CuP arising near posterior angle of triangle; posterior hamuli with outer rami apically rounded; vulvar lamina ca. as long as abdominal segment 9.

Distribution.--Known from the states of AL, AR, FL, GA, IN, KY, LA, MD, MS, NC, OH, OK, PA, SC, TN, TX, VA, and WV. Known from the Virginia counties of Charles City, Essex, and Montgomery, and from the cities of Norfolk, Suffolk, and Virginia Beach. Known distribution among the counties of neighboring states include: Kentucky- Union; Maryland- Montgomery and Prince Georges; North Carolina- Catawba, Chatham, Craven, Davidson, Duplin, Durham, Edgecomb, Johnston, McDowell, Moore, New Hanover, Onslow, Pender, Stanly, Transylvania, Union, Wake, and Wilson; Pennsylvania- Bucks and Delaware; Tennessee- Johnson and Monroe; West Virginia- Pendleton.

Virginia Records.--Charles City Co.; Marl pit on Rt. 5, 18 June 1938, 1 male, V. M. D. and MED, (Det. MED), W&M; Marl pit on Rt. 5, 18 June 1938, 2 males, 1 female, MED, (Det. MED, MDR notes); Marl pit on Rt. 5, 3 Aug. 1938, 1 male, MED, VPI&SU. Essex Co.; Dunbrooke, 28 July 1899, 1 male, RPC, FLC; Dunbrooke, 29 July 1899, 1 male, 1 female, RPC, USNM. Montgomery Co.; Heath Pd. at Blacksburg off Rt. 685, 1 Aug. 1977, 1 male, FLC. City of Norfolk; locality unknown, 8 July 1974, 1 male, 1 female, JFM, ODU; locality unknown, 11 July 1973, 8 males, JFM, ODU; locality unknown, 25 Sept. 1974, 1 male, D. P. Childs, VPI&SU. City of Suffolk; Cypress Chapel, 13 Sept. 1934, 2 males, LKG, (Det. LKG, Gloyd

1951); Cypress Chapel, 14 Sept. 1934, 1 male, LKG, (Det. LKG, Gloyd 1951). City of Virginia Beach; Back Bay Refuge, 8 June 1975, 1 male, 1 female, J. O'Hop, ODU; White Lk. at Seashore State Park, 16 Sept. 1979, 1 male, JFM, ODU.

Flight Season.--Year-round (FL); in Virginia June 8 to Sept. 25. Known season in neighboring states are: Kentucky- June; Maryland- Aug. 5 to Oct. 6; North Carolina- May 9 to Oct. 14; Pennsylvania- July 16 to Aug. 15; Tennessee- Aug. 19 to 20; West Virginia- Aug. 5.

Biology.--*Erythrodiplax minuscula* inhabits shallow ponds. Adults alight upon low vegetation near shore.

Remarks.--This species is considered by some authors a subspecies of *E. connata*. However, the apparent absence of intergrades in characteristics including body size, abdominal color pattern, wing venation, and penis structure indicate that further study is needed before the two can be considered subspecies.

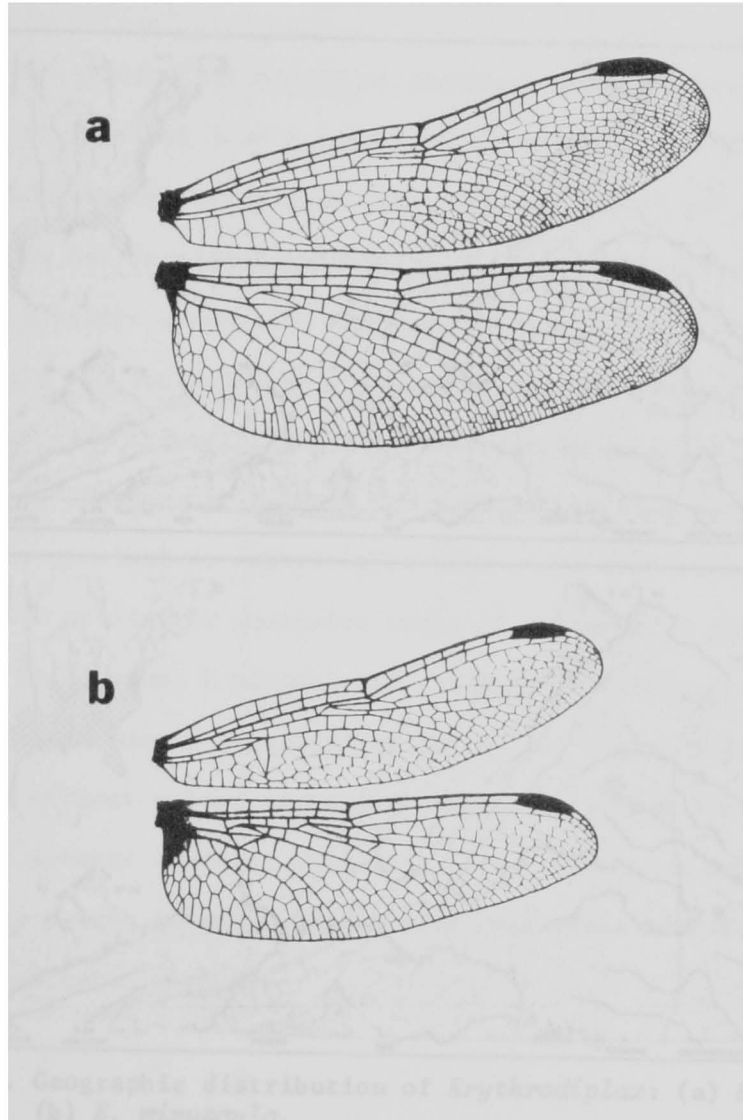


Figure 170. Wings of *Erythrodiplax* x3: (a) *E. berenice*; (b) *E. minuscula*.

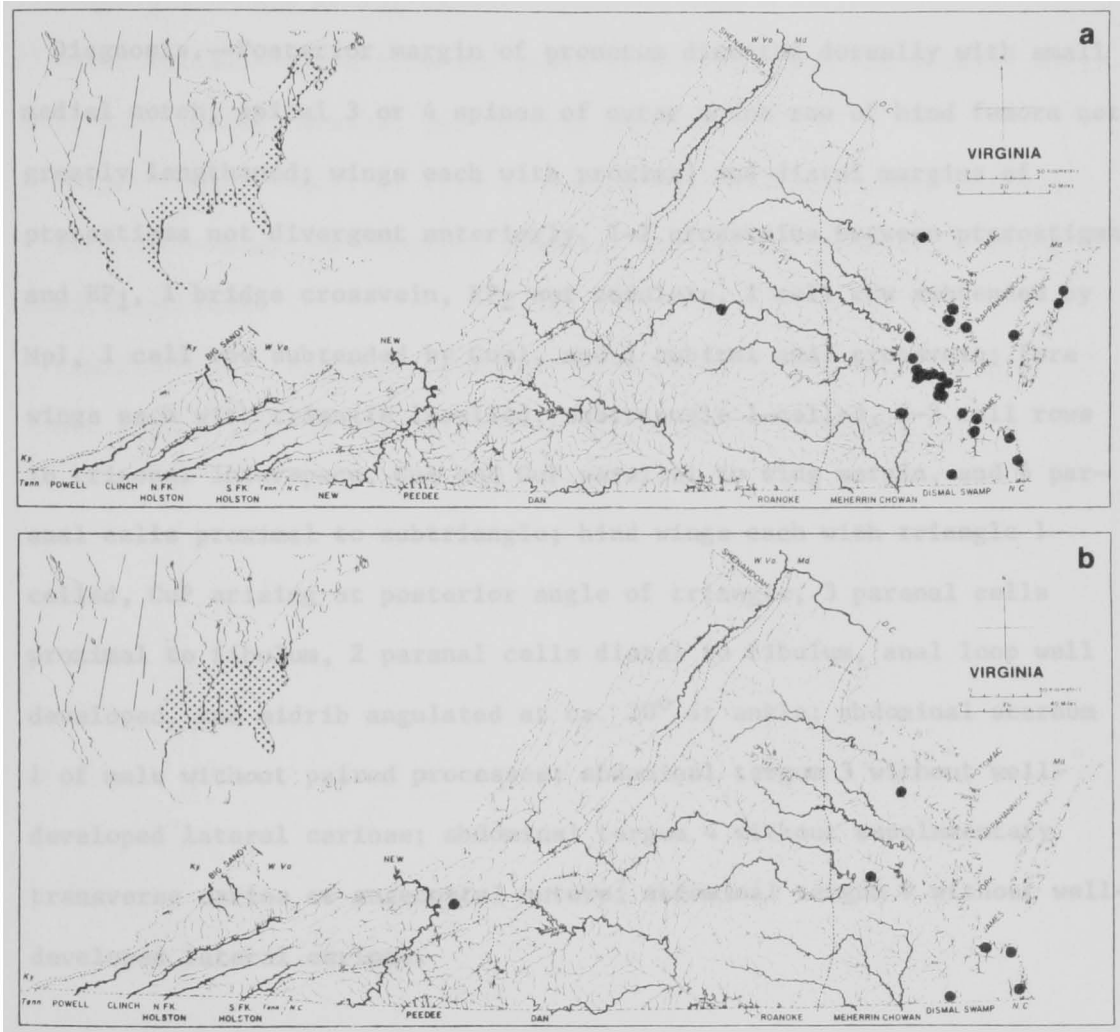


Figure 171. Geographic distribution of *Erythrodiplax*: (a) *E. berenice*; (b) *E. minuscula*.

Genus *Idiataphe* Cowley 1934Syn: *Ephidatia* Kirby

Cowley 1934. Entomol. Mo. Mag. 70:243.

Type Species.--*Erythemis longipes* Hagen.

Diagnosis.--Posterior margin of pronotum directed dorsally with small medial notch; apical 3 or 4 spines of outer spine row of hind femora not greatly lengthened; wings each with proximal and distal margins of pterostigma not divergent anteriorly, 1-2 crossveins between pterostigma and RP_1 , 1 bridge crossvein, RP_2 not undulate, 1 cell row subtended by Mpl , 1 cell row subtended by Cup_1 , and 1 cubital anal crossvein; fore wings each with triangle 1-celled, subtriangle 1-celled, 2-3 cell rows in trigonal interspace, CuA and CuP parallel to wing margin, and 6 paranal cells proximal to subtriangle; hind wings each with triangle 1-celled, CuP arising at posterior angle of triangle, 3 paranal cells proximal to fibulum, 2 paranal cells distal to fibulum, anal loop well developed, and midrib angulated at ca. 20° at ankle; abdominal sternum 1 of male without paired processes; abdominal tergum 3 without well-developed lateral carinae; abdominal tergum 4 without supplementary transverse carina at antecostal suture; abdominal tergum 9 without well-developed lateral carinae.

Idiataphe cubensis Scudder

Scudder 1866. Proc. Boston Soc. Nat. Hist. 10:190 (in *Macromia*).

Length 36-41 mm; abdomen 24-27 mm; hind wings 28-30 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the state of FL, and from the Greater Antilles, West Indies, Mexico, and Central America.

Flight Season.--Mar. 17 (FL) to Dec. 8 (FL) and year-round southward.

Biology.--*Idiataphe cubensis* inhabits the aquatic vegetation along coastal marshes.

Remarks.--This species is closely related to *I. longipes* Hagen of South America; it is unlikely to be collected in Virginia.

Genus *Ladona* Needham 1897

Needham 1897. Can. Entomol. 29:146.

Type Species.--*Libellula exusta* Say.

Diagnosis.--Posterior margin of pronotum directed posterodorsally without medial notch; apical 3 or 4 spines of outer spine row of hind femora not greatly lengthened; wings each with proximal and distal margins of pterostigma not divergent anteriorly, 2-4 crossveins between pterostigma and RP_1 , 2-4 bridge crossveins, RP_2 undulate, 2 (occasionally 3) cell rows subtended by Mp_1 , 1 cell row subtended by Cu_1 , and 1 cubital anal crossvein; wings each with basal dark area; fore wings each with triangle 2 or 3-celled, subtriangle 2 or 3-celled, 2 or 3 cell rows in trigonal interspace, CuA and CuP divergent to wing margin, and 5-7 paranal cells proximal to subtriangle; hind wings each with triangle 2-celled, CuP arising at posterior angle of triangle, 3 paranal cells proximal to fibulum, 2 or 3 paranal cells distal to fibulum, anal loop well developed, and midrib angulated at ca. 35° at ankle; abdominal sternum 1 of male without paired processes; abdominal tergum 3 with well-developed lateral carinae; abdominal tergum 4 without supplementary transverse carina at antecostal suture; abdominal tergum 9 without well-developed lateral carinae.

Remarks.--The inclusion of the European *Libellula* (*Eurothemis*) *fulva* in this group by Walker and Corbet (1975) seems justified if *Eurothemis* is considered a subgenus of *Ladona*.

Species Key to Adult *Ladona*

1. Hind wings each with basal opaque area not extended to triangle;
 mesanepisternal pale stripes wider than middorsal brown band
 (stripes obscured by pruinosity in mature individuals)
 *L. julia* p. 743
- Hind wings each with basal opaque area extended to triangle; mesanepisternal pale stripes narrower than middorsal brown band
 (stripes often not obscured by pruinosity in mature individuals) .
 2
2. Fore wings each with midbasal space hyaline; abdominal segments with
 posterodorsal triangular dark brown areas (abdominal segments
 blue-pruinose in mature individuals) . . . *L. deplanata* p. 739
- Fore wings each with midbasal space not hyaline; abdominal segments
 with narrow middorsal dark brown bands (abdominal segments white-pruinose in mature individuals) *L. exusta* p. 741

Ladona deplanata (Rambur)

(Figures 172a, 173a)

Rambur 1842. Ins. Neur., p. 75 (in *Libellula*).

Length 29-38 mm; abdomen 18-25 mm; hind wings 24-29 mm.

Diagnosis.--Mesanepisternal pale stripes narrower than mesanepisternal middorsal dark band, dorsal surface of mesanepisterna slightly pruinose in mature individuals; fore wings each with basal dark area extended distally to cover cubital anal crossvein, midbasal space hyaline, 9-14

antenodal crossveins, and subtriangle 2 or 3-celled; hind wings each with basal dark area extended to proximal side of triangle, midbasal space transparent saffron to opaque brown, 7-10 (occasionally 11) antenodal crossveins, and 0 or 1 ankle cell in anal loop; abdominal segments with posterodorsal triangular black spots apparent when not pruinose; vulvar lamina with lateral lobes nearly contiguous basally, widest laterally; male epiproct in lateral view widest at ca. 1/2 length.

Distribution.--Known from the states of AL, AR, FL, GA, IN, KS, KY, LA, MD, MS, MO, NJ, NY, NC, OK, SC, TN, TX, and VA. Known from the Virginia counties of Bedford, Brunswick, Charlotte, Cumberland, Fairfax, Franklin, Hanover, Henrico, James City, Lunenburg, Northampton, Prince Edward, Southampton, and the city of Suffolk. Known distribution among the counties of neighboring states include: Kentucky- Breckinridge, Edmonson, and Hart; Maryland- Prince Georges; North Carolina- Alamance, Chowan, Craven, Davidson, Davie, Durham, Greene, Orange, and Wake; Tennessee- Knox and Sullivan.

Virginia Records.--Bedford Co.; Preston Pd. off Rt. 627, May, 1 male, 1 female, J. Bragg, VPI&SU. Brunswick Co.; Waqua Cr. at Rt. 1, 15 Apr. 1978, 1 male (teneral), FLC; Nottoway R. at Rt. 1, 15 Apr. 1978, 1 female, FLC. Charlotte Co.; Twittys Cr., 23 Apr. 1976, 1 male, M. Mauney, VPI&SU; Twittys Cr. Reservoir, 18 May 1978, 1 male, FLC; Twittys Cr. Reservoir, 23 May 1977, 1 male, FLC. Cumberland Co.; locality unknown, 29 Apr. 1974, 1 male, T. Bailey, VPI&SU; Bear Cr. Lk., 23 May 1977, 1 male, 1 female, FLC. Fairfax Co.; Great Falls, 30 Apr. 1915, 1 male, BPC, USNM; Great Falls, 30 Apr. 1915, 1 female, RPC, USNM; Great Falls, 19 May 1917, 1 female, RPC, USNM. Franklin Co.; Rt. 40 ca. 8 miles E.

of Rocky Mount, 27 Apr. 1979, 1 male, BCK, VPI&SU. Hanover Co.; Lukart's farm, 12 Apr. 1974, 1 female, T. Kline, VCU. James City Co.; Lk. Powell at Williamsburg, 12 Apr. 1938, 1 male, MED, VPI&SU; Lk. Matoaka at Williamsburg, 18 May 1966, 1 female, MDR, VPI&SU; Pond in Long Hill Swamp, 24 May 1966, 1 male, 2 females, MDR, VPI&SU. Lunenburg Co.; Nottoway R. at Rt. 49, 14 Apr. 1978, 4 males, 1 female (teneral), FLC: Nottoway R. at Rt. 49, 14 Apr. 1978, 1 male (teneral), SWB, FLC Collection. Northampton, 1 June 1937, 1 male, F. M. Jones, VPI&SU. Prince Edward Co.; Prince Edward State Forest, 17 Apr. 1977, 1 male, Cannon and Keil, VPI&SU. Southampton Co.; Nottoway R. at Rt. 653, 16 Apr. 1978, 2 males, 3 females (teneral), FLC: Nottoway R. at Rt. 653, 1 male, SWB, FLC Collection. City of Richmond; Maymont Park, 12 June 1974, 1 male, G. Cotron, VCU. City of Suffolk; Williamson Ditch in Dismal Swamp Wildlife Refuge, 17 Apr. 1978, 2 males, 1 female (teneral), FLC.

Flight Season.--Jan. 4 (FL) to June 29 (NJ); in Virginia Apr. 12 to June 12. Known season in neighboring states are: Kentucky- May 14 to June 5; Maryland- May 18; North Carolina- Mar. 26 to May 28; Tennessee- Apr. 17 to June 14.

Biology.--*Ladona deplanata* inhabits ponds and lakes. Adults frequently perch near shore on banks or on vegetation.

Remarks.--Needham, Calvert, and Byers all at one time incorrectly considered this species a synonym of *L. exusta*. This species is the most common species of *Ladona* in Virginia.

Ladona exusta (Say)

(Figures 172b, 173b)

Say 1839. J. Acad. Phila. 8:29 (in *Libellula*).

Length 30-40 mm; abdomen 19-26 mm; hind wings 25-32 mm.

Diagnosis.--Mesanepisternal pale stripes narrower than mesanepisternal middorsal dark band, dorsal surface of mesanepisterna not pruinose in mature individuals; fore wings each with basal dark area extended distally to cover cubital-anal crossvein, midbasal space transparent saf-fron to opaque brown, 10-14 antenodal crossveins, and subtriangle 3- (occasionally 2) celled; hind wings each with basal dark area extended to proximal side of triangle, midbasal space opaque brown, 8-11 antenodal crossveins, and 0 or 1 ankle cell in anal loop; abdominal segments each with narrow middorsal black stripe apparent when not pruinose; vulvar lamina with lateral lobes nearly contiguous basally, widest medially; male epiproct in lateral view widest at ca. 1/2 length.

Distribution.--Known from the states of CT, GA(?), KY(?), LA(?), ME, MA, NH, NJ, NY, NC(?), PA, TN(?), VT, and VA, and the province of N.S. Known from the Virginia county of Richmond. Known distribution among the counties of neighboring states include: Kentucky- Ohio; Pennsylvania- Monroe.

Virginia Records.--Richmond Co.; Gardys Mill Pd. on Rt. 663 nr. Warsaw, 20 May 1975, 1 male, FLC.

Flight Season.--May 19 (New England) to July 28 (New England); in Virginia May 20.

Biology.--*Ladona exusta* inhabits boggy ponds. Adults perch near shore on the bank and on vegetation.

Remarks.--This species has been confused with *L. julia* by some authors

and with *L. deplanata* by others. It can be easily distinguished from these species by the basal wing markings. All three species of *Ladona* have established breeding populations in southern New Jersey; there is no evidence of hybridization between these populations. Previous records of this species south of Virginia need further verification.

Ladona julia (Uhler)

(Figures 172c, 173c)

Uhler 1857. Proc. Acad. Phila., p. 88 (in *Libellula*).

Diagnosis.--Mesanepisternal pale stripes wider than mesanepisternal middorsal dark band, dorsal surface of mesanepisterna pruinose in mature individuals; fore wings each with basal dark area not extended distally to cover cubital-anal crossvein, midbasal space hyaline, transparent saffron basally, 13-16 (occasionally 12) antenodal crossveins, and sub-triangle 3 or 4-celled; hind wings each with basal dark area not extended to proximal side of triangle, midbasal space hyaline distally, transparent saffron proximally, 10-13 antenodal crossveins, and 0-3 (occasionally 4) ankle cells in anal loop; abdominal segments with wide middorsal black band apparent when not pruinose; vulvar lamina with lateral lobes separated medially, widest laterally; male epiproct in lateral view widest at ca. 2/3 length.

Distribution.--Known from the states of CA, CT, ID, IN, ME, MA, MI, MN, MT, NH, NJ, NY, ND, OH, PA, UT, VT, VA, WA, WV, and WI, and the provinces of Alta., B.C., Man., N.B., N.S., Ont., Que., and Sask. Known from the Virginia county of Highland. Known distribution among the

counties of neighboring states include: Pennsylvania- Bradford, Bucks, Centre, Clearfield, Clinton, Columbia, Delaware, Elk, Huntingdon, Lackawanna, Lycoming, McKean, Monroe, Montgomery, Pike, Sullivan, Union, Warren, Wayne, and Wyoming.

Virginia Records.--Highland Co.; Buck Run beaver pds., 10 June 1979, 1 male, BCK; Buck Run beaver pds., 12 June 1980, 1 nymphal exuviae, FLC; Buck Run beaver pds., 8 Aug. 1978, 1 male, FLC.

Flight Season.--May 15 (IN) to Sept. 10 (IN); in Virginia June 10 to Aug. 8. Known season in neighboring states are: Pennsylvania- May 16 to July 31.

Biology.--*Ladona julia* inhabits bog ponds and marsh-bordered lakes. Adults perch near shore on banks and on vegetation.

Remarks.--The Highland county population is apparently the most southern record for this species.

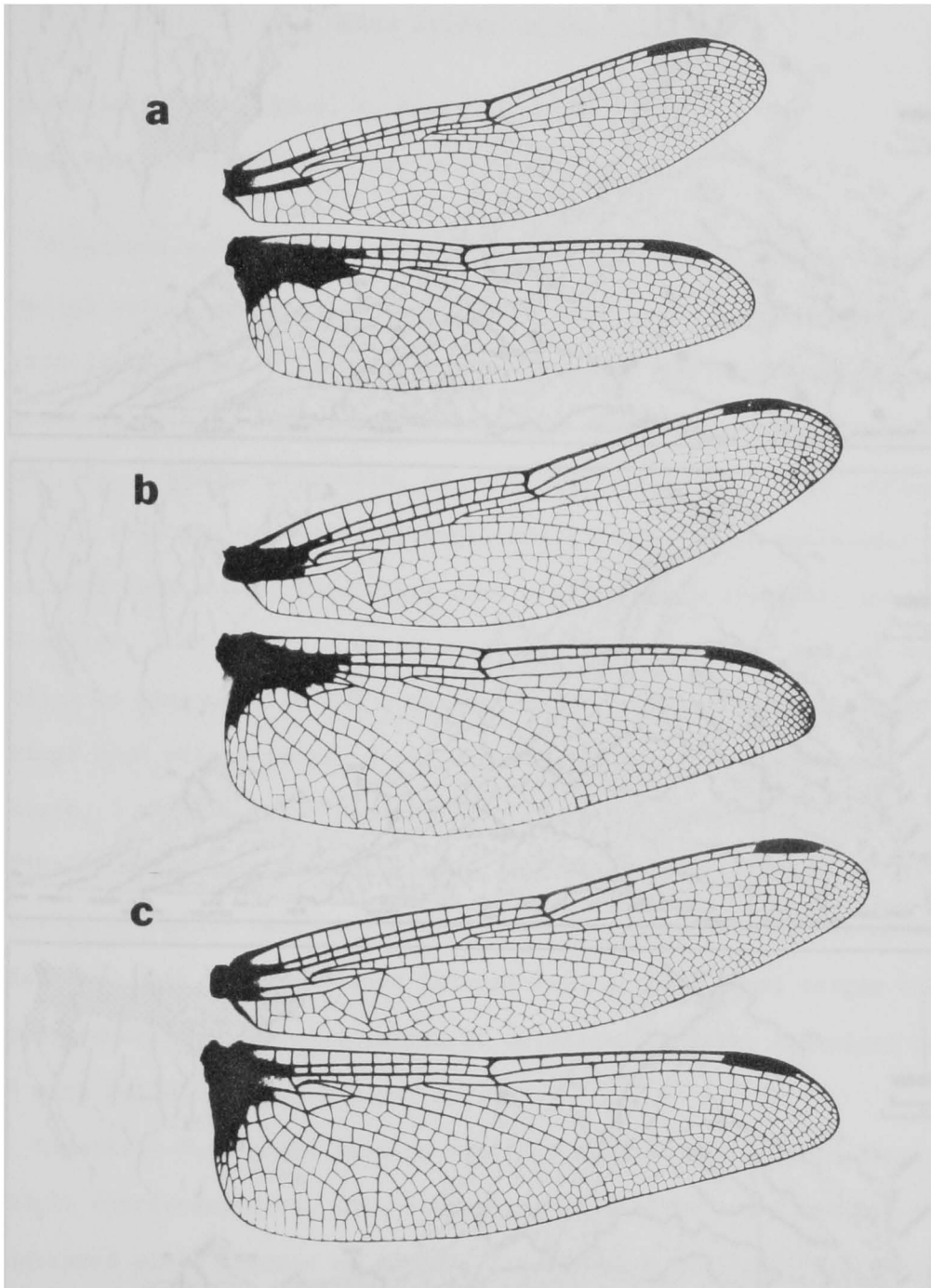


Figure 172. Wings of *Lidona* x3: (a) *L. deplanata*; (b) *L. exusta*; (c) *L. julia*.

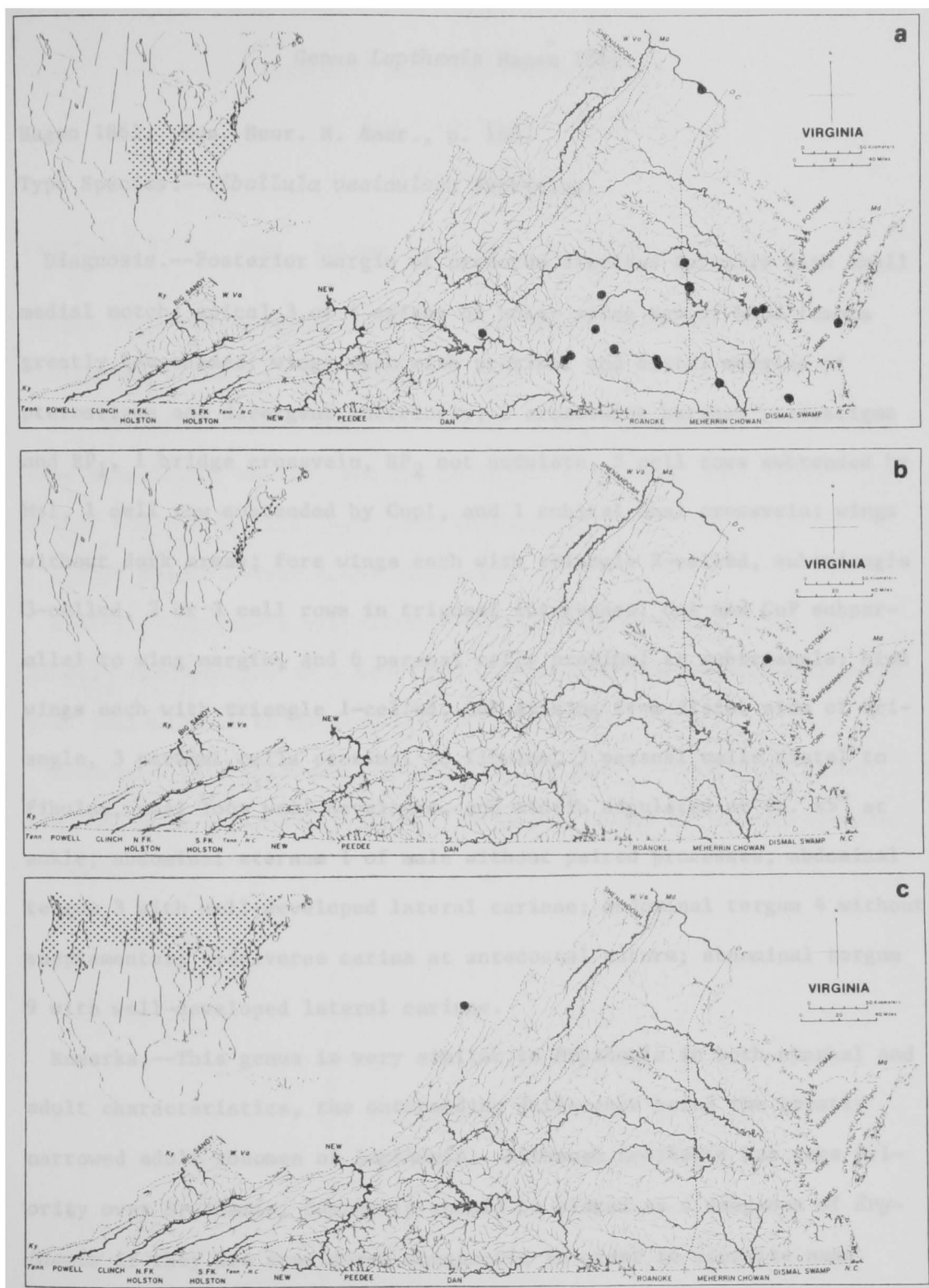


Figure 173. Geographic distribution of *Ladona*: (a) *L. deplanata*; (b) *L. exusta*; (c) *L. julia*.

Genus *Leptthemis* Hagen 1861

Hagen 1861. Syn. Neur. N. Amer., p. 160.

Type Species.--*Libellula vesiculosa* Fabricius.

Diagnosis.--Posterior margin of pronotum directed dorsally with small medial notch; apical 3 or 4 spines of outer spine row of hind femora greatly lengthened; wings each with proximal and distal margins of pterostigma not divergent anteriorly, 2 crossveins between pterostigma and RP_1 , 1 bridge crossvein, RP_2 not undulate, 2 cell rows subtended by Mpl , 1 cell row subtended by Cup_1 , and 1 cubital anal crossvein; wings without dark areas; fore wings each with triangle 2-celled, subtriangle 3-celled, 2 or 3 cell rows in trigonal interspace, CuA and CuP subparallel to wing margin, and 6 paranal cells proximal to subtriangle; hind wings each with triangle 1-celled, CuP arising from distal side of triangle, 3 paranal cells proximal to fibulum, 3 paranal cells distal to fibulum, anal loop well developed, and midrib angulated at ca. 45° at ankle; abdominal sternum 1 of male without paired processes; abdominal tergum 3 with well-developed lateral carinae; abdominal tergum 4 without supplementary transverse carina at antecostal suture; abdominal tergum 9 with well-developed lateral carinae.

Remarks.--This genus is very similar to *Erythemis* in both nymphal and adult characteristics, the outstanding difference being the greatly narrowed adult abdomen of *Leptthemis*. Although *Leptthemis* has page priority over *Erythemis*, *Leptthemis* should be placed as a subgenus of *Erythemis* if they are considered congeneric in order to minimize name changes.

Leptemis vesiculosa (Fabricius)Syn.: *acuta* Say

(Figure 174)

Fabricius 1775. Syst. Entomol., p. 421 (in *Libellula*).

Length 54-64 mm; abdomen 39-46 mm; hind wings 35-43 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of FL, OK, and TX. Known also from Tamaulipas, Mexico, and the Antilles- Cuba, Dom. Rep., Haiti, Jamaica, and Puerto Rico, and south to Paraguay.

Flight Season.--Year-round southward.

Biology.--*Leptemis vesiculosa* inhabits marsh-bordered ponds and lakes. This species is a bold swift flyer which seems to prefer large prey including other dragonflies.

Remarks.--This species is easily distinguished by its large green body and long attenuate abdomen. It is not likely to be collected in Virginia.

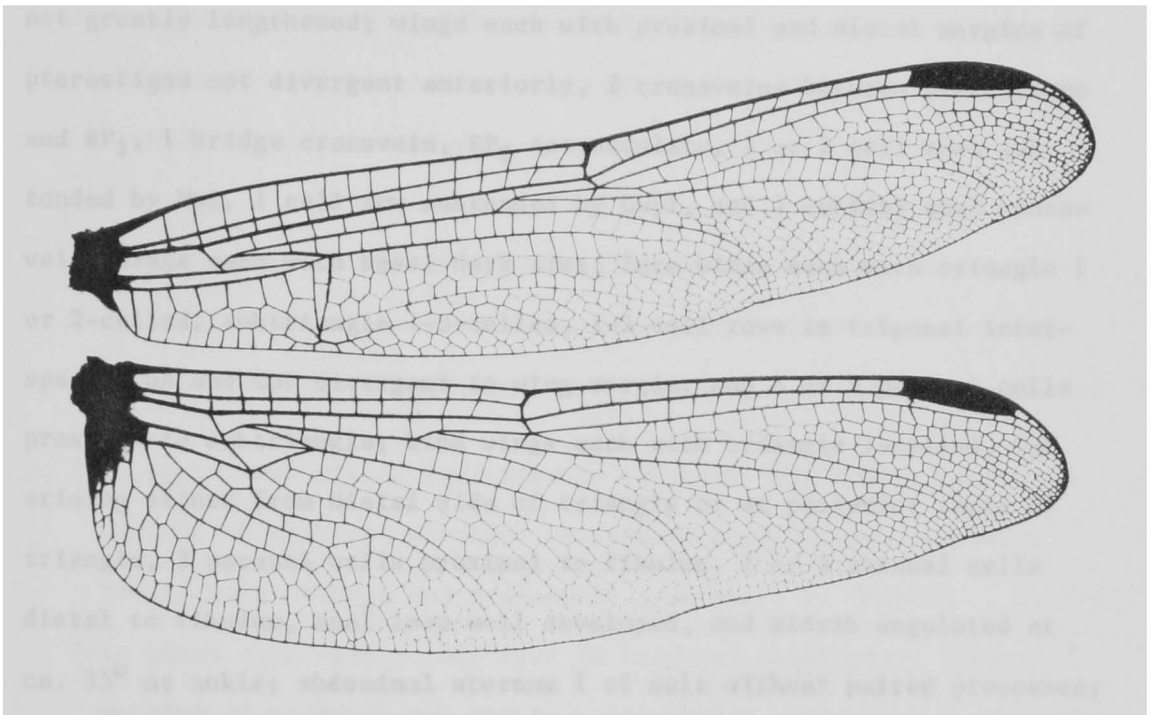


Figure 174. Wings of *Leptemia vesiculosa* X3.

Genus *Leucorrhinia* Brittinger 1850

Brittinger 1850. S. B. Acad. Wiss. Wien. 4:333.

Type Species.--*Libellula albifrons* Burmeister.

Diagnosis.--Posterior margin of pronotum directed dorsally with wide medial notch; apical 3 or 4 spines of outer spine row of hind femora not greatly lengthened; wings each with proximal and distal margins of pterostigma not divergent anteriorly, 2 crossveins between pterostigma and RP_1 , 1 bridge crossvein, RP_2 not undulate, 1 or 2 cell rows subtended by Mp_1 , 1 cell row subtended by Cu_1 , and 1 cubital anal crossvein; wings each with basal dark area; fore wings each with triangle 1 or 2-celled, subtriangle 1-3-celled, 1-3 cell rows in trigonal interspace, CuA and CuP divergent to wing margin, and 4 or 5 paranal cells proximal to subtriangle; hind wings each with triangle 1-celled, CuP arising either from distal side of triangle or at posterior angle of triangle, 3 paranal cells proximal to fibulum, 2 or 3 paranal cells distal to fibulum, anal loop well developed, and midrib angulated at ca. 35° at ankle; abdominal sternum 1 of male without paired processes; abdominal terga 3 and 4 without well-developed lateral carinae; abdominal tergum 4 without supplementary transverse carina at antecostal suture; abdominal tergum 9 without well-developed lateral carinae.

Biology.--The males of this genus all apparently exhibit guarding behavior after mating.

Species Key to Adult Male *Leucorrhinia* of Virginia

1. Abdominal segment 7 with middorsal red or yellow spot; cerci each with distinct subapical ventral angulation 2
 Abdominal segment 7 without middorsal red or yellow spot; cerci each without distinct subapical ventral angulation 3
2. Abdominal segments 4-6 with dorsal arrowhead-shaped spots; lateral margins of epiproct not strongly divergent; posterior hamuli each with posterolateral process longer than wide
 *L. hudsonica* p. 755
 Abdominal segments 4-6 without dorsal arrowhead-shaped spots; lateral margins of epiproct strongly divergent; posterior hamuli each with posterolateral process wider than long.. *L. intacta* p. 756
3. Fore wings each with 2 cell rows in trigonal interspace; lateral margins of epiproct strongly convergent posteriorly; posterior hamuli each without posterolateral process... *L. frigida* p. 752
 Fore wings each with 3 cell rows in trigonal interspace; lateral margins of epiproct not strongly convergent posteriorly; posterior hamuli each with posterolateral process 4
4. Wings each with 2 cell rows subtended by Mpl; labial palpi each without lateral white spot; posterior hamuli each with posteroventral process longer than wide *L. glacialis* p. 754
 Wings each with 1 cell row subtended by Mpl; labial palpi each with lateral white spot; posterior hamuli each with posteroventral process wider than long *L. proxima* p. 758

Species Key to Adult Female *Leucorrhinia* of Virginia

1. Vulvar laminal lobes less than 1/3 as long as wide; wings each with
 2 cell rows subtended by Mpl *L. glacialis* p. 754
 Vulvar laminal lobes more than 1/2 as long as wide; wings each with
 1 cell row subtended by Mpl 2
2. Vulvar laminal lobes approximate distal to base; labial palpi each
 without white lateral spots 3
 Vulvar laminal lobes not approximate distal to base; labial palpi
 each with white lateral spots 4
3. Vulvar laminal lobes twice as long as wide; abdominal segments 5-7
 with middorsal spots not triangular *L. frigida* p. 752
 Vulvar laminal lobes ca. as long as wide; abdominal segments 5-7
 with middorsal spots triangular *L. hudsonia* p. 755
4. Vulvar laminal lobes not contiguous basally, longer than wide; ab-
 dominal segment 7 with middorsal spot ca. 2 times as long as wide
 *L. intacta* p. 756
 Vulvar laminal lobes contiguous basally, shorter than wide; abdominal
 segment 7 with middorsal spot ca. 3 times as long as wide
 *L. proxima* p. 758

Leucorrhinia frigida Hagen

(Figures 175a, 177a, 179a)

Hagen 1890. Trans. Amer. Entomol. Soc. 17:231.

Length 27-32 mm; abdomen 18-22 mm; hind wings 21-25 mm.

Diagnosis.--Labial palpi each black without lateral white spots; wings each with 1 cell row subtended by Mpl; fore wings each with 2 cell rows in trigonal interspace, and subtriangle 1-3-celled; hind wings each with 5 or 6 antenodal crossveins; posterior hamuli each with posterolateral process absent, and posteroventral process well developed; male abdominal segments 4-7 black without dorsal spots; female abdominal segments 4-7 black with middorsal lanceolate yellow spots; vulvar laminal lobes contiguous distal to base, ca. 2.0 times as long as wide at base; male cerci each with slight subapical ventral angulation; male epiproct with lateral margins strongly convergent.

Distribution.--Known from the states of CT, IN, ME, MA, MI, NH, NJ, NY, ND, PA, VT, VA, and WI, and the provinces of B.C., Man., N.S., Ont., and Que. Known from the Virginia county of Highland. Known distribution among the counties of neighboring states include: Pennsylvania-Bucks, Centre, Clearfield, Clinton, Delaware, Elk, Huntingdon, Luzerne, McKean, Monroe, Pike, Sullivan, Susquehanna, and Wayne.

Virginia Records.--Highland Co.; Buck Run beaver pds., 18 June 1978, 1 male, FLC.

Flight Season.--May 30 (Ont.) to Aug. 29 (VT); in Virginia June 18. Known season in neighboring states are: Pennsylvania- June 1 to Aug. 15.

Biology.--*Leucorrhinia frigida* inhabits boggy ponds and lakes. Adults fly within 30 cm of the water preferring areas of emergent vegetation upon which they alight frequently.

Remarks.--Adult males are easily distinguished by the dorsal pruinosity of basal abdominal segments. A nymph collected in Louisa county has

been reported as this species (Voshell and Simmonds, 1977). Virginia records are the southernmost for the species.

Leucorrhinia glacialis Hagen

(Figures 175b, 177b, 179b)

Hagen 1890. Trans. Amer. Entomol. Soc. 17:234.

Length 32-38 mm; abdomen 21-26 mm; hind wings 21-26 mm.

Diagnosis.--Labial palpi each black without lateral white spots; wings each with 2 cell rows subtended by Mpl; fore wings each with 3 cell rows in trigonal interspace, and subtriangle 3-celled; hind wings each with 6 or 7 antenodal crossveins; posterior hamuli each with posterolateral process small, and posteroventral process well developed; male abdominal segments 4-7 black without dorsal spots; female abdominal segments 4-7 black with middorsal half-length oval yellow spots; vulvar laminal lobes contiguous basally, ca. 0.3 times as long as wide at base; male cerci each without subapical ventral angulation; male epiproct with lateral margins slightly convergent.

Distribution.--Known from the states of CA, ME, MA, MI, MN, MT, NV, NH, NY, PA, VT, WA, WI, and WY, and the provinces of Alta., B.C., Man., N.B., Nfld., N.S., Ont., Que., and Sask. Known distribution among the counties of neighboring states include: Pennsylvania- Centre, Clearfield, Schuylkill, and Warren.

Flight Season.--May 19 (New England) to Aug. 29 (VT). Known season in neighboring states are: Pennsylvania- June 1 to July 15.

Biology.--*Leucorrhinia glacialis* inhabits boggy lakes and ponds.

Adults typically alight upon shore line bushes at from 30-150 cm above ground.

Remarks.--The known southern limit of this species in eastern North America is 75 miles to the north of Virginia, indicating that this species may occur in the upland bog ponds of Virginia.

Leucorrhinia hudsonica (Selys)

Syn.: *hageni* Calvert

(Figures 175c, 177c, 179c)

Selys 1850. *Revue Odon.*, p. 53 (in *Libellula*).

Length 26-32 mm; abdomen 18-23 mm; hind wings 21-26 mm.

Diagnosis.--Labial palpi each black without lateral white spots; wings each with 1 cell row subtended by Mpl; fore wings each with 2 or 3 cell rows in trigonal interspace, and subtriangle 1-3-celled; hind wings each with 5-7 antenodal crossveins; posterior hamuli each with posterolateral process large and acute, and posteroventral process well developed; male abdominal segments 4-7 black with middorsal arrowhead-shaped red spots; female abdominal segments 4-7 black with middorsal arrowhead-shaped yellow spots; vulvar laminal lobes contiguous distally, ca. 1.1 times as long as wide at base; male cerci each with small subapical ventral angulation; male epiproct with lateral margins parallel.

Distribution.--Known from the states of AK, CA, ID, ME, MA, MI, MN, MT, NE, NH, NY, OR, PA, UT, VA, WA, WV, WI, and WY, and the provinces of Alta., B.C., Lab., Man., N.B., Nfld., NW. Terr., N.S., Ont., P.E.I., Que., Sask., and the Yukon. Known from the Virginia county of Highland.

Known distribution among the counties of neighboring states include: Pennsylvania- Centre, Clinton, Forest, Huntingdon, Monroe, Sullivan, and Warren; West Virginia- Pendleton and Tucker.

Virginia Records.--Highland Co.; Buck Run beaver pds., 10 June 1979, 2 males, 1 female (1 pair in tandem), BCK; Buck Run beaver pds., 18 June 1978, 11 males, 1 female (1 pair in tandem), FLC.

Flight Season.--May 7 (B.C.) to Aug. 30 (Lab.); in Virginia June 10 to 18. Known season in neighboring states are: Pennsylvania- May 16 to Aug. 15; West Virginia- June 29 to July 31.

Biology.--*Leucorrhinia hudsonica* inhabits the marshy borders of boggy ponds and lakes. Adults frequently alight upon emergent marsh vegetation near the water surface.

Remarks.--This species is very abundant in the bog ponds of Highland county, Virginia.

Leucorrhinia intacta (Hagen)

(Figures 176a, 178a, 180a)

Hagen 1861. Syn. Neur. N. Amer., p. 179 (in *Diplax*).

Length 28-36 mm; abdomen 18-25 mm; hind wings 22-28 mm.

Diagnosis.--Labial palpi each black with lateral white spots; wings each with 1 cell row subtended by Mpl; fore wings each with 2 or 3 cell rows in trigonal interspace, and subtriangle 1-3-celled; hind wings each with 5 or 6 antenodal crossveins; posterior hamuli each with posterolateral process blunt, and posteroventral process well developed; male abdominal segments 4-7 black with middorsal yellow spot on tergum 7;

female abdominal segments 4-7 black with middorsal arrowhead-shaped yellow spots; vulvar laminal lobes not contiguous, ca. 1.5 times as long as wide at base; male cerci each with distinct subapical ventral angulation; male epiproct with lateral margins strongly divergent.

Distribution.--Known from the states of CA, CO, CT, ID, IL, IN, IA, KY, ME, MA, MI, MN, MO, MT, NE, NV, NH, NJ, NY, ND, OH, OR, PA, RI, SD, TN, UT, VT, VA, WA, WV, WI, and WY, and the provinces of Alta., B.C., Man., N.B., N.S., Ont., P.E.I., Que., and Sask. Known from the Virginia counties of Alleghany, Augusta, Bath, Highland, and Montgomery. Known distribution among the counties of neighboring states include: Kentucky-Cumberland, McCreary, Pulaski, and Russell; Pennsylvania- Beaver, Berks, Blair, Butler, Centre, Clearfield, Clinton, Columbia, Crawford, Delaware, Elk, Erie, Fayette, Franklin, Fulton, Huntingdon, Juniata, Lawrence, Lebanon, Lehigh, Luzerne, McKean, Mercer, Monroe, Montgomery, Northampton, Perry, Philadelphia, Potter, Somerset, Sullivan, Susquehanna, Union, Venango, Warren, Wayne, and Westmoreland; Tennessee-Cheatham, Madison, and Sumner; West Virginia- Pendleton and Ohio.

Virginia Records.--Alleghany Co.; Potts Bog, 28 May 1977, 1 male, FLC. Augusta Co.; Shenandoah Pd., 13 June 1980, 1 male, FLC. Bath Co.; Beaver pd. along Rt. 600, 18 June 1978, 8 males, FLC. Highland Co.; Buck Run beaver pds., 18 June 1978, 2 males, FLC; Buck Run beaver pds., 1 July 1972, 2 males, OSF, USNM; Buck Run beaver pds., 3, 4 July 1971, 7 males, OSF, USNM. Montgomery Co.; Craig Cr. beaver pd. along Rt. 621, 17 May 1977, 1 male, R. Damon, VPI&SU; Pandapas Pd., 10 July 1974, 1 male, FLC, VPI&SU.

Flight Season.--Apr. 18 (NJ) to Aug. 26 (Ont.); in Virginia May 17 to

July 10. Known season in neighboring states are: Kentucky- May; Pennsylvania- Apr. 24 to Aug. 15; Tennessee- Aug. 18; West Virginia- June 29 to July 8.

Biology.--*Leucorrhinia intacta* inhabits ponds and marsh-bordered lakes. Adult males frequently alight upon the banks or low vegetation near shore.

Remarks.--This species is easily recognized by the dorsal yellow spot of abdominal segment 7 in the male; it is the most abundant *Leucorrhinia* in Virginia.

Leucorrhinia proxima Calvert

(Figures 176b, 178b, 180b)

Calvert 1890. Trans. Amer. Entomol. Soc. 17:38.

Length 31-36 mm; abdomen 22-25 mm; hind wings 23-29 mm.

Diagnosis.--Labial palpi each black with (occasionally without) lateral white spots; wings each with 1 cell row subtended by Mpl; fore wings each with 3 cell rows in trigonal interspace, and subtriangle 3-celled; hind wings each with 5 or 6 antenodal crossveins; posterior hamuli each with posterolateral process blunt, well developed, and posteroventral process vestigial; male abdominal segments 4-7 black with middorsal carinae red proximally; female abdominal segments 4-7 black with middorsal lance-and-arrowhead-shaped yellow spots; vulvar laminal lobes contiguous basally, ca. 0.5 times as long as wide at base; male cerci each without subapical ventral angulation; male epiproct with lateral margins parallel.

Distribution.—Known from the states of AK, CO, ID, ME, MA, MI, MN, MT, NH, NJ, NY, OR, PA, UT, VT, VA, WA, WI, and WY, and the provinces of Alta., B.C., Man., N.B., NW. Terr., N.S., Ont., Que., Sask., and the Yukon. Known from the Virginia county of Highland. Known distribution among the counties of neighboring state include: Pennsylvania- Luzerne.

Virginia Records.—Highland Co.; Small pd. nr. Rt. 250 E. of Monterey, 23 June 1978, 1 female, FLC.

Flight Season.—May 15 (B.C.) to Aug. 22 (B.C.); in Virginia June 23. Known season in neighboring states are: Pennsylvania- June 16 to 23.

Biology.—*Leucorrhinia proxima* inhabits bog ponds. Adults frequently alight upon shoreline bushes and upon emergent vegetation near shore.

Remarks.—The Virginia record for this species significantly extends its range southward. However, only one specimen is known from Virginia indicating that reproducing populations of this species may not exist in the state. The lone specimen possibly represents an immigrant from further north.

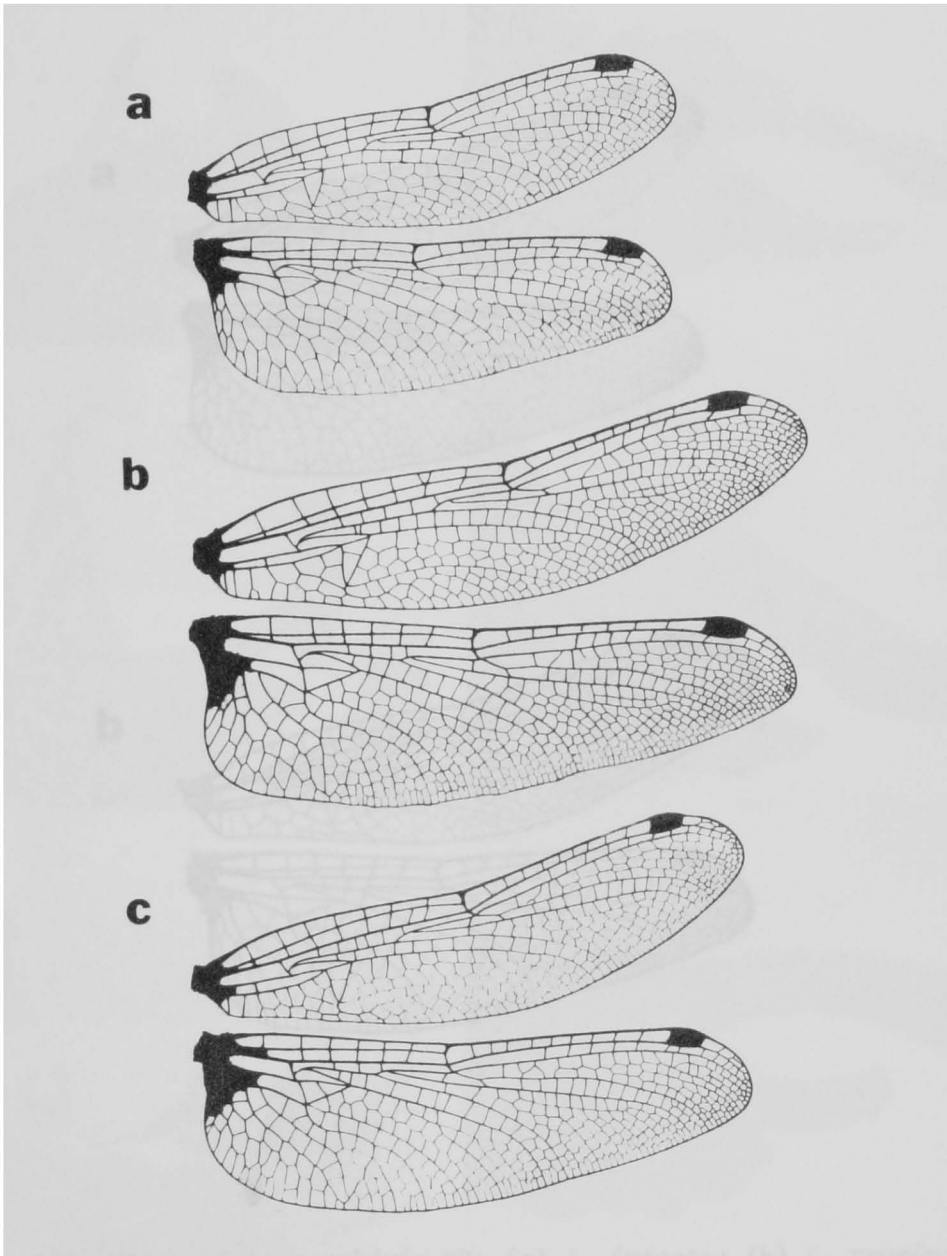


Figure 175. Wings of *Leucorrhinia* x3: (a) *L. frigida*; (b) *L. glacialis*; (c) *L. hudsonica*.

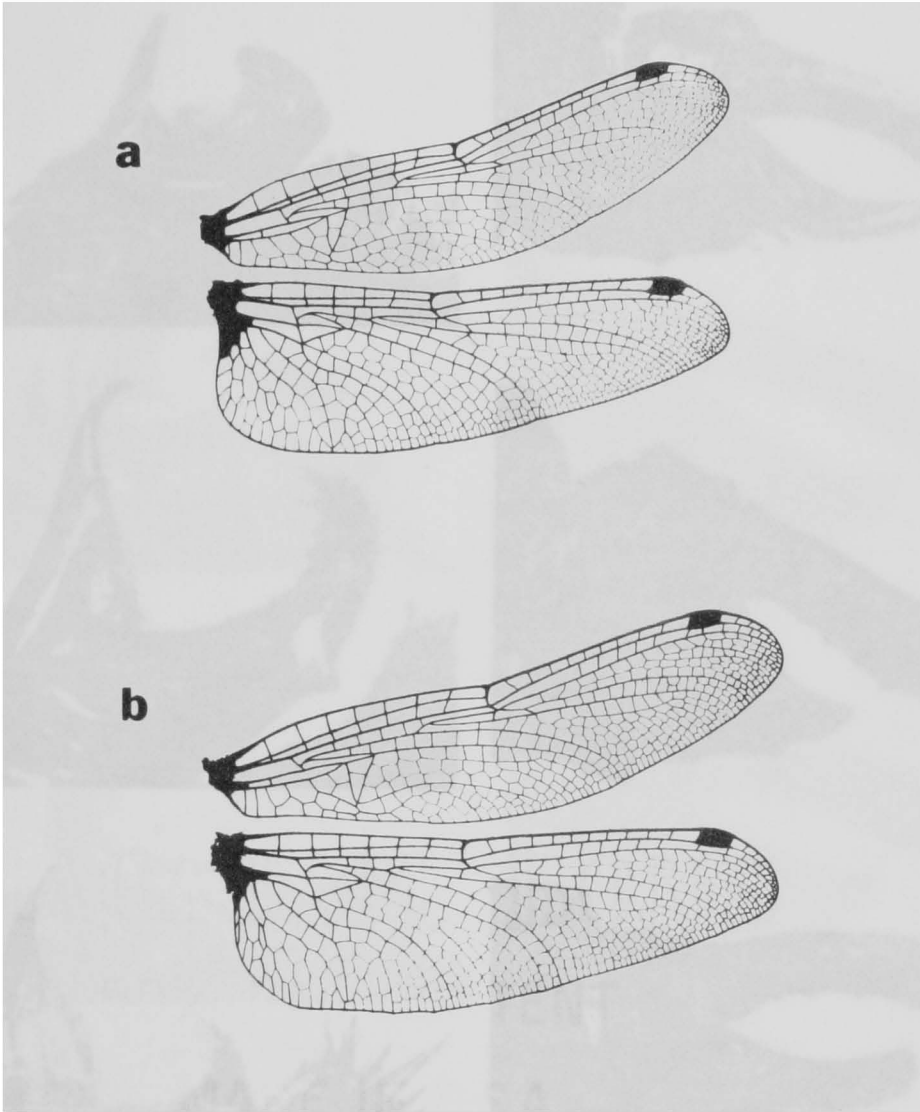


Figure 176. Wings of *Leucorrhinia* x3: (a) *L. intacta*; (b) *L. proxima*.

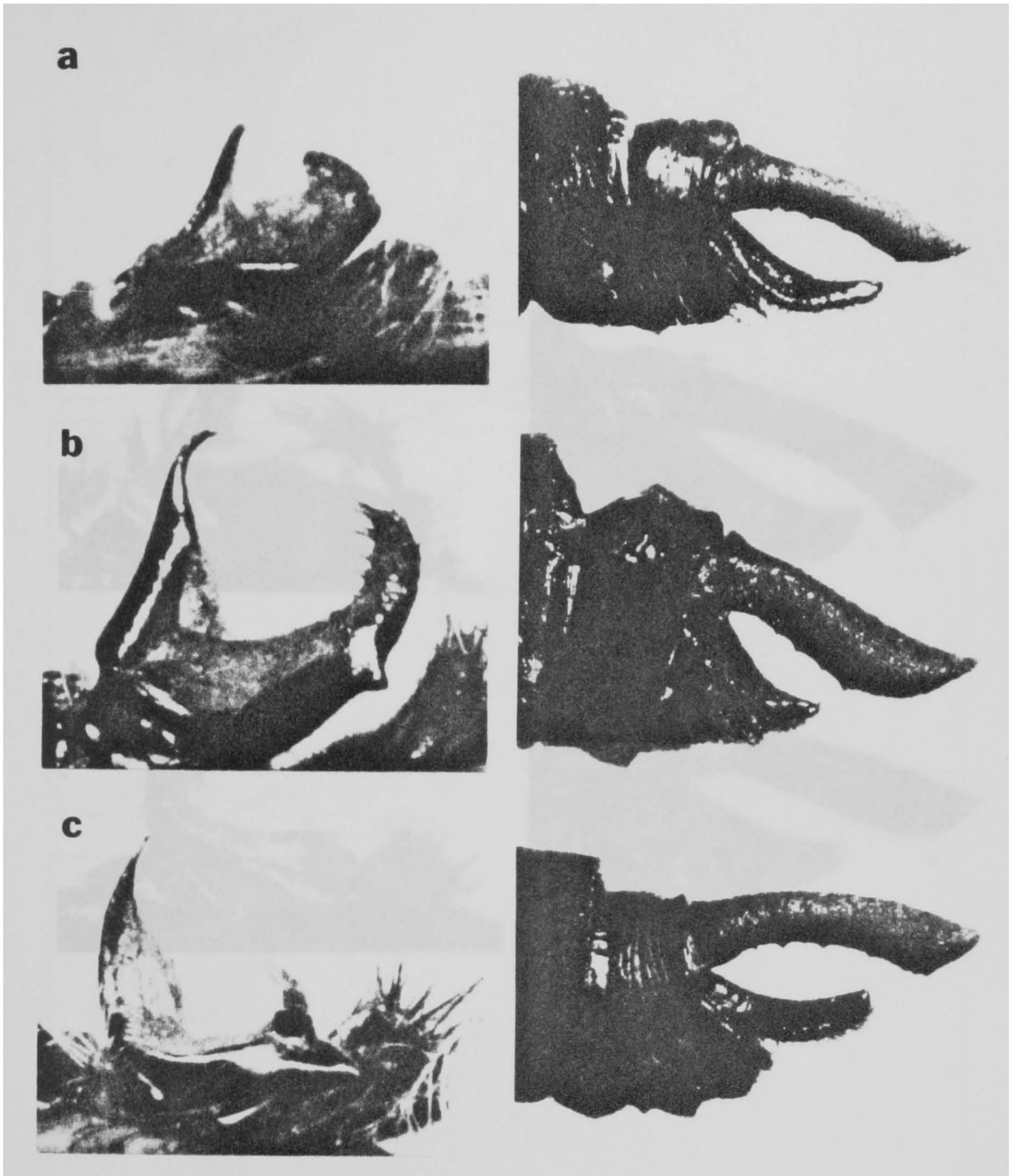


Figure 177. Posterior hamuli x50 and male terminalia x30 in lateral view of *Leucorhina*: (a) *L. frigida*; (b) *L. glacialis*; (c) *L. hudsonica*.

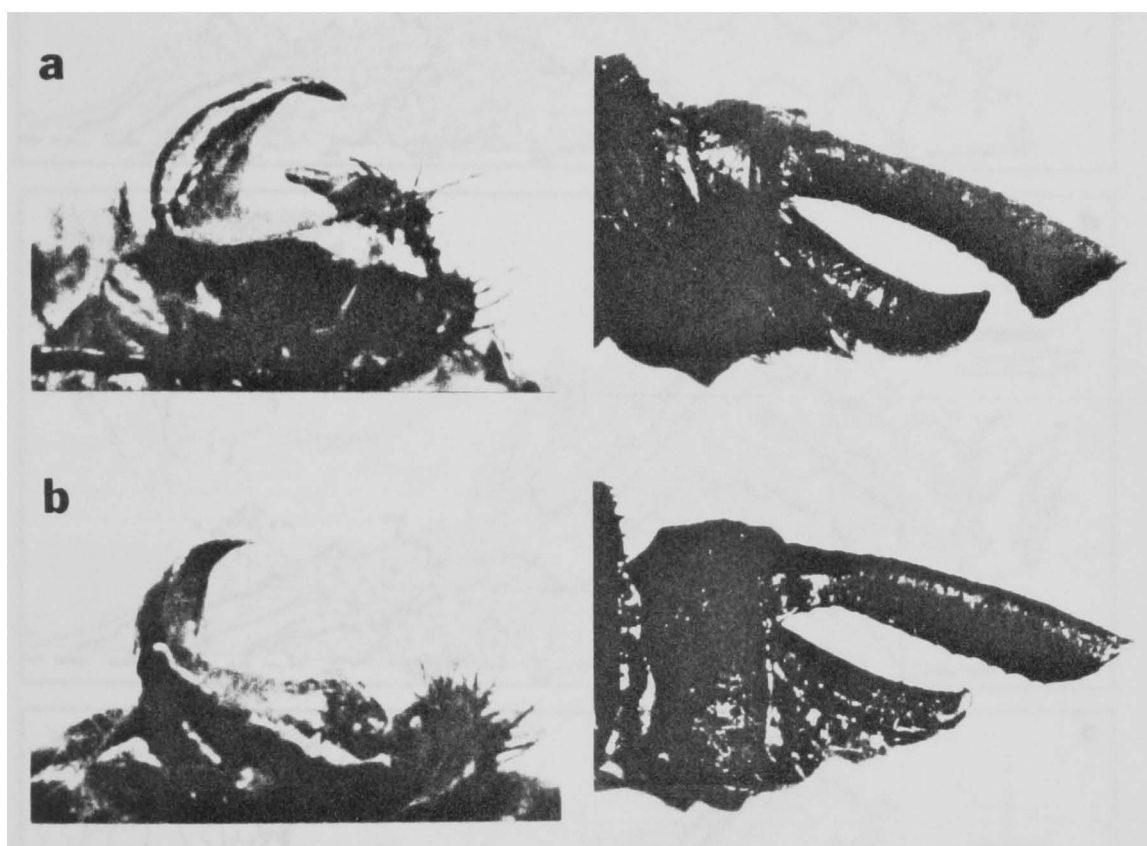


Figure 178. Posterior hamuli x50 and male terminalia x30 in lateral view of *Leucorrhinia*: (a) *L. intacta*; (b) *L. rosicima*.

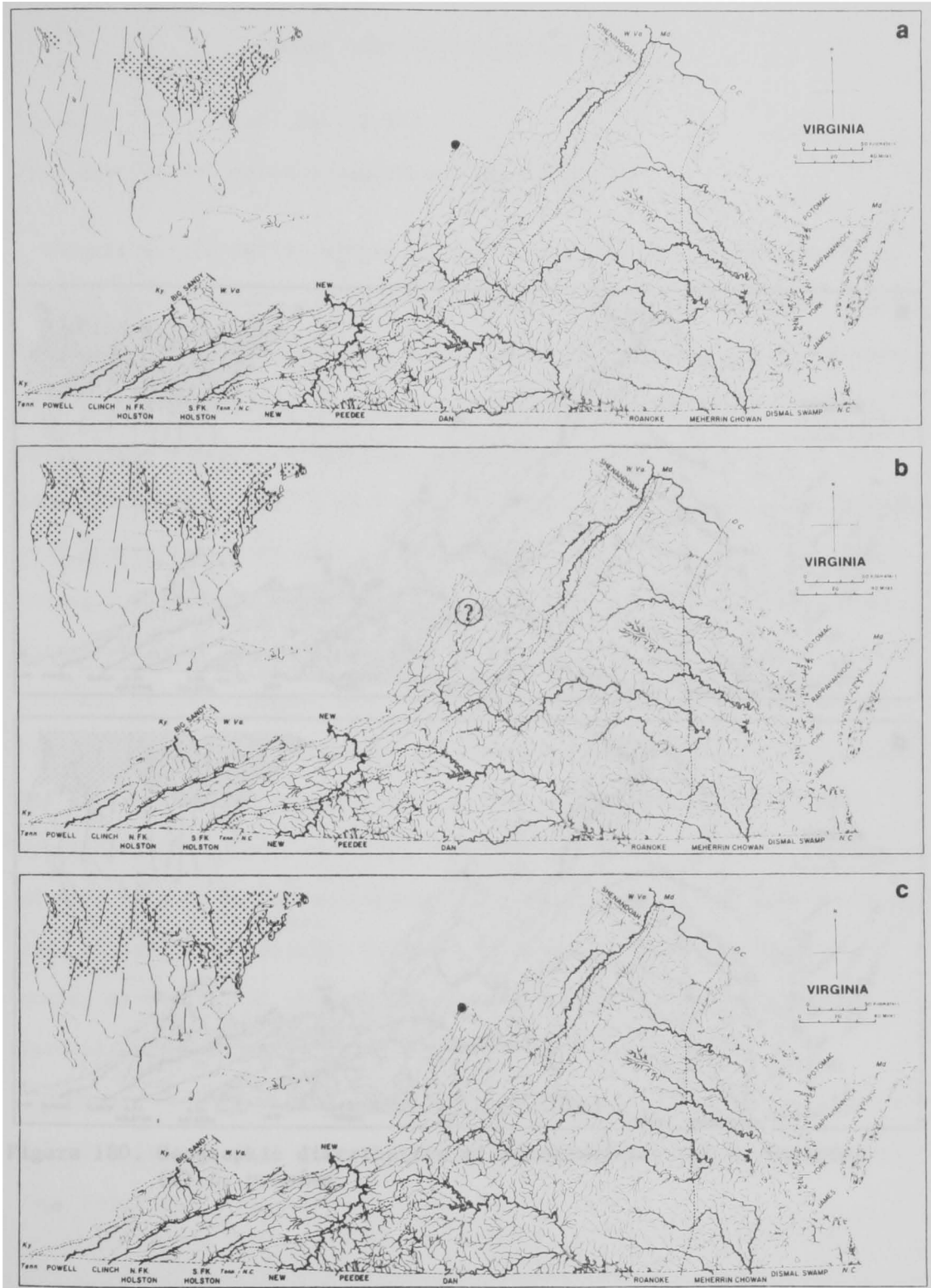


Figure 179. Geographic distribution of *Leucorrhinia*: (a) *L. frigida*; (b) *L. glacialis*; (c) *L. hudsonica*.

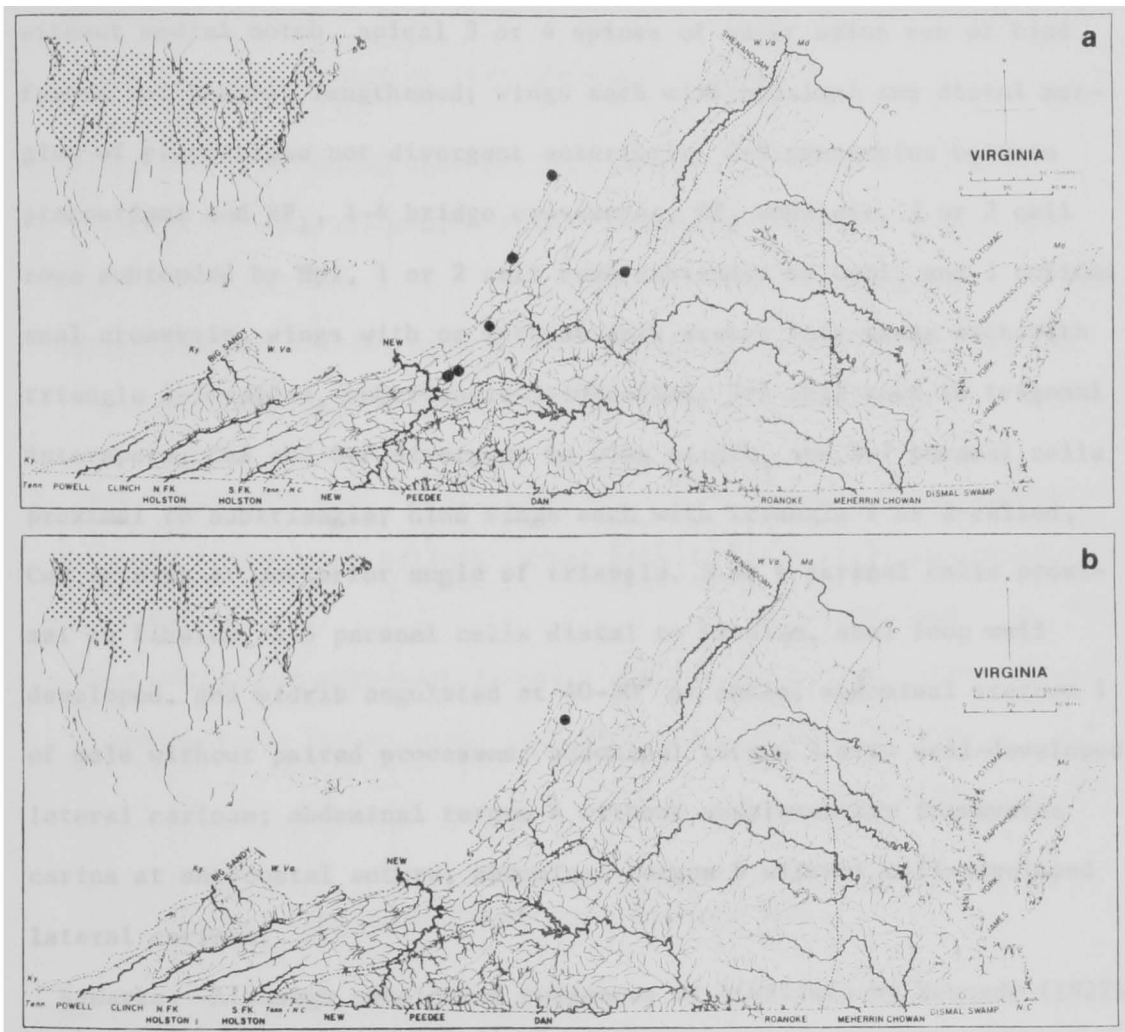


Figure 180. Geographic distribution of *Leucorrhinia*: (a) *L. intacta*; (b) *L. proxima*.

Genus *Libellula* Linnaeus 1758

Linnaeus 1758. Syst. Nat. 1:543.

Type Species.--*Libellula quadrimaculata* Linnaeus.

Diagnosis.--Posterior margin of pronotum directed posterodorsally without medial notch, apical 3 or 4 spines of outer spine row of hind femora not greatly lengthened; wings each with proximal and distal margins of pterostigma not divergent anteriorly, 2-5 crossveins between pterostigma and RP_1 , 1-4 bridge crossveins, RP_2 undulate, 2 or 3 cell rows subtended by Mpl , 1 or 2 cell rows subtended by $Cupl$, and 1 cubital anal crossvein; wings with or without dark areas; fore wings each with triangle 2-5-celled, subtriangle 3-10-celled, 3-5 cell rows in trigonal interspace, CuA and CuP divergent to wing margin, and 5-7 paranal cells proximal to subtriangle; hind wings each with triangle 1 or 2-celled, CuP arising at posterior angle of triangle, 3 or 4 paranal cells proximal to fibulum, 2-5 paranal cells distal to fibulum, anal loop well developed, and midrib angulated at 40-50° at ankle; abdominal sternum 1 of male without paired processes; abdominal tergum 3 with well-developed lateral carinae; abdominal tergum 4 without supplementary transverse carina at antecostal suture; abdominal tergum 9 without well-developed lateral carinae.

Remarks.--Although considered subgenera of *Libellula* by Kennedy (1922), *Belonia*, *Ladona*, *Plathemis*, and *Platetrum* apparently deserve the generic rank originally attributed to them.

Subgeneric Key to Adult *Libellula* of Virginia

1. Abdominal segment 2 with lateral carinae shorter than posteroventral carinae; cerci longer than abdominal segment 8
 *Libellula* p. 819
- Abdominal segment 2 with lateral carinae longer than posteroventral carinae; cerci shorter than abdominal segment 8 2
2. Wings each with nodal spot not extended posteriorly beyond RP;
 lateral penile lobes more than 10 times as long as wide at base .
 *Holotania* p. 774
- Wings each with nodal spot extended posteriorly beyond RP; lateral penile lobes less than 10 times as long as wide at base 3
3. Fore wings each with supertriangle and hind wings each with midbasal space transparent saffron; wings each with 1 or 2 bridge crossveins
 *Eolibellula* p. 767
- Fore wings each with supertriangle and hind wings each with midbasal space opaque brown; wings each with 3-6 bridge crossveins
 *Neotetrum* p. 823

Subgenus *Eolibellula* Kennedy 1922

Kennedy 1922. Entomol. News 33:111.

Type Species.--*Libellula semifasciata* Burmeister.

Diagnosis.--Wings each with nodal spots extended posteriorly beyond RP, midbasal space transparent saffron, 1 or 2 bridge crossveins, and

opaque white areas in male absent; fore wings each with supratriangle transparent saffron; hind wings each with triangle opaque brown; penile lateral lobes not extended distally beyond cornua, cornua bifurcate to base, lateral lobes ca. 5 times as long as wide at base; abdomen yellowish orange, segments 6 and 7 with posterodorsal black triangle, 8-10 with black dorsal band, color pattern not obscured by pruinosity in mature males, abdominal segment 2 with lateral carinae (not including anterior extension of transverse carinae) ca. 1.1 times length of posteroventral carinae; cerci shorter than abdominal segment 8.

Remarks.--The abdominal color pattern of *Eolibellula* is most similar to that of the European subgenus *Eurothemis*.

Libellula semifasciata Burmeister

Syn.: *hersilia* Blanchard, *maculata* Rambur, *ternaria* Say

(Figures 181, 182)

Burmeister 1839. Handb., p. 862.

Length 40-49 mm; abdomen 23-30 mm; hind wings 31-38 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AL, AR, CT, DE, DC, FL, GA, IL, IN, KY, LA, ME, MD, MA, MI, MS, NH, NJ, NY, NC, OH, PA, RI, SC, TN, TX, VA, WV, and WI, and the province of Ont. Known from the Virginia counties of Augusta, Charles City, Charlotte, Craig, Floyd, Henrico, Highland, James City, Montgomery, New Kent, Washington, and Westmoreland, and the cities of Chesapeake, Norfolk, Suffolk, and Virginia Beach. Known distribution among the counties of neighboring states include:

Kentucky- Breckinridge, Cumberland, Edmonson, Fayette, Green, Hardin, Hart, Jefferson, Marion, McCreary, Taylor, Trigg, and Warren; Maryland- Cecil, Prince Georges, and Talbot; North Carolina- Davie, Duplin, Edgecombe, Mitchell, Swain, and Wake; Pennsylvania- Allegheny, Beaver, Bucks, Centre, Clearfield, Clinton, Crawford, Delaware, Elk, Erie, Forest, Franklin, Huntingdon, Juniata, Luzerne, Mercer, Monroe, Montgomery, Northampton, Philadelphia, Potter, Somerset, Warren, Washington, Westmoreland, and York; Tennessee- Davidson, Fentress, Hawkins, and Knox; West Virginia- Pendleton, Preston, Ritchie, and Taylor.

Virginia Records.--Augusta Co.; Shenandoah Pd., 13 June 1980, 1 male, FLC; Shenandoah Pd., 17 July 1980, 1 male, BCK. Charles City Co.; Marl pit on Rt. 5, 19 Apr. 1938, 1 female, MED and D. T. R., (Det. MED, MDR notes); Marl pit on Rt. 5, 23 May 1938, 3 males, MED, (Det. MED, MDR notes); Marl pit on Rt. 5, 18 June 1938, 2 males, 1 female, W. M. D. and MED, VPI&SU; Marl pit on Rt. 5, 1 Aug. 1937, 1 male, D. W. Davis and MED, (Det. MED, MDR notes). Charlotte Co.; Twittys Cr. at Rt. 642, 14 June 1975, 1 male, FLC. Craig Co.; Johns Cr. at Rt. 311, 14 June 1974, 1 male, FLC. Floyd Co.; Little R. at Rt. 686, 10 June 1978, 1 male, FLC. Henrico Co.; nr. Richmond, 20 Sept. 1935, 2 males, 1 female, A. Walker, (Det. A. Walker), VSEC. Highland Co.; Bullpasture R. at head of gorge, 30 May 1977, 1 female, FLC. James City Co.; Rt. 5 W. of Five Forks, 10 May 1937, 1 male, MED, VPI&SU; Jamestown, 9 June 1938, 1 female, MED, VPI&SU; Rt. 5 W. of Five Forks, 13 June 1938, 1 female, MED, (Det. MED, MDR notes). Montgomery Co.; Craig Cr. beaver pd., 15 May 1979, 1 male, BCK; Craig Cr. beaver pd., 17 May 1977, 2 males, J. Schmidt, VPI&SU; Toms Cr. marsh 0.5 miles downstreams from Rt. 655,

24 May 1973, 1 male, 1 female (in tandem), FLC; locality unknown, 1 June 1901, 1 male, collector unknown, USNM; locality unknown, 8 June 1901, 1 female, collector unknown, USNM; locality unknown, 15 July 1907, 2 males, collector unknown, USNM. New Kent Co.; Plum Point, 30 Apr. 1970, observation, C. Shiffer. Washington Co.; Straight Branch beaver ponds below Beartree campground, 12 June 1979, 1 male, JRV and TJV, VPI&SU; Straight Branch beaver ponds, 19 Aug. 1979, 1 female, BCK. Westmoreland Co.; nr. Coles Point, 22 June 1917, 1 male, J. E. Benedict, (Det. MED), USNM; nr. Coles Point, 27 June 1917, 1 male, 1 female, J. E. Benedict, USNM. City of Chesapeake; locality unknown, 18 May 1969, 1 male, J. P. Akens, ODU. City of Norfolk; locality unknown, 7 July 1974, 1 female, J. Hancock, ODU. City of Suffolk; Dismal Swamp Wildlife Refuge, 25 Apr. 1970, 1 male, 1 female, JFM, ODU; Dismal Swamp Wildlife Refuge, 10 May 1937, 1 male, 2 females, CC, (Det. CC), CC Collection; Dismal Swamp Wildlife Refuge, 10 May 1970, 1 female, Donaldson, ODU; Dismal Swamp Wildlife Refuge, 11 May 1970, 1 female, J. C. Steere, ODU; Dismal Swamp Wildlife Refuge, 15 May 1974, 1 male, T. D. B., ODU; Jericho Lane in Dismal Swamp Wildlife Refuge, 22 June 1975, 1 male, 1 female, FLC; Dismal Swamp Wildlife Refuge, 19 Aug. 1974, 2 males, J. Hancock, ODU. City of Virginia Beach; Virginia Beach, May 1900, 1 female, C. L. Pollard and W. R. Maxon, (Det. C. L. Pollard and W. R. Maxon), USNM; Back Bay Refuge, 20 May 1975, 1 male, 1 female, J. O'Hop, ODU; White L. at Seaside State Park, 22 May 1977, 1 female, FLC; Back Bay Refuge, 25 May 1975, 1 female, J. O'Hop, ODU; Back Bay Refuge, 31 May 1975, 1 male, J. O'Hop, ODU; Fort Story, 2 June 1970, 2 males, JFM, ODU; North Landing, 14 Aug. 1948, 1 female, R. L. Hoffman, (Det. LKG).

Flight Season.--Apr. 1 (SC) to Oct. 6 (NC); in Virginia Apr. 19 to Sept. 20. Known season in neighboring states are: District of Columbia- May 28 to July 9; Kentucky- Apr. to July 26; Maryland- May 1 to Sept. 24; North Carolina- Apr. 19 to Oct. 6; Pennsylvania- Apr. 24 to Sept. 15; Tennessee- Apr. 30 to July 5; West Virginia- June 3 to July 21.

Biology.--*Libellula semifasciata* inhabits seepage pools and spring-fed marshes. Adult males perch on vegetation near the nymphal habitat at from 0.5-4 m above ground. Copulation occurs in flight and the males guard their mates during oviposition.

Remarks.--This species is among the earliest species of dragonfly to appear in the spring. Although the species is widespread it is rarely found in large numbers.

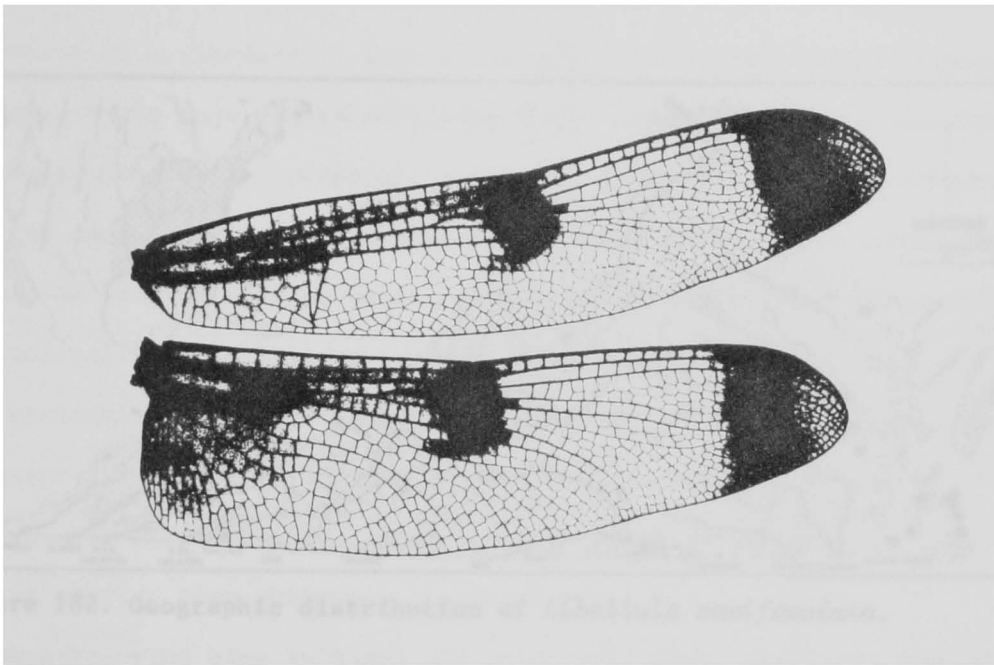


Figure 181. Wings of *libellula(Eolibellula) semi-fasciata* x3.

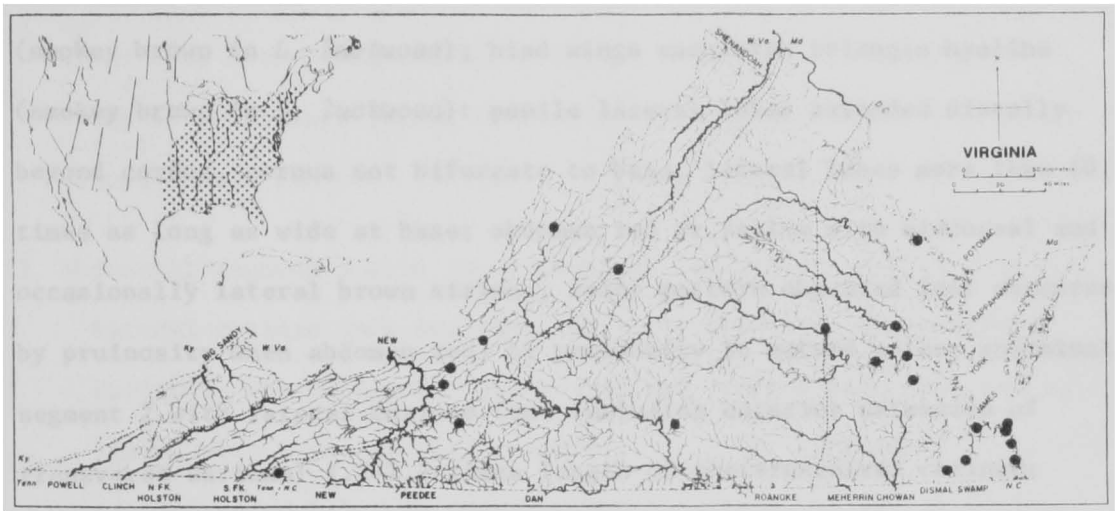


Figure 182. Geographic distribution of *Libellula semifasciata*.

Subgenus *Holotania* Kirby 1889

Kirby 1889. Syn. Cat. Neur., p. 261.

Type Species.--*Libellula axilena* Westwood.

Diagnosis.--Wings each with nodal spots not extended (often absent) posteriorly beyond RP, midbasal space hyaline (smokey brown in *L. luctuosa*), 2-7 bridge crossveins, and opaque white areas in male absent (present in *L. luctuosa*); fore wings each with supratriangle hyaline (smokey brown in *L. luctuosa*); hind wings each with triangle hyaline (smokey brown in *L. luctuosa*): penile lateral lobes extended distally beyond cornua, cornua not bifurcate to base, lateral lobes more than 10 times as long as wide at base; abdomen red or yellow with middorsal and occasionally lateral brown stripes, color pattern obscured (not obscured by pruinosity when abdomen red) by pruinosity in mature males; abdominal segment 2 with lateral carinae (not including anterior extension of transverse carinae) 1.2-2.2 times length of posteroventral carinae; cerci shorter than abdominal segment 8.

Remarks.--The wing markings and relatively short abdominal segments of *L. luctuosa* indicate an affinity with *Neotetrum*. However, the long lateral lobes of the penis indicate that *Holotania* represents a monophyletic group. For these and other reasons it is probable that *Holotania* and *Neotetrum* are more closely related to each other than to other subgenera of *Libellula*. The western *L. composita* also seems aberrant, but it too possesses the long lateral penile lobes.

Species Key to Adult Male *Libellula* (*Halotania*)
of Eastern North America

1. Wings each without basal opaque area 2
 Wings each with basal opaque area 4

2. Wings each with costa black distal to nodus; cerci, epiproct, and
 pterostigmata dark brown; penile segment 3 with ventral boot-
 shaped process *L. incesta* p. 791
 Wings each with costa not black distal to nodus; cerci, epiproct,
 and pterostigmata yellow to red; penile segment 3 without ventral
 boot-shaped process 3

3. Abdominal segment 3 with posteroventral carinae ca. 2/5 as long as
 lateral carinae (not including lateral extension of transverse
 carinae); penile segment 3 with ventral process hoodlike; anterior
 lamina with distinct medial cleft *L. auripennis* p. 779
 Abdominal segment 3 with posteroventral carinae ca. 1/2 as long as
 lateral carinae (not including lateral extension of transverse
 carinae); penile segment 3 with ventral process pyramidlike;
 anterior lamina without distinct medial cleft
 *L. needhami* p. 804

4. Hind wings each with basal 1/3 brown; abdominal segment 3 with medial carina ca. as long as posterolateral carinae; wings of mature individuals each with opaque white area beyond nodus *L. luctuosa* p. 796
- Hind wings each without basal 1/3 brown; abdominal segment 3 with medial carina longer than posterolateral carinae; wings of mature individuals each without opaque white area beyond nodus 5
5. Mesanepisterna each with anteroventral corner brown; abdominal segment 3 with posteroventral carinae ca. 1/2 length of medioventral carinae; apices of penile lateral lobes directed ventrally 6
- Mesanepisterna each with anteroventral corner white; abdominal segment 3 with posteroventral carinae less than 3/8 length of medioventral carinae; apices of penile lateral lobes directed dorsally 7
6. Wings each with more than apical 1/3 of pterostigma dark brown; hind wings each with pterostigma ca. 4 times as long as wide; penile lateral lobes threadlike, not widened distally *L. cyanea* p. 783
- Wings each with less than apical 1/3 of pterostigma dark brown; hind wings each with pterostigma ca. 6 times as long as wide; penile lateral lobes ladlelike, widened distally *L. flavida* p. 789

7. Face dark brown; dark area along metapleural sulci widened ventrad;
hind wings each with antenodal spot extended to fourth antenodal
crossvein; penile segment 3 without ventral process
. *L. acilena* p. 781
- Face white; dark area along metapleural sulci not widened ventrad;
hind wings each with antenodal spot not extended to fourth anteno-
dal crossvein; penile segment 3 with ventral process
. *L. vibrans* p. 808

Species Key to Adult Female *Libellula* (*Holotania*)
of Eastern North America

1. Hind wings each with basal 1/4 brown; lateral carinae of segment 8
not convex; abdominal segment 3 with mediodorsal carina shorter
than posterodorsal carinae *L. luctuosa* p. 796
- Hind wings each with basal 1/4 not brown; lateral carinae of segment
8 convex; abdominal segment 3 with mediodorsal carina longer than
posterodorsal carinae 2
2. Wings each with costa not black distal to nodus; wings each without
basal opaque areas 3
- Wings each with costa black distal to nodus; wings each with basal
opaque areas (except in some *L. incesta*) 4

3. Wings each with costa yellow or red proximal to nodus; mesanepisterna each with anteroventral corner brown; abdominal segment 3 with posteroventral carinae less than $2/5$ as long as lateral carinae (not including lateral extension of transverse carinae)
 *L. auripennis* p. 779
- Wings each with costa brown proximal to nodus; mesanepisterna each with anteroventral corner white; abdominal segment 3 with posteroventral carinae more than $2/5$ as long as lateral carinae (not including lateral extension of transverse carina)
 *L. needhami* p. 804
4. Mesanepisterna each with anteroventral corner brown; mesanepimeral and metanepisternal pale stripes not confluent ventrad; abdominal segment 3 with posteroventral carinae more than $1/2$ as long as medioventral carinae 5
- Mesanepisterna each with anteroventral corner white; mesanepimeral and metanepisternal pale stripes confluent ventrad; abdominal segment 3 with posteroventral carinae less than $1/2$ as long as medioventral carinae 6
5. Wings each with more than apical $1/3$ of pterostigma dark brown, and antenodal crossveins brown posterior to CP; hind wings each with pterostigma ca. 5 times as long as wide *L. cyanea* p. 783
- Wings each with less than apical $1/3$ of pterostigma dark brown, and antenodal crossveins yellow posterior to CP; hind wings each with pterostigma ca. 7 times as long as wide . . . *L. flavida* p. 789

6. Dorsal surface of vertex white, labrum and dorsal surface of frons mostly dark brown; dark area along metapleural sulci widened ventrad; hind wings each with antenodal spot extended to fourth antenodal crossvein *L. axilena* p. 781
- Dorsal surface of vertex not white, labrum and dorsal surface of frons not mostly dark brown; dark area along metapleural sulci not widened ventrad; hind wings each with antenodal spot not extended to fourth antenodal crossvein 7
7. Hind femora each with proximal 1/2 dark brown; mesanepimera and metanepisterna with brown extended ventrad of dorsolateral carinae; fore wings each with subtriangle generally 3 or 4-celled
 *L. incesta* p. 791
- Hind femora each with proximal 1/2 pale; mesanepimera and metanepisterna with brown not extended ventrad of dorsolateral carinae; fore wings each with subtriangle generally 5-7-celled
 *L. vibrans* p. 808

Libellula auripennis Burmeister

Syn.: *costalis* Rambur, *jesseana* Williamson

(Figures 183a, 187a)

Burmeister 1839. Handb., p. 861,

Length 49-58 mm; abdomen 33-40 mm; hind wings 35-43 mm.

Diagnosis.--Face of mature male red, face of mature female yellow; posteroventral corners of mesanepisterna not white; proximal half of

hind femora brown; wings each with basal opaque brown areas absent; opaque white areas in mature males absent, costa red or yellow between nodus and pterostigma, and pterostigma red or yellow; fore wings each with subtriangle 6-8-celled (generally 6-celled); hind wings each with 3 or 4 paranal cells proximal to fibulum (generally 3); penile segment 3 with ventral process hoodlike; lateral penile lobes with apices directed ventrally; abdominal segment 3 with posteroventral carinae ca. 0.36 in male and 0.38 in female as long as medioventral carinae; female with lateral carinae of segment 8 slightly convex; cerci red or yellow.

Distribution.--Known from the states of AL, AR, CT, DC, FL, GA, KY, LA, MD, MA, MS, MO, NJ, NY, NC, OH, OK, PA, RI, SC, TN, TX, and VA, and from Tamaulipas, Mexico. Known from the Virginia counties of Arlington and Westmoreland, and the cities of Norfolk, Suffolk, and Virginia Beach. Known distribution among the counties of neighboring states include: Kentucky- Fulton; Maryland- Calvert; Pennsylvania- Bucks, Centre, and York; North Carolina- Craven, Dare, Franklin, Henderson, Lee, Macon, New Hanover, Pamlico, Richmond, Transylvania, and Wake; Tennessee- Davidson, Grundy, and Marion.

Virginia Records.--Arlington Co.; locality unknown, 8 June 1914, 1 male, A. W. J. Pomeroy, USNM. Westmoreland Co.; nr. Coles Point, 23 June 1917, 2 males, 1 female, J. E. Benedict, USNM; nr. Coles Point, 24 June 1917, 1 male, 1 female, J. E. Benedict, USNM; nr. Coles Point, 25 June 1917, 5 males, 1 female, J. E. Benedict, USNM; nr. Coles Point, 27 June 1917, 2 males, 1 female, J. E. Benedict, USNM; nr. Coles Point, 4 Aug. 1917, 1 male, 1 female, J. E. Benedict, USNM. City of Chesapeake; Ditch nr. Fentress, 19 June 1975, 2 males, FLC. City of Norfolk; Airport,

25 May 1970, 1 female, JFM, ODU. City of Suffolk; Dismal Swamp Wildlife Refuge, 29 June 1957, 1 male, W. H. Cross, FSCA. City of Virginia Beach; locality unknown, 10 Aug. 1973, 1 male, P. W. Larkins, VPI&SU.

Flight Season.--Feb. 23 (FL) to Oct. 8 (SC); in Virginia May 25 to Aug. 10. Known season in neighboring states are: District of Columbia-- Aug. 1; Kentucky-- June; Maryland-- July 23; Pennsylvania-- June 16 to July 23; North Carolina-- May to Sept. 24; Tennessee-- June 6 to Aug. 16.

Biology.--*Libellula auripennis* inhabits ponds. Adult males perch near shore at from 0.3-2 m above the ground.

Remarks.--The bright red abdomen and wing venation of the males makes this species very conspicuous in life. This species is not common in Virginia.

Libellula axilena Westwood

Syn.: *leda* Say

(Figures 183b, 187b)

Westwood 1837. Ill. Exot. Ins. 2:96.

Length 51-63 mm; abdomen 34-43 mm; hind wings 39-48 mm.

Diagnosis.--Face of mature male dark brown, face of mature female brown; posteroventral corners of mesanepisterna white; proximal half of hind femora dark brown; wings each with basal opaque brown areas present, opaque white areas in mature males absent, costa black between nodus and pterostigma, and pterostigma dark brown; fore wings each with subtriangle 5-7-celled (generally 5-celled); hind wings each with 3 or 4 paranal cells proximal to fibulum (generally 3); penile segment 3 with

ventral process low-pyramidal; lateral penile lobes with apices directed dorsally; abdominal segment 3 with posteroventral carinae ca. 0.30 in male and 0.37 in female as long as medioventral carinae; female with lateral carinae of segment 8 convex; cerci brown.

Distribution.--Known from the states of AL, FL, GA, KY, LA, MS, NJ, NY, NC, OK(?), PA, SC, and VA. Known from the Virginia counties of Charles City, Chesterfield, Essex, James City, Montgomery, Prince Edward, and Princess Anne, and the cities of Newport News, Norfolk, Suffolk, and Virginia Beach. Known distribution among the counties of neighboring states include: Kentucky- Breckinridge, Bullitt, Edmonson, Green, Hart, McCreary, Ohio, and Union; North Carolina- Bladen, Carteret, Chowan, Currituck, Dare, Durham, Hoke, Jones, New Hanover, Scotland, Tyrrell, Wake, and Washington; Pennsylvania- Centre.

Virginia Records.--Charles City Co.; Marl pit on Rt. 5, 23 May 1938, 1 male, MED, VPI&SU; Marl pit on Rt. 5, 3 Aug. 1938, observation, MED, (MDR notes). James City Co.; Laurel Hill Cr., 5 July 1938, 1 female, MED, VPI&SU. Essex Co.; Dunbrooke, 29 July 1899, 2 males, RPC, USNM. Montgomery Co.; Prices Forks, 13 July 1975, 1 female, M. Parrella, VPI&SU. City of Newport News; locality unknown, 10 June 1977, 1 male, R. Dunkum, VPI&SU. City of Norfolk; locality unknown, 13 May 1970, 1 female, H. Rilley, ODU. City of Petersburg; locality unknown, 26 July 1970, 1 male, D. A. Williams, VCU. City of Suffolk; Jericho Lane in Dismal Swamp Wildlife Refuge, 1 June 1970, 1 male, JFM, ODU; Jericho Lane in Dismal Swamp Wildlife Refuge, 22 June 1975, 4 males, 2 females, FLC; Dismal Swamp Wildlife Refuge, 29 June 1956, 1 male, W. H. Cross, FSCA; Dismal Swamp Wildlife Refuge, 19 Aug. 1974, 2 males, J. Hancock,

ODU. City of Virginia Beach; locality unknown, 18 May 1965, 1 female, collector unknown, ODU; Back Bay Refuge, 31 May 1975, 1 male, J. O'Hop, ODU; Back Bay Refuge, 8 June 1975, 2 males, J. O'Hop, ODU; Seashore State Park, 26 June 1971, 1 female, collector unknown, VPI&SU; Sand Bridge Beach, 30 June 1957, 1 male, W. H. Cross, FSCA; locality unknown, 1 Aug. 1928, 1 female, collector unknown, (Det. MED), U. of Wisconsin.

Flight Season.--Mar. 26 (FL) to Oct. 15 (NC); in Virginia May 13 to Aug. 19. Known season in neighboring states are: Kentucky- June 26 to Aug. 25; North Carolina- May 9 to Oct. 15; Pennsylvania- June 16 to 23.

Biology.--*Libellula axilena* inhabits seepage pools and marsh-bordered ponds. Adult males perch at from 0.5-3 m above water from which they are quick to fly if disturbed.

Remarks.--This species is easily distinguished by the postnodal spots and starlike lateral pale area of the thorax. *Libellula axilena* is perhaps the most wary species of the genus. Although widespread it is local in occurrence.

Libellula cyanea Fabricius

Syn.: *bistigma* Uhler, *quadrupla* Say

(Figures 184a, 187a)

Fabricius 1775. Syst. Entomol., p. 424.

Length 38-47 mm; abdomen 25-32 mm; hind wings 32-37 mm.

Diagnosis.--Face of mature male dark brown, anteclypeus pale, face of mature female light brown, anteclypeus pale; posteroventral corners of mesanepisterna not white; proximal half of hind femora dark brown; wings

each with basal opaque brown areas present, opaque white areas in mature males absent, costa black between nodus and pterostigma, and pterostigma bicolored, proximal 3/5 white, distal 2/5 dark brown; fore wings each with subtriangle 3-7-celled (generally 3-celled); hind wings each with 3 or 4 paranal cells proximal to fibulum (generally 3); penile segment 3 with ventral process low-pyramidal; lateral penile lobes with apices directed anteroventrally; abdominal segment 3 with posteroventral carinae ca. 0.50 in male 0.57 in female as long as medioventral carinae; female with lateral carinae of segment 8 convex; cerci brown.

Distribution.--Known from the states of AL, AR, CT, DC, DE, FL, GA, IL, IN, KS, KY, LA, ME, MD, MA, MI, MS, MO, NH, NJ, NY, NC, OH, OK, PA, SC, TN, TX, VT, VA, and WV. Known from the Virginia counties of Albemarle, Alleghany, Arlington, Augusta, Bath, Bedford, Charles City, Charlotte, Chesterfield, Craig, Cumberland, Essex, Fairfax, Fauquier, Goochland, Hanover, Henrico, Highland, Isle of Wight, James City, King William, Lee, Louisa, Mecklenburg, Montgomery, New Kent, Patrick, Pittsylvania, Powhatan, Spotsylvania, Washington, and Westmoreland, and the cities of Hampton, Norfolk, Richmond, Suffolk, and Virginia Beach. Known distribution among the counties of neighboring states include: Kentucky-- Allen, Barren, Bell, Breckinridge, Bullitt, Butler, Carter, Casey, Edmonson, Fayette, Fulton, Green, Hardin, Harrison, Hart, Henderson, Jefferson, Marion, McCreary, Meade, Metcalfe, Ohio, Pike, Pulaski, Russell, Taylor, Todd, Trigg, Union, Warren, and Wayne; Maryland-- Charles, Montgomery, Prince Georges, and Worcester; North Carolina-- Alamance, Bertie, Chowan, Cumberland, Davidson, Davie, Elmwood, Guilford, Halifax, Harnett, Hoke, Johnston, Lenoir, McDowell, Mecklenburg,

Orange, Rowan, Stanly, Wake, Washington, and Wayne; Pennsylvania- Berks, Bucks, Centre, Chester, Columbia, Delaware, Fayette, Franklin, Fulton, Huntingdon, Juniata, Lebanon, Luzerne, Monroe, Montgomery, Northampton, Perry, Philadelphia, Union, Wayne, and York; Tennessee- Anderson, Blount, Campbell, Claiborne, Cumberland, Hamblen, Hawkins, Johnson, Sevier, Sullivan, and Unicoi; West Virginia- Doddridge, Hampshire, Mason, Pendleton, Raleigh, Ritchie, and Taylor.

Virginia Records.--Albemarle Co.; nr. Charlottesville, 1 June 1948, 1 male, R. L. Hoffman, (Det. LKG). Alleghany Co.; Griffith, 21 June 1953, 2 males, R. L. Hoffman, (Det. LKG); Griffith, 11 July 1951, 1 female, R. L. Hoffman, (Det. LKG); Griffith, 29 July 1951, 1 male, R. L. Hoffman, VPI&SU. Arlington Co.; locality unknown, 8 June 1914, 1 female, A. W. J. Pomeroy, USNM; Arlington, "June 15 to July 27", (Donnelly 1961). Augusta Co.; Shenandoah Pd., 13 June 1980, 1 male (teneral), 1 female, FLC. Bath Co.; Beaver pd. along Rt. 600, 18 June 1978, 1 male, 1 female, FLC. Bedford Co.; 8 miles W. of Lynchburg, 20 June 1948, 1 male, R. L. Hoffman, (Det. LKG); 8 miles W. of Lynchburg, 28 June 1948, 1 male, R. L. Hoffman, (Det. LKG). Charles City Co.; Marl pit on Rt. 5, 23 May 1938, 1 male, MED, VPI&SU; Harrison Lk. below dam, 28 May 1967, 1 male, 3 females, MDR, VPI&SU; Harrison Lk., 3 June 1967, 2 males, 3 females, MDR, VPI&SU; Harrison Lk., 9 June 1967, 1 female, MDR. VPI&SU; Fish Hatchery, 22 June 1976, 1 male, L. Westermann, VCU; U.S. Fish Hatchery, 22 June 1976, 1 male, G. Brown, P. Thomas Collection; Berkeley Mills, 5 July 1938, 1 male, MED, VPI&SU. Charlotte Co.; Twittys Cr. at Rt. 642, 23 May 1977, 1 male, FLC; Twittys Cr. 1 mile upstream from Drakes Br., 23 May 1977, 4 males, 1 female (teneral), FLC; Twittys Cr.

dam, 18 June 1975, 1 female, FLC; 1.5 miles N.W. of Keysville, 10 July 1938, 2 males, 1 female, J. T. Baldwin, VPI&SU; Twittys Cr. at Rt. 642, 12 July 1974, 1 male, 1 female, FLC; swamp, 16 July 1970, 1 female, R. H. Perry, VPI&SU; Twittys Cr. at Rt. 642, 22 July 1978, 1 female, FLC; 1 mile W. of Keysville, 21 Aug. 1938, 1 male, J. T. Baldwin, VPI&SU: 1 mile W. of Keysville, 21 Aug. 1938, 1 male, J. T. Baldwin, (Det. MED, MDR notes); 1.5 miles N.W. of Keysville, 24 Aug. 1938, 2 males, J. T. Baldwin, VPI&SU. Chesterfield Co.; Pocahontas State Park, 19 June 1974, 1 male, G. Catron, VCU; Pocahontas State Park, 20 June 1974, 1 male, D. H. Beals, VCU; Pocahontas State Park, 20 June 1974, 2 males, 1 female, W. C. Rothery, VCU; locality unknown, 20 June 1975, 1 male, 1 female, R. H. Nugent, VCU; Pocahontas State Park, 20 July 1973, 1 male, K. Beck, VCU. Craig Co.; Johns Cr. at Rt. 311, 14 June 1974, 1 male, FLC; Craig Cr. at Rts. 621 and 651, 17 June 1978, 1 male, FLC; Johns Cr., 28 June 1975, 1 male, SWB, VPI&SU; marshy area at Rts. 311 and 611, 28 June 1979, 1 male, SWB, VPI&SU. Cumberland Co.; Bear Cr. Lk., 23 May 1977, 1 male (teneral), FLC. Essex Co.; Dunbrooke, 29 July 1899, 1 male, RPC, USNM. Fairfax Co.; pond behind Mallory House at George Mason U., 5 May 1973, 1 male, C. R. Parker, VPI&SU; Great Falls, "May 15 to July 27", (Donnelly 1961); Great Falls, 17 June 1914, 1 male, RPC, USNM; Great Falls, 4 July 1899, 4 males, G. N. Collins and W. R. Maxon, USNM; Great Falls, 10 July 1914, 2 males, RPC, USNM; Great Falls, 12 July 1905, 1 male, 1 female, D. H. Clemons, USNM; Great Falls, 23 July 1914, 2 males, 1 female, BPC, H. L. Nichols, and V. A. Roberts, USNM; Great Falls, 27 July 1907, 1 male, RPC, USNM. Fauquier Co.; Broad Run at Thorofare Gap, 15 July 1974, 1 male, OSF, USNM. Goochland Co.; Rt. 6

3 miles N. of Goochland, 27 July 1979, 2 males, BCK. Hanover Co.; N. Anna R. falls, 22 June 1977, 2 males, BCK; N. Anna R. falls, 6 July 1977, 1 male, BCK; Little R. at Rt. 1, 7 July 1978, 1 male, FLC; N. Anna R. 1 mile E. of Rt. 1, 2 Aug. 1978, 1 male, 1 female, BCK. Henrico Co.; Bailey Cr. at Curles Neck Farm, 3 June 1967, 1 female, MDR, VPI&SU; Rosmussen's Pd., 8 June 1967, 1 male, MDR, VPI&SU. Highland Co.; Buck Run beaver pds., 10 June 1979, 1 female, BCK; Buck Run beaver pds., 8 Aug. 1978, 1 male, FLC. Isle of Wight Co.; locality unknown, 1 June 1975, 4 females, JFM and J. Hancock, ODU. James City Co.; Lily Pd. on Rt. 612, 4 June 1967, 1 male, 1 female, MDR, VPI&SU; Richardsons Mill Pd., 5 June 1967, 1 female, MDR, VPI&SU; Dozier's Pd. nr. Toano, 6 June 1967, 1 female, MDR, VPI&SU; Jamestown, 9 June 1938, 1 female, MED, VPI&SU; Rt. 5 1.5 miles W. of Five Forks, 13 June 1938, 1 female, MED, VPI&SU; Williamsburg, 1 July 1937, 1 female, CC, (Det. CC); Jamestown Island, 4 July 1937, 3 males, CC, (Det. CC); Williamsburg, 23 July 1937, 2 females, MED, VPI&SU; Riverview at Norge, Sept. 1932, 3 nymphs, MED, (Det. MED), CUC. King William Co.; locality unknown, 9 June 1975, 1 male, J. O'Hop, ODU. Lee Co.; Keokee Lk., 3 July 1977, 4 males, 4 females, FLC. Louisa Co.; N. Anna Holiday Pd., 19 Aug. 1970, 1 male, G. Simmons, VCU; Mecklenburg Co.; Farm pd. at Rt. 697, 1 June 1980, 1 male, BCK. Montgomery Co.; Pandapas Pd., 14 June 1974, 1 male, FLC; Blacksburg, 25 June 1960, 1 male, R. R. Mills, VCU; Hickory Hill on Brush Mtn., 9 July 1978, 2 males, P. J. Sieburth, VPI&SU; Pandapas Pd., 10 July 1973, 1 female, FLC; Pandapas Pd., 28 July 1973, 2 males, 1 female, FLC; Heath Pd. off Rt. 685 nr. Blacksburg, 1 Aug. 1977, 1 male, 1 female, FLC; Pandapas Pd., 15 Aug. 1978, 1 male, FLC. New Kent Co.; Plum Point,

30 Apr. 1970, observation, C. Shiffer; Old Forge Pd. at Rt. 60, 8 June 1967, 1 male, 1 female, MDR, VPI&SU; Woodhaven Shores, 8 June 1967, 1 female, MDR, VPI&SU. Patrick Co.; Seepage area along Rock Castle Cr. at Rt. 605, 11 June 1978, 1 male, 2 females (teneral), FLC. Pittsylvania Co.; Johnson Farm pond at Renan, 21 June 1980, 1 male, FLC; Sandy R. at Hinesville, 25 Aug. 1975, 1 male, FLC. Powhatan Co.; locality unknown, 27 June 1975, 1 female, R. Kelly, VCU; locality unknown, 27 June 1975, 1 male, 1 female, M. Zimmermann, VCU. Spotsylvania Co.; nr. Fredericksburg, date unknown, 1 female, W. D. Richardson, (Det. P. P. Calvert, Calvert 1890); small tributary of Matta R. at Rt. 617, 29 May 1978, 1 male (teneral), FLC; Beaver dam off Rt. 617, 7 July 1978, 1 female, FLC. Washington Co.; Straight Br. beaver pds. below Beartree campground, 28 July 1979, 1 male, JRV and TJV, VPI&SU. Westmoreland Co.; nr. Coles Point, 23 June 1917, 1 male, J. E. Benedict, USNM. City of Hampton; Newmarket Cr. at Bellwood Rd., 11 May 1979, 1 male, D. Moses, VPI&SU. City of Norfolk; locality unknown, 12 June 1962, 1 female, C. V. Covell, VPI&SU; locality unknown, 7 July 1974, 1 male, J. Hancock, ODU. City of Richmond; Maymount Park, 3 July 1968, 1 male, M. Rauscher, VCU. City of Suffolk; Washington Ditch in Dismal Swamp Wildlife Refuge, 16 May 1978, 1 male, JFM, ODU; Jericho Lane in Dismal Swamp Wildlife Refuge, 22 June 1975, 1 female, FLC; Dismal Swamp Wildlife Refuge, 2 July 1973, 1 male, JFM, ODU. City of Virginia Beach; locality unknown, 20 June 1974, 1 male, E. F. Fox, VCU; locality unknown, 3 Sept. 1973, 1 male, J. Bunch, ODU.

Flight Season.--Jan. 28 (NC) to Sept. 15 (PA); in Virginia Apr. 30 to Sept. 3. Known season in neighboring states are: District of Columbia-

July 4 to 8; Kentucky- May 3 to Sept.; Maryland- June 6 to July 14;
 North Carolina- Jan. 28 to July 26; Pennsylvania- May 24 to Sept. 15;
 Tennessee- June 6 to Aug. 9; West Virginia- June 13 to Aug. 13.

Biology.--*Libellula cyanea* inhabits marshes, ponds, and marsh-bordered lakes. Adult males perch on shoreline vegetation generally at from 20-120 cm above ground. Copulation occurs in flight and the males guard their mates during oviposition.

Remarks.--This species is easily distinguished by the bicolored pterostigma.

Libellula flavida Rambur

Syn.: *plumbea* Uhler

(Figures 184b, 188a)

Rambur 1842. Ins. Neur., p. 58.

Length 42-51 mm; abdomen 27-34 mm; hind wings 34-40 mm.

Diagnosis.--Face of mature male dark brown, face of mature female brown; posteroventral corners of mesanepisterna not white; proximal half of hind femora brown in male, light brown in female; wings each with basal opaque brown areas present, opaque white areas in mature males absent, costa black between nodus and pterostigma, and pterostigma orange often with anterior and distal brown areas; fore wings each with subtriangle 3-7-celled (generally 5 or 6-celled); hind wings each with 3 or 4 paranal cells proximal to fibulum (generally 3); penile segment 3 with ventral process low-pyramidal; lateral penile lobes with apices directed ventrally; abdominal segment 3 with posteroventral carinae ca.

0.51 in male and 0.54 in female as long as medioventral carinae; female with lateral carinae of segment 8 convex; cerci brown.

Distribution.--Known from the states of AL, AR, DC, FL, GA, KY, LA, MD, MA, MS, MO, NB, NJ, NY, NC, OK, PA, SC, TN, TX, and VA. Known from the Virginia counties of Alleghany, Bedford, Culpeper, Essex, Goochland, Patrick, and Prince William, and the cities of Richmond and Suffolk.

Known distribution among the counties of neighboring states include: Kentucky- Whitley; Maryland- Montgomery and Prince Georges; North Carolina- Bladen, Chatham, Durham, Halifax, Harnett, Henderson, Hoke, Pender, Transylvania, Wake, Wayne, and Wilkes; Pennsylvania- Dauphin and Delaware; Tennessee- Blount, Coffee, Fentress, Johnson, Knox, and Sevier.

Virginia Records.--Alleghany Co.; Jordan Mines, 20 July 1951, 1 male, R. L. Hoffman, (Det. LKG). Bedford Co.; Peaks of Otter, 16 June, 1 male, W. Palmer, (Det. MED), USNM. Culpeper Co.; Hazel R., 5 June 1980, 1 male, P. Firth, BCK Collection. Essex Co.; Dunbrooke, 28 July 1899, 1 male, RPC, USNM; Rt. 17, 7 Aug. 1978, 1 female, Mr. Caret, VPI&SU. Frederick Co.; nr. Winchester, 28 June 1936, 2 females, collector unknown, VPI&SU; nr. Winchester, 1 July 1936, 2 males, collector unknown, VPI&SU. Goochland Co.; Rt. 676, 24 July 1970, 1 female, JRV, VPI&SU. Patrick Co.; Seepage area along Rock Castle Cr. at Rt. 605, 11 June 1978, 1 male (slightly teneral), FLC. Prince William Co.; 15 July 1974, 1 male, OSF and C. M. Flint, USNM. City of Richmond; locality unknown, date unknown, 1 female, collector unknown, VPI&SU. City of Suffolk; junction of Rts. 58 and 460 N. of Holiday Inn, 22 May 1978, 1 male, A. Beck, FLC Collection; Dismal Swamp Wildlife Refuge, 29 June 1957, 1 male,

W. H. Cross, FSCA; Holland, 1 July 1975, 1 female, J. W. Jenkins, VPI&SU.

Flight Season.--Mar. 16 (MS) to Sept. 28 (GA); in Virginia May 22 to Aug. 7. Known season in neighboring states are: District of Columbia- May 24 to July 16; Kentucky- June; Maryland- June 6 to Aug. 25; North Carolina- May 25 to Sept. 13; Pennsylvania- May 16 to July 23; Tennessee- June 17 to Aug. 5.

Biology.--*Libellula flavida* inhabits seepage pools and marsh-bordered spring-fed ponds. Adult males perch near the nymphal habitat at from 0.3-3 m. Copulation occurs in flight, after which the males guard their mates during oviposition. The males apparently do not hover over the female while guarding her as do other species, but "watch" from a perch and dart toward intruders.

Remarks.--This species is distinguished by the saffron area along the costa. Although widespread it is a local and relatively rare species.

Libellula incesta Hagen

(Figures 185a, 188b)

Hagen 1861. Syn. Neur. N. Amer., p. 155.

Length 42-58 mm; abdomen 28-36 mm; hind wings 34-42 mm.

Diagnosis.--Face of mature male dark brown, face of mature female light brown, labrum white; posteroventral corners of mesanepisterna white, obscured by pruinosity in mature males; proximal half of hind femora brown; wings each with basal opaque brown areas absent in male and present or absent in female; opaque white areas in mature males absent,

costa black between nodus and pterostigma, and pterostigma dark brown; fore wings each with subtriangle 3-5-celled (generally 3-celled); hind wings each with 3 or 4 paranal cells proximal to fibulum (generally 3); penile segment 3 with ventral process bootlike; lateral penile lobes with apices directed ventrally; abdominal segment 3 with posteroventral carinae ca. 0.35 in male and 0.45 in female as long as medioventral carinae; female with lateral carinae of segment 8 convex; cerci brown.

Distribution.--Known from the states of AL, AR, CT, DE, FL, GA, IL, IN, KY, LA, ME, MD, MA, MI, MS, MO, NH, NJ, NY, NC, OH, OK, PA, RI, SC, TN, TX, VA, WV, and WI, and the province of Ont. Known from the Virginia counties of Alleghany, Augusta, Bath, Charles City, Charlotte, Chesterfield, Essex, Fairfax, Goochland, Hanover, Henrico, Highland, James City, King William, Lee, Montgomery, New Kent, Powhatan, Prince William, Southampton, Spotsylvania, and York, and the cities of Chesapeake, Newport News, Norfolk, Richmond, Suffolk, and Virginia Beach. Known distribution among the counties of neighboring states include: Kentucky- Barren, Bell, Bullitt, Butler, Carter, Edmonson, Fayette, Green, Hardin, Harrison, Hart, Hickman, Ohio, Oldham, Pulaski, Taylor, Trigg, Union, and Warren; Maryland- Prince Georges, Wicomico, and Worcester; North Carolina- Moore and Wake; Pennsylvania- Bucks, Crawford, Delaware, Erie, Monroe, Montgomery, Northampton, Pike, Warren, Wayne, and Wyoming; Tennessee- Campbell, Carroll, Claiborne, Coffee, Davidson, Knox, Madison, Obion, Overton, and Sullivan.

Virginia Records.--Allegheny Co.; Griffith, 11 May 1951, 1 male, R. L. Hoffman, (Det. LKG); Griffith, 11 June 1951, 1 male, R. L. Hoffman, (Det. LKG); Griffith, 21 June 1951, 1 male, R. L. Hoffman, (Det. LKG);

Griffith, 11 July 1951, 2 males, 1 female, R. L. Hoffman, (Det. LKG); Pond Flat Marsh off Rt. 600, 10 Sept. 1978, 3 males, 1 female, FLC. Augusta Co.; Shenandoah Pd., 13 June 1980, 1 male, FLC; Shenandoah Pd., 17 July 1980, 3 males, BCK. Bath Co.; Douthat Lk. at Rt. 629, 27 June 1973, 1 male, SWD. Charles City Co.; Harrison Lk. at Roxbury, 28 May 1938, 2 males, 1 female, R. Hess, (Det. A. D. Hess), A. D. Hess Collection; Harrison Lk. at Roxbury, 12 June 1938, 1 male, R. Hess, (Det. A. D. Hess), A. D. Hess Collection; Herring Cr. Rd., 5 July 1938, 1 male, MED, VPI&SU; Berkeley Mills, 5 Sept. 1937, 4 males, MED, (Det. MED, MDR notes). Charlotte Co.; Twittys Cr. at Rt. 642, 10 June 1975, 1 male, FLC; Twittys Cr. at Rt. 642, 14 June 1975, 2 females, FLC; Twittys Cr. dam, 18 June 1975, 1 male, FLC; Twittys Cr. at Rt. 642, 12 July 1974, 1 female, FLC; Twittys Cr. at Rt. 642, 22 July 1978, 1 male, FLC; Twittys Cr. at Rt. 642, 24 July 1973, 1 male, FLC; Keysville pd., 24 Aug. 1938, 2 males, J. T. Baldwin, (Det. MED, MDR notes). Chesterfield Co.; Pocahontas State Park, 20 June 1974, 1 male, D. H. Beals, VCU; Pocahontas State Park, 20 June 1973, 1 females, M. Lacy, VCU; Pocahontas State Park, 20 June 1974, 1 male, W. C. Rothery, VCU; Pocahontas State Park, 20 July 1973, 1 male, T. Slate, VCU; Gregory Pd. Rd., 10 Aug. 1971, 1 male, JRV, VPI&SU. Essex Co.; Hewerton's farm pd., 8 Aug. 1978, 1 male, 1 female, R. L. Hoffman, VPI&SU. Fairfax Co.; Great Falls, "June 11 to Sept. 6", (Donnelly 1961); Great Falls, 4 July 1899, 1 male. W. R. Maxon and G. N. Collins, USNM; Great Falls, 10 July 1914, 1 male, 1 female, RPC, USNM; Great Falls, 23 July 1900, 1 male, RPC, USNM; Great Falls, 23 July 1914, 1 female, V. A. Roberts, USNM; Pond at Rt. 123 at George Mason U., 31 July 1974, 1 male, H. B. Williams, USNM; Pond along Potomac

at Difficult Run, 19 Sept. 1978, 1 female, FLC. Goochland Co.; small stream 3 miles N. of Goochland at Rt. 6, 27 July 1978, 1 male, 1 female (in tandem), BCK. Hanover Co.; locality unknown, 3 July 1975, 1 male, C. Lee, VCU; N. Anna R. 1 mile W. of Rt. 1, 2 Aug. 1978, 1 male, R. Baer, BCK Collection; N. Anna R. at falls, 2 Sept. 1977, 1 male, 1 female (in tandem), BCK. Henrico Co.; locality unknown, 3 July 1975, 1 male, C. Seranage, VCU. Highland Co.; Back Cr. beaver pd., 1 Aug. 1973, 1 male, FLC. James City Co.; Lily Pd. on Rt. 612, 27 May 1967, 1 female, MDR, VPI&SU; Lily Pd. on Rt. 612, 4 June 1967, 2 males, 2 females, 1 nymphal exuviae, MDR, VPI&SU; Lake Powell at Williamsburg, 1 July 1937, 1 male, CC, (Det. CC), CC Collection; Lake Powell at Williamsburg, 12 July 1937, 1 male, 1 female, CC, (Det. CC), CC Collection; Ballards Cr., 29 July 1938, 1 male, MED, VPI&SU; Youngs Mill Pd., 30 July 1938, 1 male, MED, VPI&SU; Mariner's Museum, 30 July 1938, 1 male, MED, (Det. MED, MDR notes); Lk. Matoaka at Williamsburg, 15 Aug. 1937, 2 males, J. T. Baldwin, (Det. MED, MDR notes); Tutters Neck Pd., 15 Sept. 1966, 1 male, MDR, VPI&SU; Riverview Pd., 18 Sept. 1966, 4 males, MDR, VPI&SU; pond at Bassett Hall at Williamsburg, 22 Sept. 1966, 2 males, 1 female, MDR, VPI&SU. King William Co.; locality unknown, 9 June 1975, 1 male, J. O'Hop, ODU. Lee Co.; Keokee Lk., 3 July 1977, 1 male, FLC. Montgomery Co.; Pandapas Pd., 10 July 1977, 1 male, BCK; Pandapas Pd., 28 July 1973, 2 males, 1 female, FLC; Heath Pd. off Rt. 685 nr. Blacksburg, 1 Aug. 1977, 1 male, FLC; Pandapas Pd., 12 Aug. 1973, 1 male, FLC; Pandapas Pd., 15 Aug. 1978, 1 male, FLC. New Kent Co.; Jones Run and Sawmill Pd., 8 June 1967, 1 female, MDR, VPI&SU; locality unknown, 22 July 1974, 2 females, JFM, ODU. Powhatan Co.; locality unknown, 27 June 1975,

1 male, M. Zimmerman, VCU; locality unknown, 29 June 1975, 1 male, R. Kelley, VCU. Prince William Co.; Prince William Forest Park, 19 Aug. 1973, 1 male, OSF, USNM. Southampton Co.; Nottoway R. at Rt. 653, 10 Oct. 1978, 1 male, 1 female, FLC; Nottoway R. at Rt. 753, 10 Oct. 1978, 2 males, FLC. Spotsylvania Co.; swamp off Rt. 617, 7 July 1978, 1 male, FLC. York Co.; Jones Mill Pd. on Colonial Parkway, 9 July 1938, 2 males, MED, VPI&SU; Jones Mill Pd. on Colonial Parkway, 29 July 1938, 1 male, MED, VPI&SU; Jones Mill Pd. on Colonial Parkway, 29 July 1938, 1 male, MED, (Det. MED, MDR notes); Jones Mill Pd. on Colonial Parkway, 16 Sept. 1966, 4 males, MDR, VPI&SU; Brachens Pd. on Colonial Parkway, 16 Sept. 1966, 1 male, MDR, VPI&SU; Upper Wallers Pd., 18 Sept. 1966, 1 male, MDR, VPI&SU; Newmans Pd., 18 Sept. 1966, 3 males, MDR, VPI&SU. City of Chesapeake; Dismal Swamp Wildlife Refuge, 4 Aug. 1973, 1 female, M. Lacy, VCU. City of Newport News; Warwick R. at Denbigh, 30 July 1938, 1 male, MED, VPI&SU. City of Norfolk; locality unknown, 13 June 1975, 2 males, FLC; locality unknown, 7 July 1974, 1 male, 1 female, J. Hancock, ODU; locality unknown, 9 July 1974, 1 female, JFM, ODU. City of Richmond; Maymont Park, 13 July 1973, 1 male, K. Beck, VCU; Maymont Park, 13 July 1973, 1 male, J. Krolak, VCU; Maymont Park, 13 July 1973, 1 male, J. Gainer, VCU; Maymont Park, 13 July 1973, 1 male, T. Slate, VCU; Maymont Park, 13 July 1973, 1 male, W. Smith, VCU; Maymont Park, 20 July 1975, 1 male, J. Vannoy, VCU; Maymont Park, 20 July 1973, 1 male, 1 female, J. Verburg, VCU. City of Suffolk; Jericho Lane in Dismal Swamp Wildlife Refuge, 22 June 1975, 1 male, 1 female, FLC; Dismal Swamp Wildlife Refuge, 2 July 1973, 6 males, JFM, ODU; drainage ditch in Holland, 15 July 1975, 1 male, J. W. Jenkins, VPI&SU; Dismal Swamp

Wildlife Refuge, 20 July 1974, 1 male, J. Hancock, ODU; Dismal Swamp Wildlife Refuge, 12 Aug. 1974, 2 males, 1 female, J. Hancock, ODU; Dismal Swamp Wildlife Refuge, 15 Aug. 1975, 1 male, JFM, ODU; Dismal Swamp Wildlife Refuge, 19 Aug. 1974, 1 male, 2 females, J. Hancock, ODU; Cypress Chapel, 14 Sept. 1934, 2 males, LKG, (Det. LKG, Gloyd 1951). City of Virginia Beach; Virginia Beach, 29 May 1900, 1 female, C. L. Pollard and W. R. Maxon, (Det. C. L. Pollard), USNM; Seaside State Park, 12 June 1975, 1 male, FLC.

Flight Season.--Feb. 20 (MS) to Oct. 27 (FL); in Virginia May 11 to Oct. 10. Known season in neighboring states are: Kentucky- Apr. 14 to Sept.; Maryland- Aug. 14 to 22; North Carolina- May 24 to Oct. 15; Pennsylvania- June 24 to Aug. 23; Tennessee- June 1 to Oct. 2.

Biology.--*Libellula incesta* inhabits slow-moving streams, swamps, marshes, ponds, and marsh-bordered lakes. Adult males generally perch on branches near shore at from 0.5 - 3 m. The males when encountering each other frequently indulge in a circular flight pattern, one flying over the other so that they exchange positions, perhaps explaining the origin of the specific name.

Remarks.--This species is distinguished by its clear wings and dark body; it is among the more common species of the genus in Virginia. The female hind wing length of 45 mm reported by Corbet and Walker (1975) may apply to *L. vibrans*.

Libellula luctuosa Burmeister

Syn.: *basalis* Say

(Figures 185b, 188c)

Burmeister 1839. Handb., p. 861.

Length 36-48 mm; abdomen 23-31 mm; hind wings 32-43 mm.

Diagnosis.--Face of mature male dark brown, face of mature female light brown; posteroventral corners of mesanepisterna not white; proximal half of hind femora brown; wings each with basal opaque brown areas present, opaque white areas in mature males present, costa black between nodus and pterostigma, and pterostigma brown to dark brown; fore wings each with subtriangle 4-11-celled (generally 6-10-celled); hind wings each with 3 or 4 paranal cells proximal to fibulum (generally 3); penile segment 3 with ventral process low-pyramidal; lateral penile lobes with apices directed ventrally; abdominal segment 3 with posteroventral carinae ca. 0.51 in male and 0.55 in female as long as medioventral carinae; female with lateral carinae of segment 8 not convex; cerci brown.

Distribution.--Known from the states of AL, AR, AZ, CA, CT, DC, FL, GA, IL, IN, IA, KS, KY, ME, MD, MA, MI, MN, MS, MO, NE, NJ, NM, NY, NC, OH, OK, OR(?), PA, RI, SC, SD, TN, TX, VT, VA, WV, and WI, and the provinces of B.C.(?), N.S., Ont., and Que., and also from Chihuahua, Mexico. Known from the Virginia counties of Albemarle, Arlington, Augusta, Bath, Bedford, Carroll, Charles City, Charlotte, Chesterfield, Craig, Cumberland, Dickenson, Fairfax, Floyd, Giles, Goochland, Hanover, Henrico, Highland, James City, Lee, Loudoun, Louisa, Montgomery, Nelson, Powhatan, Prince William, Pulaski, Richmond, Roanoke, Rockbridge, Rockingham, Russell, Smyth, Southampton, Spotsylvania, Warren, Washington, Wise, Wythe, and York, and the cities of Norfolk, Petersburg, Richmond, Suffolk, and Virginia Beach. Known distribution among the counties of

neighboring states include: Kentucky- Allen, Barren, Bell, Breckinridge, Bullitt, Butler, Carter, Casey, Cumberland, Fayette, Floyd, Fulton, Green, Harrison, Hart, Henderson, Hickman, Hopkins, Jefferson, Jessamine, Letcher, Marion, McCreary, Metcalfe, Ohio, Pike, Taylor, Todd, Trigg, Union, Warren, and Wayne; Maryland- Garrett, Montgomery, and Prince Georges; North Carolina- Cumberland, Guilford, Henderson, McDowell, Mecklenburg, and Wake; Pennsylvania- Adams, Allegheny, Armstrong, Beaver, Bedford, Berks, Blair, Bradford, Bucks, Butler, Cambria, Centre, Chester, Clearfield, Columbia, Crawford, Dauphin, Delaware, Elk, Erie, Fayette, Franklin, Fulton, Greene, Huntingdon, Indiana, Jefferson, Juniata, Lancaster, Lawrence, Lebanon, Lehigh, Luzerne, Mercer, Monroe, Montgomery, Northampton, Northumberland, Perry, Philadelphia, Pike, Schuylkill, Tioga, Union, Venango, Warren, Washington, Wayne, Westmoreland, Wyoming, and York; Tennessee- Anderson, Blount, Campbell, Claiborne, Cocke, Coffee, Davidson, Dickson, Giles, Hamblen, Knox, Monroe, Obion, Rutherford, Sullivan, and Williamson; West Virginia- Hampshire, Mason, Pendleton, Raleigh, Randolph, Ritchie, and Taylor.

Virginia Records.--Albemarle Co.; Charlottesville, 31 Aug. 1937, 1 male, MED, VPI&SU. Arlington Co.; Arlington, 8 June 1914, 3 males, 1 female, A. W. J. Pomeroy, USNM. Augusta Co.; Todd Lk., 30 June 1973, 1 male, SWD. Bath Co.; Douthat Lk. at Rt. 629, 27 June 1973, 1 male. SWD. Bedford Co.; 8 miles W. of Lynchburg, 20 June 1948, 1 male, R. L. Hoffman, (Det. LKG); Peaks of Otter, 22 July 1978, 1 male, FLC. Carroll Co.; New R. bridge at Fries, 29 Aug. 1976, 1 female, C. R. Parker, VPI&SU. Charles City Co.; Harrison Lk. at Roxbury, 28 May 1938, 2 males, 2 females, R. Hess, (Det. A. D. Hess), A. D. Hess Collection;

Harrison Lk. at Roxbury, 1 June 1938, 1 female, R. Hess, (Det. A. D. Hess), A. D. Hess Collection; Harrison Lk. at Roxbury, 12 June 1938, 1 male, R. Hess, (Det. A. D. Hess), A. D. Hess Collection. Charlotte Co.; Twittys Cr. Dam, 10 June 1975, 1 male, 1 female, FLC; Twittys Cr. Dam, 18 June 1975, 1 male, FLC; Keysville, 24 Aug. 1938, 1 male, J. T. Baldwin, VPI&SU. Chesterfield Co.; Pocahontas State Park, 24 June 1968, 1 male, H. Gilpin, VCU; Pocahontas State Park, 24 June 1968, 1 male, M. P. May, VCU. Craig Co.; farm pd. along Rt. 635 2 miles S.W. of Paint Bank, 9 Aug. 1978, 1 male, FLC. Cumberland Co.; Bear Cr. Lk., 23 May 1977, 1 male (teneral), FLC. Dickenson Co.; Laurel Lk. and Laurel Br. below dam at Breaks Interstate Park, 14 June 1979, 1 male, 1 female, JRV and TJV, VPI&SU; small lk. below dam at Breaks Interstate Park, 14 June 1979, 1 female, JRV and TJV, VPI&SU. Fairfax Co.; Great Falls, 17 June 1914, 1 male, RPC, USNM; Great Falls, 25 June 1914, 1 male, RPC, USNM; Great Falls, 4 July 1899, 2 males, 1 female, G. N. Collins and W. R. Maxon, USNM; Great Falls, 8 July 1915, 4 males, 2 females, RPC, USNM; Great Falls, 8 July 1915, 2 males, V. Busck, USNM; Great Falls, 10 July 1914, 7 males, 1 female, RPC and BPC, USNM; Great Falls, 12 July 1905, 1 male, D. H. Clemens, USNM; Great Falls, 12 July 1915, 1 male, BPC, USNM; Great Falls, 12 July 1915, 1 male, V. Busck, USNM; Great Falls, 23 July 1900, 1 male, G. N. Collins, USNM; Great Falls, 26 July 1913, 1 male, RPC, USNM; Great Falls, 27 July 1907, 2 males, RPC, USNM; nr. D.C., 2 Aug. 1917, 1 male, A. N. Caudell, USNM; Great Falls, 24 Aug. 1915, 1 male, RPC, USNM. Floyd Co.; Little R. at Rt. 615, 3 June 1977, 1 female, FLC. Giles Co.; Riopel Pd. at Mtn. Lk. Bio. Sta., 26 June 1977, 1 female (teneral), FLC; Walker Cr. at Rt. 622, 14 July 1978, 1

female, BCK. Goochland Co.; locality unknown, 24 June 1976, 1 male, M. Strickland, VCU; Rt. 676, 24 July 1970, 1 male, JRV, VPI&SU; locality unknown, 28 July 1969, 1 male, B. B. Winfield, VCU; locality unknown, 28 July 1969, 1 female, J. Marsh, VCU; locality unknown, 28 July 1969, 1 male, R. R. Griffin, VCU; locality unknown, 5 Aug. 1971, 2 males, T. Sink, VCU. Hanover Co.; Likhert Pd., 3 July 1975, 1 male, C. Serange, VCU; locality unknown, 3 July 1975, 1 female, N. G. Evenson, VCU. Henrico Co.; Rasmussen's Pd., 8 June 1967, 1 male, MDR, VPI&SU; locality unknown, 3 July 1975, 1 male, C. Serange, VCU; nr. Richmond, 20 Sept. 1935, 1 female, A. Walker, VSEC. Highland Co.; farm pd. at Rts. 250 and 640, 8 Aug. 1978, 1 male, JRV, VPI&SU; Buck Run beaver pds., 8 Aug. 1978, 1 male, FLC. James City Co.; Williamsburg, 10 May 1939, 1 female, MED, VPI&SU; Jollys Pd., 22 May 1938, 1 male, F. M. K., VPI&SU; Lk. Powell, 7 June 1938, 1 female, MED, VPI&SU; Jamestown, 9 June 1938, 1 female, MED, VPI&SU; Rt. 5 0.5 mile W. of Five Forks, 13 June 1938, 1 male, 1 female, MED, VPI&SU; Barretts Ferry, 18 June 1938, 1 female, V. M. D., VPI&SU; Lk. Matoaka at Williamsburg, 1 July 1937, 1 female, CC, (Det. CC), CC Collection; Williamsburg, 3 July 1937, 1 male, MED, VPI&SU; Reservoir nr. Fort Eustis, 7 July 1938, 1 male, MED, VPI&SU; Lees Mill Pd. at Fort Eustis, 30 July 1938, 1 male, 1 female, MED, (Det. MED, MDR notes); Lk. Powell at Williamsburg, 6 Aug. 1937, 2 males, V. M. D. and MED, VPI&SU; Williamsburg, 5 Sept 1937, observation, MED, (MDR notes). Lee Co.; small marsh at Rt. 606, 3 July 1977, 1 female, FLC; Keokee Lk., 3 July 1977, 3 males, FLC. Loudoun Co.; locality unknown, 12 Aug. 1971, 2 males, T. Muir, VPI&SU. Louisa Co.; L. Anna nr. Environmental Lab., 3 June 1977, 2 males, BCK; L. Anna nr. Bio. Sta.,

3 June 1977, 1 female, BCK; locality unknown, 23 June 1976, 1 male, J. Steiner, VCU; locality unknown, 3 Aug. 1970, 1 male, 1 female, G. M. Simmons, VCU; locality unknown, 7 Aug. 1970, 1 male, G. M. Simmons, VCU; locality unknown, 19 Aug. 1970, 1 male, G. M. Simmons, VCU. Montgomery Co.; Blacksburg, 25 May 1959, 1 male, C. B. Nolen, VPI&SU; Blacksburg, 25 May 1959, 1 female, Martin, VPI&SU; Blacksburg, 27 May 1959, 1 female, W. C. Duckhardt, VPI&SU; Blacksburg, 27 May 1948, 1 female (teneral), E. C. Cockrell, VPI&SU; Issaic Walton Pd., 10 June 1978, 1 male, FLC; Toms Cr. at Rt. 655, 12 June 1977, 2 females, BCK; Blacksburg, 14 June 1975, 2 males, T. E. Bailey, VPI&SU; Heath Pd. at Blacksburg, 20 June 1977, 1 male (teneral), BCK; Blacksburg, 20 June 1951, 1 female (teneral), G. M. Boush, VPI&SU; Chandler's Pd., 21 June 1969, 1 male, S. Goldberg, VPI&SU; Blacksburg, 23 June 1948, 2 males, G. M. Boush, VPI&SU; Blacksburg, 25 June 1948, 5 males, 2 females, G. M. Boush, VPI&SU; Blacksburg, 29 June 1960, 1 female, R. R. Mills, VCU; Blacksburg, 3 July 1948, 3 males, G. M. Boush, VPI&SU; Heath Pd., 8 July 1978, 1 female, BCK; Blacksburg, 12 July 1967, 1 male, E. C. Turner, VPI&SU; Pandapas Pd., 15 July 1973, 1 male, FLC; Blacksburg, 16 July 1960, 1 female, RRM, VCU; Kelly's Pd. in Blacksburg, 18 July 1977, 1 male, 1 female, S. Mudre, VPI&SU; Heath Pd. at Blacksburg, 23 July 1977, 1 female, FLC; Blacksburg, 25 July 1951, 1 male, H. Jordan, VPI&SU; VPI&SU Pd. at Blacksburg, 30 July 1948, 1 male, C. F. Byers, (Det. C. F. Byers, Byers 1951); Heath Pd. off Rt. 685 at Blacksburg, 1 Aug. 1977, 1 male, 1 female, FLC; locality unknown, 4 Aug. 1960, 1 male, C. U. Correll, VPI&SU; Blacksburg, 13 Aug. 1960, 1 female, RRM, VCU; Pandapas Pd., 15 Aug. 1978, 1 male, FLC; VPI&SU Pd. at Blacksburg, 20 Aug. 1978, P. J.

Sieburth, VPI&SU; Stroubles Cr. downstream from VPI&SU Duck Pd., 13 Sept. 1977, 1 male, FLC. Nelson Co.; pd. at campground on Rt. 56 nr. Montebello, 19 July 1978, 1 male, JRV and TJV, VPI&SU; Nelson Lk. at Rt. 812, 20 July 1978, 1 female, JRV and TJV, VPI&SU. Powhatan Co.; locality unknown, 27 June 1975, 1 female, D. Custer, VCU; locality unknown, 27 June 1975, 2 males, M. Zimmerman, VCU; locality unknown, 27 June 1975, 2 males, R. H. Nugent, VCU; locality unknown, 27 June 1975, 1 male, 1 female, R. Kelly, VCU; locality unknown, 29 June 1975, 1 female, M. Zimmerman, VCU. Prince William Co.; Manassas, 14 July 1973, 1 female, J. Verberg, VCU; Broad Run below Jackson Lk. nr. Independent Hill, 15 Aug. 1953, observation, TWD, (TWD field notes); Quantico, 20 Sept. 1975, 1 male, N. Legere, ODU. Pulaski Co.; Claytor Lk., 5 Aug. 1949, 1 male, C. F. Byers, (Det. C. F. Byers, Byers 1951). Richmond Co.; locality unknown, 30 June 1977, 1 female, C. Greene, VCU. Roanoke Co.; Roanoke R. at Blueridge Parkway, 29 June 1975, 1 male, SWB, VPI&SU. Rockbridge Co.; Lk. Merriweather, 23 June 1978, 1 male, FLC. Rockingham Co.; locality unknown, 3 Sept. 1974, 1 male, R. Hall, VPI&SU. Russell Co.; Laurel Bed Lk., 4 July 1977, 1 male, FLC. Smyth Co.; Saltville salt pds., 14 Aug. 1978, 1 male, FLC. Southampton Co.; Nottoway R. at Rt. 753, 10 Oct. 1978, 1 female, FLC. Spotsylvania Co.; Rappahannock R. at Rt. 618, 16 July 1980, 2 males, BCK. Warren Co.; Surber's Pd. at Rt. 634, 6 June 1977, 1 male, FLC; Surber's Pd. at Rt. 634, 27 June 1974, 1 female, E. Surber, VPI&SU; Surber's Pd. at Rt. 634, 5 July 1975, 1 male, FLC; Surber's Pd. at Rt. 634, 6 July 1975, 1 male, SWB, VPI&SU; Surber's Pd. at Rt. 634, 2 Sept. 1970, 1 male, E. W. Surber, VPI&SU. Washington Co.; small pd. along Rt. 663, 15 June 1980,

1 male, FLC; junction of Rts. 663 and 665, 4 July 1978, 1 male, G. Anderson, VPI&SU. Wise Co.; N. Fork Reservoir at Phillips Cr. Recreation Area at Rt. 834, 12 July 1980, 1 male, FLC. Wythe Co.; Wytheville, 30 June 1935, CA, (Det. CA), CA Collection; Campbell Pd. on Pine Ridge Rd., 3 July 1970, 1 female, W. R. Chitwood, VPI&SU. York Co.; Queens Cr. at Capital Landing, 1 July 1938, 1 male, MED, (Det. MED, MDR notes); Jones Pd., 9 July 1938, 1 male, MED, (Det. MED, MDR notes); Jones Pd., 15 July 1938, 2 males, MED, VPI&SU; Jones Pd., 29 July 1938, 1 male, MED, VPI&SU; Brachens Pd., 16 Sept. 1966, 1 male, MDR, VPI&SU. City of Norfolk; locality unknown, 7 July 1974, 2 males, 2 females, J. Hancock, ODU; locality unknown, 11 July 1973, 1 female, D. Laist, ODU. City of Petersburg; locality unknown, 29 June 1968, 1 male, D. R. Goodwin, VCU. City of Richmond; Maymont Park, 5 June 1977, 1 male, C. Muzidal, VCU; Maymont Park, 13 June 1973, 1 male, K. Beck, VCU; Maymont Park, 21 June 1974, 1 male, J. K. Kittrel, VCU; Maymont Park, 24 June 1968, 2 males, K. F. O'Barr, VCU; Maymont Park, 29 June 1968, 1 female, P. A. Bateman, VCU; Maymont Park, 13 June 1973, 1 male, J. Gainer, VCU; Maymont Park, 13 July 1973, 1 male, J. Verburg, VCU; Maymont Park, 13 July 1973, 1 male, J. Verburg, VCU; Maymont Park, 13 July 1973, 1 male, J. Krolak, VCU; Maymont Park, 10 Aug. 1968, 1 male, M. Rauscher, VCU. City of Suffolk; locality unknown, 20 June 1975, 1 female, ODU; Jericho Lane in Dismal Swamp Wildlife Refuge, 22 June 1975, 1 female, FLC. City of Virginia Beach; Back Bay Refuge, 31 May 1975, 1 male, J. O'Hop, ODU.

Flight Season.--Apr. 10 (TX) to Oct. 19 (KY); in Virginia May 10 to Oct. 10. Known season in neighboring states are: District of Columbia-- June 8 to July 23; Kentucky-- Apr. 14 to Oct. 19; Maryland-- June 6 to

Oct. 5; North Carolina- Apr. to Sept. 4; Pennsylvania- May 24 to Sept. 30; Tennessee- May 5 to Oct. 3; West Virginia- June 14 to Aug. 13.

Biology.--*Libellula luctuosa* inhabits ponds, marshes, and marsh-bordered lakes. Adult males perch on vegetation and branches near shore generally at from 0.5-2 m above water. The males are among the most conspicuous individuals in the territorial battles along pond margins.

Remarks.--This species is distinguished by the large basal brown spots of the wings and its relatively short abdomen.

Libellula needhami Westfall

(Figures 186a, 189a)

Westfall 1943. Trans. Amer. Entomol. Soc. 69:22.

Length 48-56 mm; abdomen 32-38 mm; hind wings 35-44 mm.

Diagnosis.--Face of mature male red, face of mature female yellow; posteroventral corners of mesanepisterna white (often obscured in mature males); proximal half of hind femora yellow to reddish brown (femora not bicolored); wings each with basal opaque brown areas absent, opaque white areas in mature males absent, costa red or yellow between nodus and pterostigma, and pterostigma yellow to orange; fore wings each with subtriangle 4-7-celled (generally 5 or 6-celled); hind wings each with 3 or 4 paranal cells proximal to fibulum (generally 4); penile segment 3 with ventral process pyramidal; lateral penile lobes with apices directed ventrally; abdominal segment 3 with posteroventral carinae ca. 0.40 in male and 0.42 in female as long as medioventral carinae; female with lateral carinae of segment 8 convex; cerci red or yellow, often

brown apically.

Distribution.--Known from the states of AL, AR, CT, DC, DE, FL, GA, LA, MD, MA, MS, NJ, NC, PA, RI, SC, TX, and VA, and also from Tamaulipas, Mexico, and from Cuba. Known from the Virginia counties of Accomack, Arlington, Charles City, Chesterfield, Essex, Isle of Wight, James City, Middlesex, New Kent, Richmond, Westmoreland, and York, and the cities of Newport News, Norfolk, Petersburg, Richmond, Suffolk, and Virginia Beach. Known distribution among the counties of neighboring states include: Maryland- Anne Arundel, Baltimore, Calvert, Cecil, Frederick, Kent, and Worcester; Pennsylvania- Delaware; North Carolina- Brunswick, Carteret, Chowan, Craven, Dare, Hyde, New Hanover, Pasquotank, Pender, Perquimans, Tyrrell, and Washington.

Virginia Records.--Accomack Co.; locality unknown, 7 Aug. 1975, 1 male, J. O'Hop, ODU. Arlington Co.; Arlington, 16 June 1914, 1 female, A. W. J. Pomeroy, (Westfall 1943), USNM; Arlington, "June 16 to Aug. 22", (Donnelly 1961). Charles City Co.; Harrison Lk. at Roxbury, 1 June 1938, 1 female, R. Hess, (Det. A. D. Hess), A. D. Hess Collection; Harrison Lk. at Roxbury, 13 June 1938, 1 female, R. Hess, (Det. A. D. Hess), A. D. Hess Collection; Bass Fish Hatchery, 21 June 1976, 1 female, G. Brown, P. Thomas Collection; Chickahominy R. at Barretts Ferry, 1 Aug. 1937, 1 male, 2 females, D. W. Davis and MED, VPI&SU. Chesterfield Co.; Presquile National Wildlife Refuge, 8 July 1969, 1 female, R. R. Griffin, VCU. Essex Co.; Hewerton's farm pd., 8 Aug. 1978, 1 female, R. L. Hoffman, VPI&SU. Isle of Wight Co.; locality unknown, 1 June 1975, 1 female, JFM and J. Hancock, ODU; James City Co.; Jamestown Island, 20 May 1938, 1 male, MED, VPI&SU; Richarson's Mill Pd., 5 June

1967, 1 female, MDR, VPI&SU; Jamestown, 9 June 1938, 3 females, MED, VPI&SU; Jamestown, 9 June 1938, 7 males, 12 females, MED, (Det. MED, MDR notes); Jamestown Island, 12 June 1937, 3 males, 2 females, CC, (Det. CC), CC Collection; Reservoir nr. Fort Eustis, 7 July 1938, 1 female, MED, VPI&SU; Barretts Ferry, 12 July 1938, 2 females, V.M.D., VPI&SU; Jamestown Island Pd., 19 July 1938, 1 male, MED, VPI&SU; Williamsburg, 23 July 1937, 1 male, MED, VPI&SU; Mariner's Museum, 30 July 1938, 1 male, MED, (Det. MED, MDR notes); Lk. Powell at Williamsburg, 6 Aug. 1937, 3 males, 2 females, V. M. Davis and MED, VPI&SU; Williamsburg, 10 Sept. 1929, 1 male, MED, VPI&SU; Toano, 8 Oct. 1937, 1 male, R. W. Menzel, (Det. R. W. Menzel, MDR notes). Middlesex Co.; locality unknown, 15 June 1974, 1 female, W. C. Rothery, VCU; Stingray Point, 30 June 1938, 1 female, CC, (Det. CC), CC Collection; Stingray Point, 4 July 1937, 2 females, CC, (Det. CC), CC Collection. New Kent Co.; locality unknown, 22 July 1974, 3 females, JFM, ODU; West Point, 2 Aug. 1975, 1 female, J. O'Hop, ODU. Richmond Co.; Warsaw, 28 June 1977, 1 male, C. J. Greene, VCU; Naylers Beach, 29 June 1975, 1 female, D. Ziletti, VCU. Westmoreland Co.; nr. Coles Point, 4 Aug. 1917, 1 male, 1 female, J. E. Benedict, USNM; nr. Coles Point, 25 June 1917, 1 male, J. E. Benedict, USNM. York Co.; Yorktown, 10 June 1938, 1 female, MED, VPI&SU; Kings Cr., 24 June 1938, 1 female, MED, VPI&SU; Jones Pd., 15 July 1938, 1 male, MED, VPI&SU; Jones Pd., 29 July 1938, 1 female, MED, (Det. MED, MDR notes); Wallers Pd., 17 Sept. 1966, 1 female, MDR, VPI&SU. City of Newport News; marsh at Denbigh, 30 July 1938, 1 female, MED, (Det. MED, MDR notes). City of Norfolk; locality unknown, 7 July 1974, 1 male, J. Hancock, ODU; locality unknown, 11 July 1973, 9 males,

6 females, JFM, ODU; Old Deep Cr. Blvd. in Portsmouth, 24 Aug. 1938, 5 males, T. D. McCahill, (Det. T. D. McCahill), T. D. McCahill Collection; Old Deep Cr. Blvd. in Portsmouth, 25 Aug. 1938, 2 males, T. D. McCahill, VPI&SU; Old Deep Cr. Blvd. in Portsmouth, 25 Aug. 1938, 3 males, T. D. McCahill, (Det. MED), T. D. McCahill Collection; swamp nr. Green Acres, 27 Aug. 1938, 1 male, T. D. McCahill, VPI&SU; Old Deep Cr. Blvd. in Portsmouth, 28 Aug. 1938, 1 female, T. D. McCahill, VPI&SU; Old Deep Cr. Blvd. in Portsmouth, 28 Aug. 1938, 1 male, T. D. McCahill, (Det. MED). T. D. McCahill Collection. City of Petersburg; locality unknown, 11 July 1976, 1 female, J. Steiner, VCU. City of Richmond; Boad Bridge, 15 June 1973, 1 female, T. Plate, VCU; Carters Wharf, 12 Aug. 1980, 1 male, 1 female, E. B. Jones, VCU. City of Suffolk; Jericho Lane in Dismal Swamp Wildlife Refuge, 22 June 1975, 3 females, FLC; Dismal Swamp Wildlife Refuge, 2 July 1973, 1 female, JFM, ODU; Dismal Swamp Wildlife Refuge, 19 Aug. 1974, 2 males, J. Hancock, ODU; Dismal Swamp Wildlife Refuge, 28 Sept. 1974, 1 male, K. W., ODU. City of Virginia Beach; Back Bay Refuge, 20 May 1975, 1 male, J. O'Hop, ODU; White Lk. at Seaside State Park, 22 May 1977, 4 females (slightly teneral), FLC; Back Bay Refuge, 25 May 1975, 1 female, J. O'Hop, ODU; Back Bay Refuge, 8 June 1975, 1 male, J. O'Hop, ODU; Seaside State Park, 12 June 1975, 4 males, FLC; Back Bay Refuge, 26 June 1973, 5 males, 2 females, JFM, ODU; locality unknown, 10 July 1971, 1 female, G. B. Stanley, VPI&SU; Back Bay Refuge, 14 July 1974, 6 males, 2 females, FLC; locality unknown, 20 July 1 female, C. L. Pollard, USNM; locality unknown, 1 Aug. 1928, 2 males, collector unknown, (MDR notes), U. of Wisconsin.

Flight Season.--Feb. 20 (FL) to Oct. 8 (VA) in Virginia May 20 to

Oct. 8. Known season in neighboring states are: Maryland- June 3 to Sept. 5; North Carolina- May 19 to Sept. 4.

Biology.--*Libellula needhami* inhabits brackish marshes and ponds of the coastal plain. Adult males generally perch near shore at from 0.3-2 m above water. It is often found in association with *Brachymesia grandidata* and *Erythrodiplax berenice*.

Remarks.--This species is similar to *L. auripennis* in general appearance. In Virginia its distribution is primarily limited to the coast.

Libellula vibrans Fabricius

(Figures 186b, 189b)

Fabricius 1793. Syst. Entomol. 2:380.

Length 52-65 mm; abdomen 35-44 mm; hind wings 40-52 mm.

Diagnosis.--Face of mature male white, face of mature female white; posteroventral corners of mesanepisterna white; proximal half of hind femora pale (femora bicolored); wings each with basal opaque brown areas present, opaque white areas in mature males absent, costa black between nodus and pterostigma, and pterostigma dark brown to black; fore wings each with subtriangle 3-8-celled (generally 5 or 6-celled); hind wings each with 3-4 paranal cells proximal to fibulum (generally 4); penile segment 3 with ventral process elongate; lateral penile lobes with apices directed dorsally; abdominal segment 3 with posteroventral carinae ca. 0.35 in male and 0.38 in female as long as medioventral carinae; female with lateral carinae of segment 8 convex; cerci dark

brown.

Distribution.--Known from the states of AL, AR, CT, DC, FL, GA, IL, IN, KS, KY, LA, MD, MA, MS, MO, NJ, NY, NC, OH, OK, PA, SC, TN, TX, VA, and WI, and the province of Ont. Known from the Virginia counties of Accomack, Albemarle, Charlotte, Chesterfield, Essex, Fairfax, Halifax, Henrico, James City, Roanoke, Spotsylvania, and York, and the cities of Chesapeake, Hampton, Newport News, Norfolk, Suffolk, and Virginia Beach. Known distribution among the counties of neighboring states include: Kentucky- Adair, Ballard, Breckinridge, Edmonson, Green, Hart, Marshall, Trigg, and Union; Maryland- Cecil, Wicomico, and Worcester; North Carolina- Dare, Macon, and Wake; Pennsylvania- Berks, Bucks, Centre, Delaware, Perry, and Philadelphia; Tennessee- Blount, Bradley, Coffee, Greene, Hardeman, Johnson, Monroe, Obion, and Sevier.

Virginia Records.--Accomack Co.; Chincoteague Island, 27 Aug. 1891, 1 female, F. M. Jones, (Det. MED), ANSP. Albemarle Co.; Charlottesville, 20 May 1948, 1 male, R. L. Hoffman, (Det. LKG). Charlotte Co.; Spring Cr. at Rt. 654, 10 June 1975, 1 male, FLC; Twittys Cr. at Rt. 642, 24 July 1973, 2 males, 1 female, FLC. Chesterfield Co.; Presquile Island, 6 Aug. 1970, 1 male, J. Loe, VCU; Presquile Island, 8 Aug. 1969, 1 male, P. L. Lambdin, VCU. Essex Co.; Dunbrooke, 28 July 1899, 1 male, RPC, USNM. Fairfax Co.; Great Falls, 4 July 1899, 3 males, 1 female, G. N. Collins and W. R. Maxon, USNM. Halifax Co.; trib. of Hyco R. 7.8 miles W. of Virgilina, 22 Aug. 1953, 1 female, R. L. Hoffman, USNM. Henrico Co.; Richmond, 20 Sept. 1935, 1 male, A. Walker, (Det. A. Walker), VSEC. James City Co.; locality unknown, 7 June 1937, 1 female, MED, VPI&SU; Lk. Powell, 7 June 1938, 1 female, MED, VPI&SU; Lk. Powell, 7

June 1938, 1 female, MED, (Det. MED, MDR notes); Lk. Matoaka at Williamsburg, 10 June 1937, 1 female, CC, (Det. MED, Davis 1938); Jamestown Island, 12 June 1937, 1 male, 1 female, CC, (Det. CC); Jamestown Rd., 1 July 1937, 1 male, CC, (Det. CC); Jamestown Island, 4 July 1937, 2 females, CC, (Det. CC); Williamsburg, 15 Sept. 1929, 1 male, MED, VPI&SU. Roanoke Co.; Roanoke R. at Blueridge Parkway, 29 June 1975, 2 males, SWB, VPI&SU. Spotsylvania Co.; swamp off Rt. 617, 7 July 1978, 2 males, FLC. York Co.; locality unknown, 5 July 1938, MED, (Det. MED, MDR notes). City of Chesapeake; Stumpy Lk., 31 May 1970, 1 female, JFM, ODU. City of Hampton; locality unknown, 1938, 1 male, V. Buchsen, (Det. MED, MDR notes). City of Newport News; Warwick R. at Denbigh, 30 July 1938, 1 male, MED, VPI&SU. City of Norfolk; locality unknown, 12 June 1962, 1 female, C. V. Corell, VPI&SU; pd. off Rt. 168, 13 June 1975, 1 male, 1 female, FLC; Old Deep Cr. Blvd. in Portsmouth, 24 Aug. 1938, 2 males, T. D. McCahill, VPI&SU; Old Deep Cr. Blvd. in Portsmouth, 24 Aug. 1938, 1 male, T. D. McCahill, (Det. MED). City of Suffolk; Jericho Lane in Dismal Swamp Wildlife Refuge, 22 June 1975, 3 males, FLC; Dismal Swamp Wildlife Refuge, 20 July 1974, 1 male, 1 female, J. Hancock, ODU; Dismal Swamp Wildlife Refuge, 5 Aug. 1974, 1 male, 1 female, J. Hancock, ODU; Dismal Swamp Wildlife Refuge, 12 Aug. 1974, 1 male, J. Hancock, ODU; Green Acres nr. Churchland, 27 Aug. 1938, 1 female, T. D. McCahill, VPI&SU; Green Acres nr. Churchland, 27 Aug. 1938, 1 male, T. D. McCahill, (Det. MED); Cypress Chapel, 13 Sept. 1934, 1 female, LKG, (Det. LKG, Gloyd 1951); Dismal Swamp Wildlife Refuge, 15 Sept. 1974, 1 male, 1 female, JFM, ODU. City of Virginia Beach; Back Bay Refuge, 8 June 1975, 1 male, 2 females, J. O'Hop, ODU; locality

unknown, 10 Aug. 1973, 1 male, P. W. Larkins, VPI&SU; North Landing, 14 Aug. 1948, 1 male, R. L. Hoffman, (Det. LKG); locality unknown, 4 Oct. 1973, 1 female, Munsen, ODU.

Flight Season.--Apr. 1 (FL) to Dec. 8 (MS); in Virginia May 20 to Oct. 4. Known season in neighboring states are: District of Columbia- June 21; Kentucky- June 26 to Sept. 3; Maryland- July 10 to Aug. 22; North Carolina- May to Sept. 5; Pennsylvania- May 16 to Aug. 31; Tennessee- June 17 to Aug. 25.

Biology.--*Libellula vibrans* inhabits slow-flowing streams, swamps, marshes, and ponds. Adult males generally perch at from 1-3 m above the water near the nymphal habitat.

Remarks.--This species is distinguished by its large size and white face.

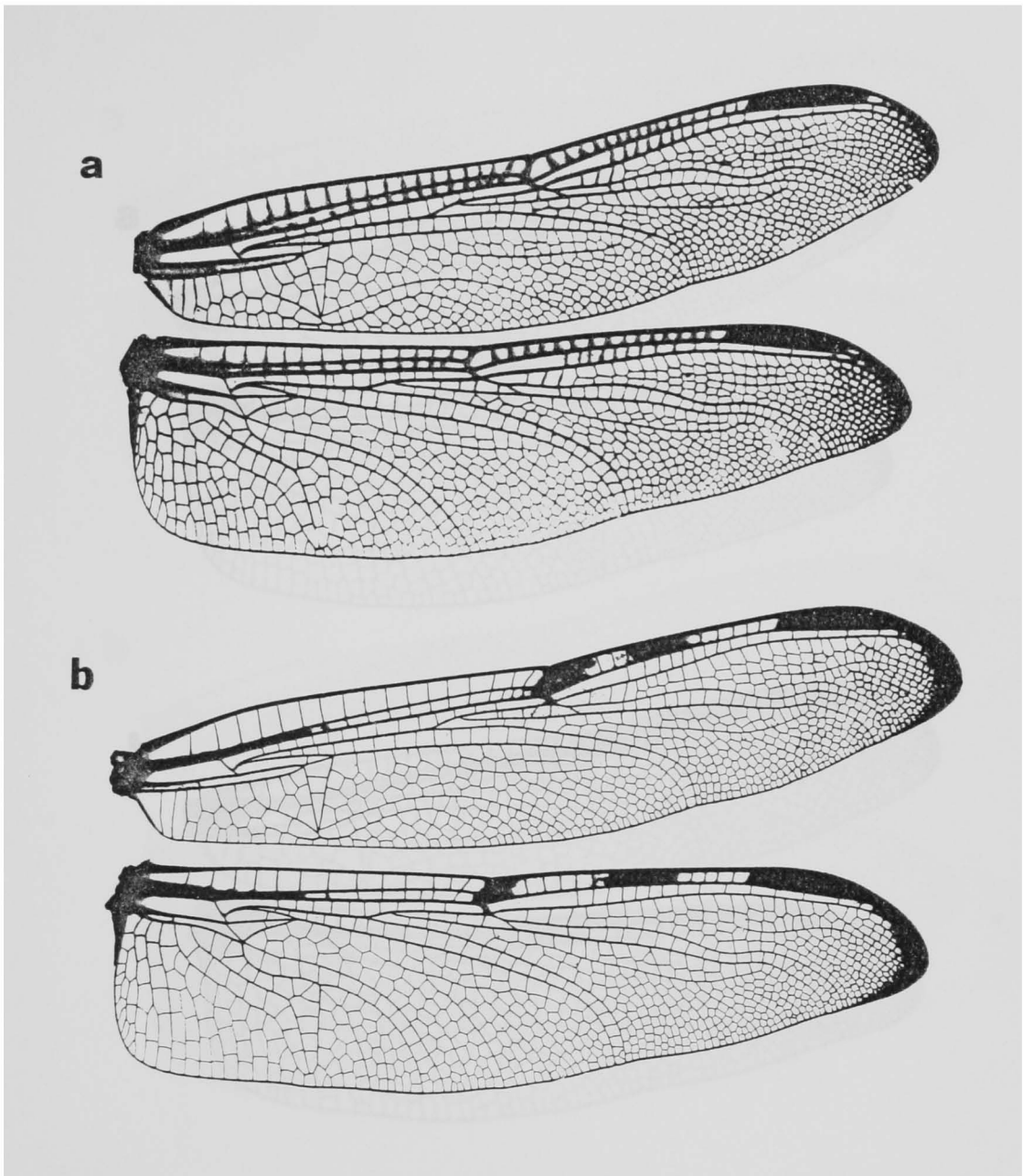


Figure 183. Wings of *Libellula*(*Holotania*) x3: (a) *L. auripennis*;
(b) *L. axilena*.

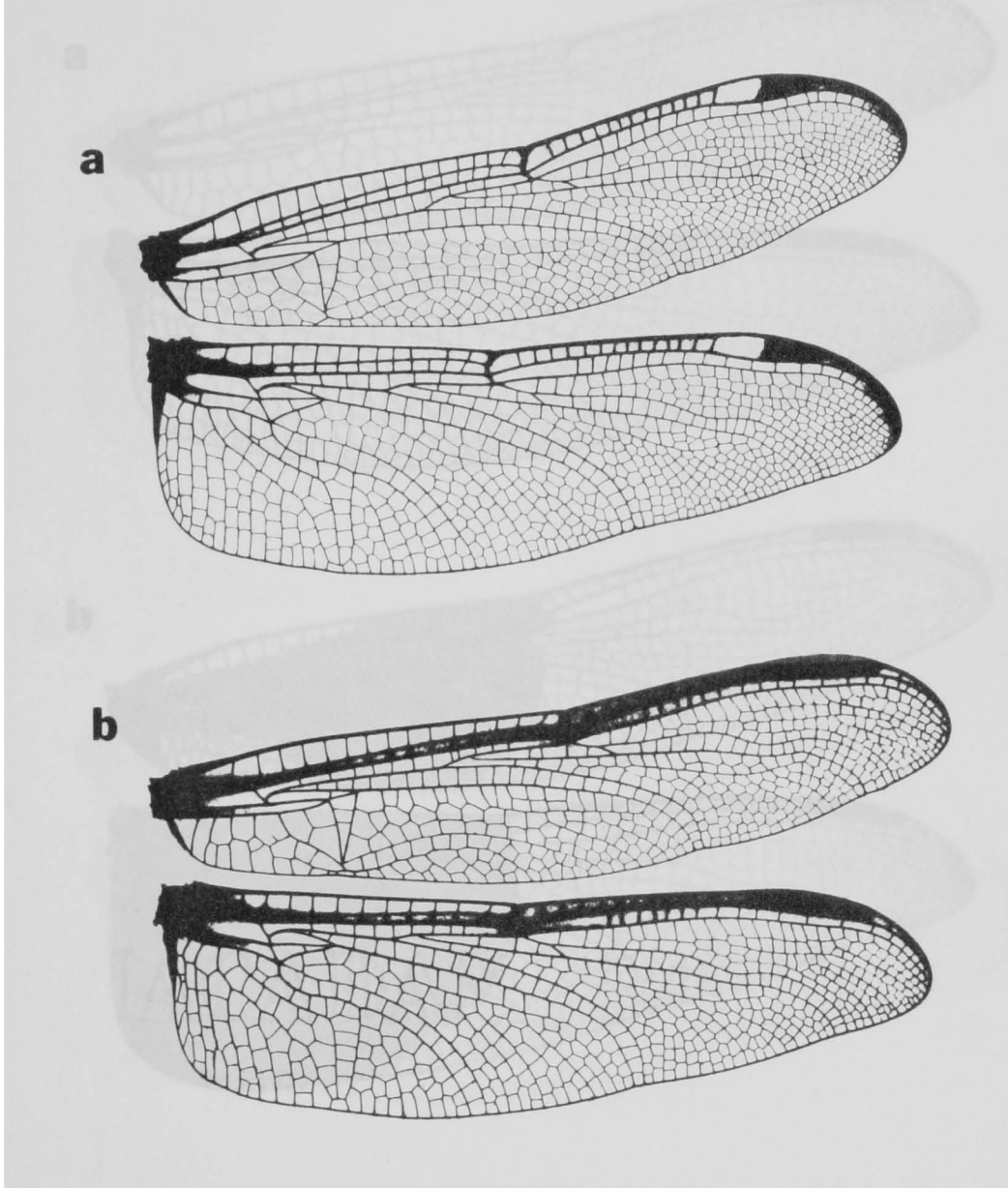


Figure 184. Wings of *Libellula*(*Holotania*) x3: (a) *L. cyanea*;
(b) *L. flavida*.

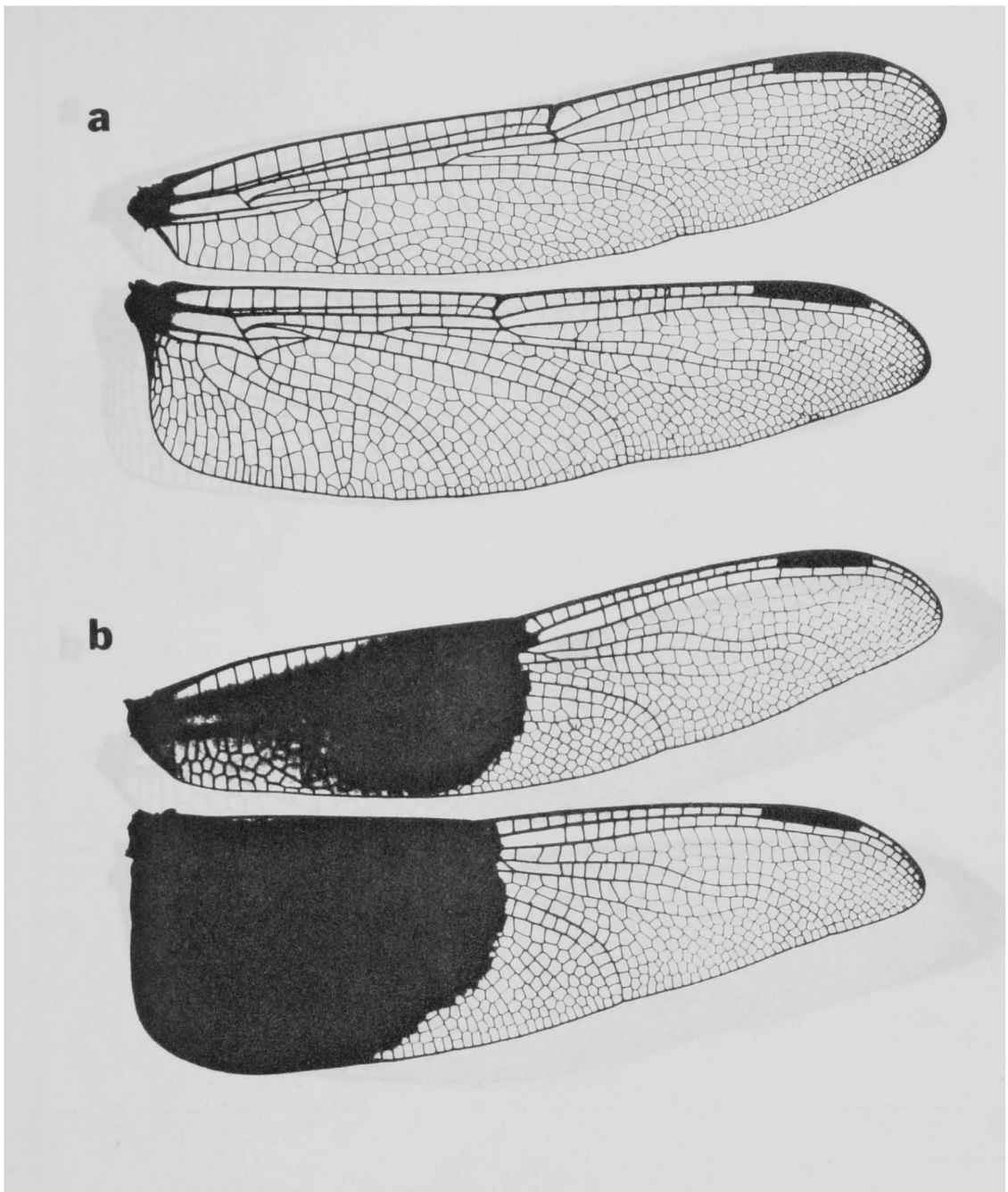


Figure 185. Wings of *Libellula*(*Holotania*) x3: (a) *L. incesta*;
(b) *L. luctuosa*.

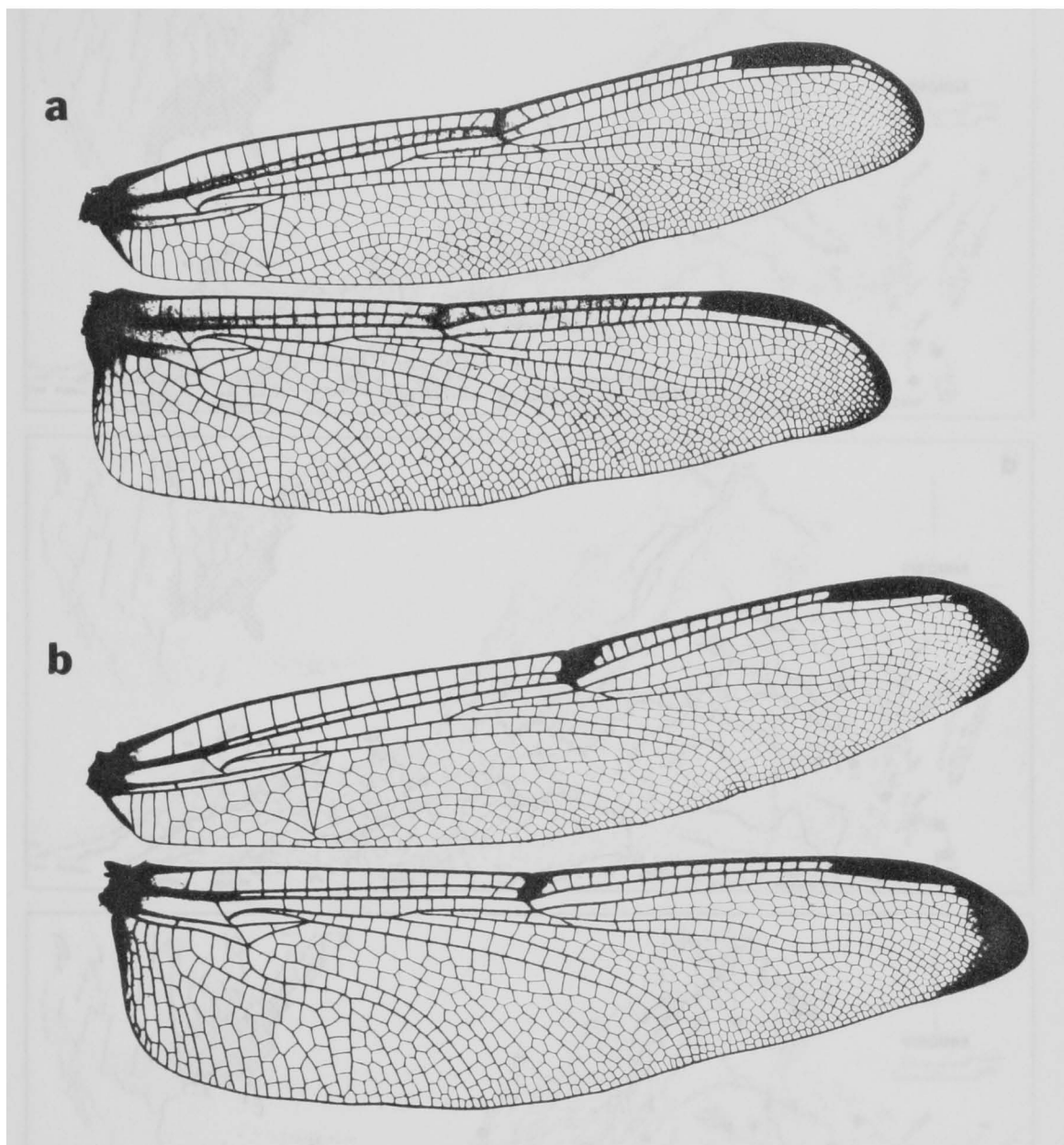


Figure 186. Wings of *Libellula*(*Holotania*) x3: (a) *L. needhami*;
(b) *L. vibrans*.

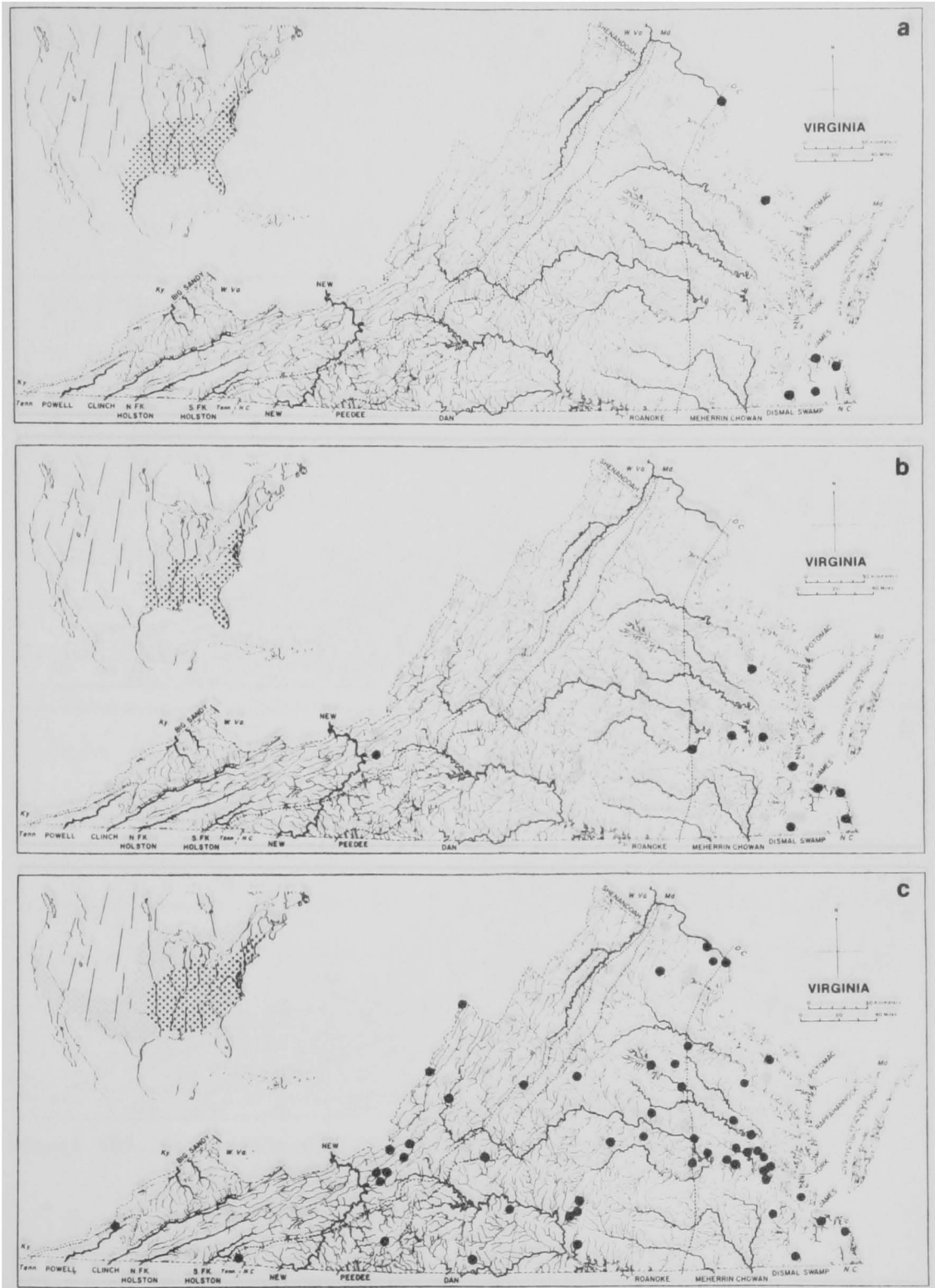


Figure 187. Geographic distribution of *Libellula*: (a) *L. auripennis*; (b) *L. axilena*; (c) *L. cyanea*.

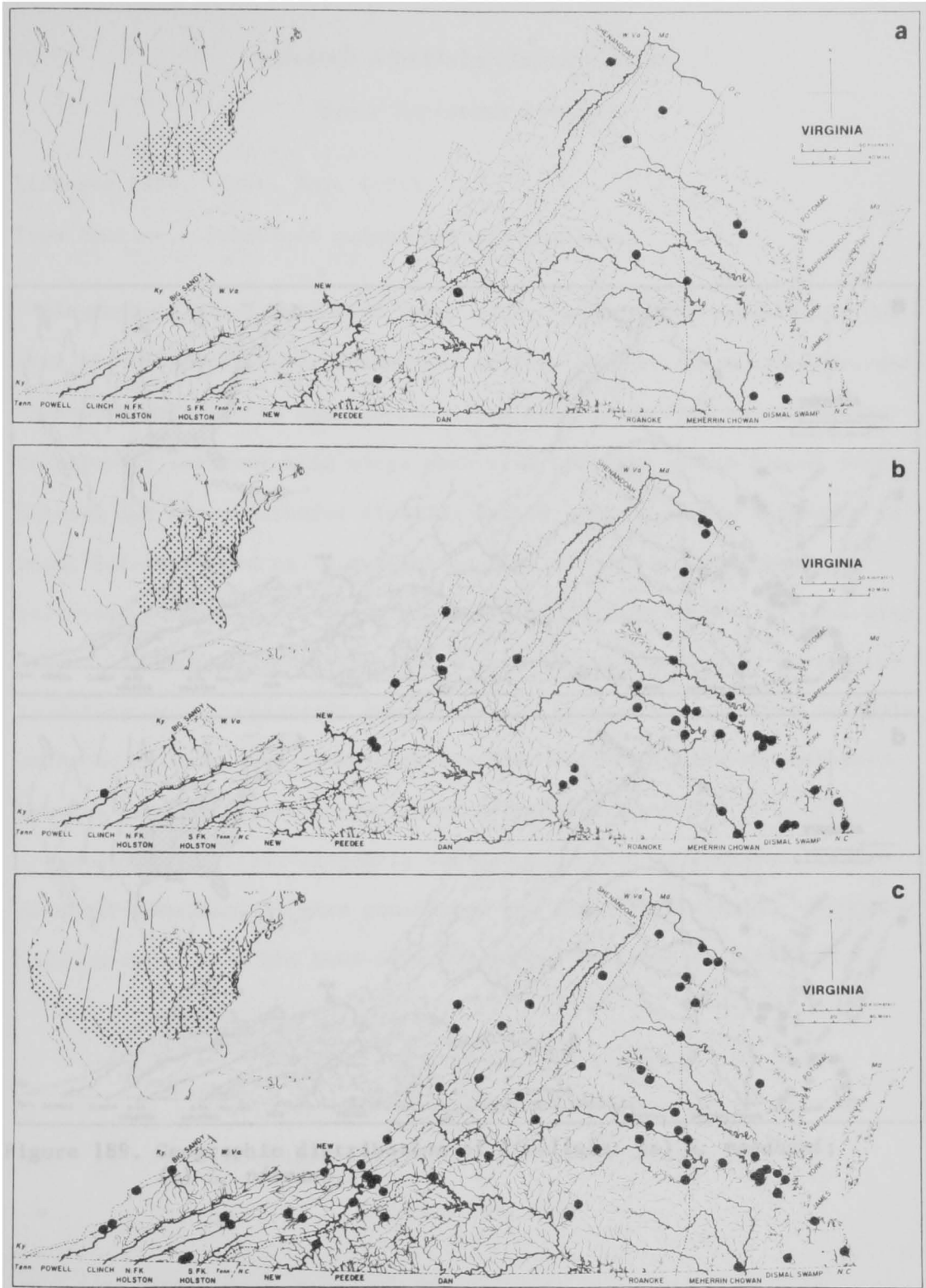


Figure 188. Geographic distribution of *Libellula*: (a) *L. flavida*; (b) *L. incesta*; (c) *L. luctuosa*.

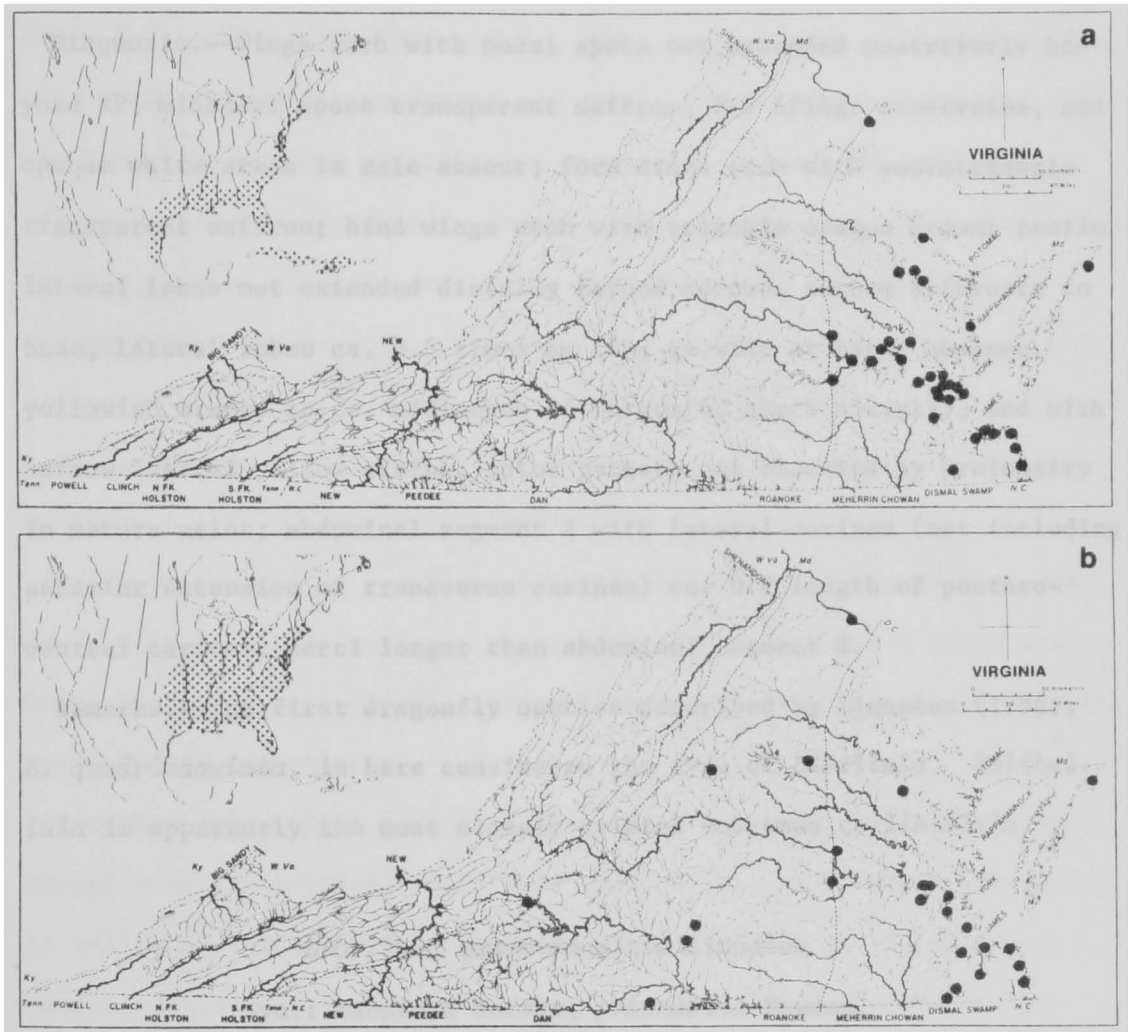


Figure 189. Geographic distribution of *Libellula*: (a) *L. needhami*; (b) *L. vibrans*.

Subgenus *Libellula* Linnaeus 1758Syn.: *Leptetrum* Newman

Linnaeus 1758. Syst. Nat. 1:543.

Type Species.--*Libellula quadrimaculata* Linnaeus.

Diagnosis.--Wings each with nodal spots not extended posteriorly beyond RP, midbasal space transparent saffron, 2-5 bridge crossveins, and opaque white areas in male absent; fore wings each with supratriangle transparent saffron; hind wings each with triangle opaque brown; penile lateral lobes not extended distally beyond cornua, cornua bifurcate to base, lateral lobes ca. 0.5 times as long as wide at base; abdomen yellowish orange to ca. midlength of tergum 6, black distally, and with narrow lateral yellow stripe, color pattern not obscured by pruinosity in mature males; abdominal segment 2 with lateral carinae (not including anterior extension of transverse carinae) ca. 0.7 length of postero-ventral carinae; cerci longer than abdominal segment 8.

Remarks.--The first dragonfly species described by Linnaeus (1758), *L. quadrimaculata*, is here considered the type of *Libellula*. *Eolibellula* is apparently the most closely related subgenus to *Libellula*.

Libellula quadrimaculata Linnaeus

Syn.: *maculata* Harris, *praemubila* Newman,
quadripunctata Fabricius, *ternaria* Say

(Figures 190, 191)

Linnaeus 1758. Syst. Nat., p. 543.

Length 39-46 mm; abdomen 24-29 mm; hind wings 32-38 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AK, AZ, CO, CT, ID, IL, IN, IA, ME, MA, MI, MN, NE, NV, NH, NJ, NM, NY, NC, OH, OK, OR, PA, SD, TX, UT, VT, VA, WA, WV, WI, and WY, and the provinces of Alta., B.C., Labr., Man., N.B., Nfld., NW. Terr., N.S., Ont., P.E.I., Que., and Sask, and also known from northern Europe and Asia. Known from the Virginia county of James City. Known distribution among the counties of neighboring states include: Pennsylvania- Centre, Clinton, Crawford, Elk, Huntingdon, Luzerne, McKean, Mercer, and Wayne; West Virginia- Jackson.

Virginia Records.--James City Co.; Williamsburg, date unknown, 1 male, collector unknown, (Det. MED, Davis 1938), W&M.

Flight Season.--May 7 (B.C.) to Sept. 29 (B.C.). Known season in neighboring states are: Pennsylvania- May 24 to Aug. 7.

Biology.--*Libellula quadrimaculata* inhabits marsh-bordered bog ponds. Adult males perch on emergent vegetation generally 0.5-2 m above water. Copulation occurs in flight, after which the males generally guard their mates during oviposition.

Remarks.--The flight season of this species begins very early. Although breeding populations of this species are not known in Virginia, it will occasionally be collected in Virginia owing to its migratory habits. This species is the most widely distributed species of the genus *Libellula*.

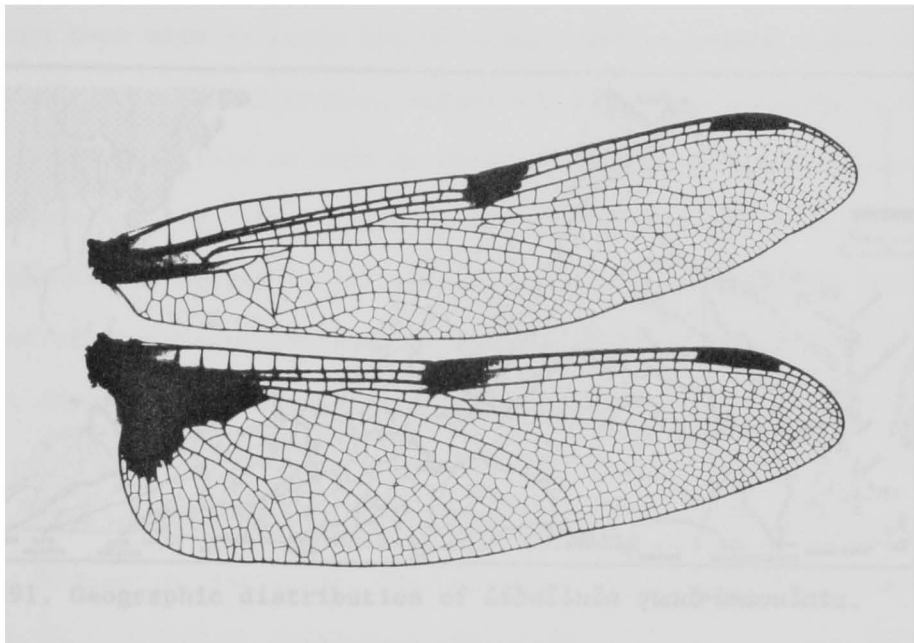


Figure 190. Wings of *Libellula (Libellula) quadrimaculata* x3.

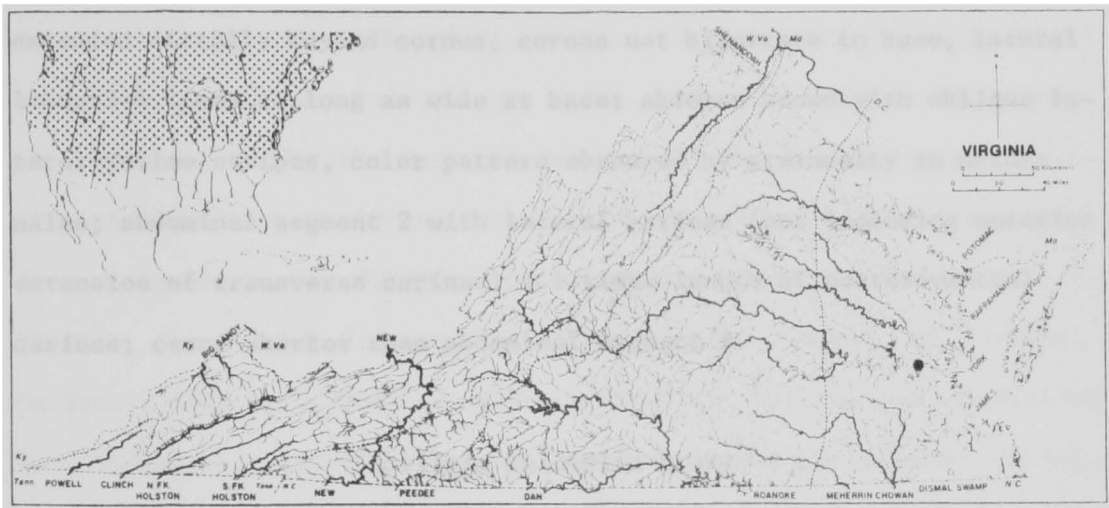


Figure 191. Geographic distribution of *Libellula quadrimaculata*.

Subgenus *Neotetrum* Kennedy 1922

Kennedy 1922. Entomol. News 33:111.

Type Species.--*Libellula forensis* Hagen.

Diagnosis.--Wings each with nodal spots extended posteriorly beyond RP, midbasal space opaque brown, 3-6 bridge crossveins, and opaque white areas in male present; fore wings each with supratriangle opaque brown; hind wings each with triangle opaque brown; penile lateral lobes not extended distally beyond cornua, cornua not bifurcate to base, lateral lobes 3-6 times as long as wide at base; abdomen brown with oblique lateral yellow stripes, color pattern obscured by pruinosity in mature males; abdominal segment 2 with lateral carinae (not including anterior extension of transverse carinae) 1.1 times length of posteroventral carinae; cerci shorter than abdominal segment 8.

Libellula pulchella Drury

Syn.: *bifasciata* Fabricius, *confusa* Uhler, *versicolor* Fabricius

(Figures 192, 193)

Drury 1770. Ill. Exot. Ins. 1:115.

Length 42-57 mm; abdomen 26-36 mm; hind wings 35-46 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AL, AR, CA, CO, CT, DC, FL, GA, ID, IL, IN, IA, KS, KY, LA, ME, MD, MA, MI, MN, MS, MO, NE, NV, NH, NJ, NY, NC, ND, OH, OK, OR, PA, RI, SC, SD, TN, TX, UT, VT, VA, WA, WV, WI, and WY, and the provinces of B.C., Man., N.B., N.S., Ont., Que., and

and Sask. Known from the Virginia counties of Albemarle, Alleghany, Augusta, Bath, Buchanan, Charlotte, Fairfax, Frederick, Giles, Highland, James City, Lee, Loudoun, Montgomery, Nelson, Pulaski, Roanoke, Warren, Washington, Westmoreland, Wise, and Wythe. Known distribution among the counties of neighboring states include: Kentucky- Allen, Barren, Bell, Breckinridge, Bullitt, Butler, Carter, Casey, Cumberland, Edmonson, Fayette, Floyd, Fulton, Grayson, Green, Hardin, Harrison, Hart, Henderson, Hickman, Hopkins, Jefferson, Jessamine, Letcher, Lincoln, Marion, McCreary, Metcalfe, Ohio, Oldham, Pike, Powell, Pulaski, Robertson, Russell, Taylor, Todd, Trigg, Union, Warren, and Wayne; Maryland- Anne Arundel, Frederick, Garrett, Montgomery, and Prince Georges; North Carolina- Chatham, Davidson, Durham, and Wake; Pennsylvania- Allegheny, Beaver, Berks, Blair, Bradford, Bucks, Butler, Cambria, Carbon, Centre, Chester, Clearfield, Clinton, Columbia, Crawford, Cumberland, Dauphin, Delaware, Elk, Erie, Fayette, Forest, Franklin, Fulton, Greene, Huntingdon, Indiana, Jefferson, Juniata, Lancaster, Lawrence, Lebanon, Lehigh, Luzerne, Lycoming, Mercer, Monroe, Montgomery, Northampton, Perry, Philadelphia, Pike, Potter, Schuylkill, Somerset, Sullivan, Tioga, Union, Venango, Warren, Washington, Wayne, Westmoreland, Wyoming, and York; Tennessee- Campbell, Carter, Cocke, Coffee, Davidson, Fentress, Greene, Hardin, Hawkins, Johnson, Knox, Overton, Rutherford, Sevier, Sullivan, Trousdale, and Williamson; West Virginia- Gilmer, Hampshire, Lincoln, Mason, Pendleton, Pocahontas, Preston, Raleigh, Randolph, Ritchie, Summers, and Taylor.

Virginia Records.--Albemarle Co.; Charlottesville, 31 Aug. 1937, 1 male, 1 female, MED, VPI&SU; Charlottesville, 1 Sept. 1937, 1 male, 1

female, MED, VPI&SU. Alleghany Co.; Pond Flat Marsh off Rt. 600, 10 Sept. 1978, 1 male, FLC. Augusta Co.; Shenandoah Pd., 13 June 1980, 1 male, FLC; Hearthstone Lk. and stream, 30 June 1973, 1 male, SWD. Bath Co.; beaver pd. along Rt. 600, 18 June 1978, 1 male, FLC; Cowpasture R. at Rt. 632 S. of Nimrod Hall, 29 June 1973, 1 male, SWD. Buchanan Co.; Russell Prater Cr. at Rt. 83, 12 July 1978, 1 male, FLC. Charlotte Co.; 1.5 miles N.W. of Keysville, 10 July 1938, 1 male, J. T. Baldwin, VPI&SU; Keysville, 24 Aug. 1938, J. T. Baldwin, VPI&SU. Fairfax Co.; Great Falls, "May 1 to Sept. 8", (Donnelly 1961); Great Falls, 17 June 1914, 1 male, 1 female, RPC, USNM; Great Falls, 4 July 1899, G. N. Collins and W. R. Maxon, USNM; Great Falls, 8 July 1914, 1 male, RPC, USNM; Great Falls, 10 July 1914, 1 male, RPC, USNM; Bull Run Cr., 14 Aug. 1980, 1 male, BCK; nr. mouth of Four Mile Run, 17 Sept. 1916, 1 female, W. L. McAtee, USNM; Potomac R. at Rt. 495, 19 Sept. 1978, 1 male, FLC. Frederick Co.; locality unknown, June 1945, 1 male, collector unknown, USNM. Giles Co.; Mtn. Lk., 9 Aug. 1949, 1 male, C. F. Byers, (Det. C. F. Byers, Byers 1951). Highland Co.; Buck Run beaver pds., 3, 4 July 1971, 2 males, OSF, USNM; Monterey, 29 July 1939, 1 male, T. Howard, USNM; Back Cr. beaver pd. at Rt. 250, 8 Aug. 1978, 1 male, JRV, VPI&SU. James City Co.; Williamsburg, 12 Sept. 1929, 1 male, MED, VPI&SU. Lee Co.; Keokee Lk., 3 July 1977, 10 males, 1 female (teneral), FLC. Loudoun Co.; Hillsboro, 22 Aug. 1898, 2 males, RPC, USNM. Montgomery Co.; Toms Cr. marsh 0.5 mile downstream from Rt. 655, 29 Apr. 1973, 1 male (teneral), FLC, VPI&SU; temporary pd. on Rt. 685, 16 May 1978 (emerged 30 May 1978), 2 female nymphs, J. Henderson, VPI&SU; temporary pd. on Rt. 685, 16 May 1978 (emerged 30 May 1978), 1 female nymph, A. Taylor, VPI&SU; Toms Cr.

marsh 0.5 mile downstream from Rt. 655, 24 May 1973, 1 male, 1 female (in tandem), FLC; Poverty Cr. at Rt. 708, 25 May 1978, 1 male, FLC; temporary pd. at Rt. 685, 29 May 1978, 1 male, A. Taylor, VPI&SU; Toms Cr. at Rt. 655, 12 June 1977, 1 male, BCK; Blacksburg, 14 June 1975, 1 male, T. E. Bailey, VPI&SU; Blacksburg, 23 June 1948, 1 male, G. M. Boush, VPI&SU; Blacksburg, 12 July 1967, 1 male, E. C. Turner, VPI&SU; Heath Pd. off Rt. 685 at Blacksburg, 1 Aug. 1977, 1 male, 1 female, FLC; Craig Cr. beaver pd. at Rt. 621, 22 Aug. 1978, 3 males, BCK. Nelson Co.; Seaman's pd. at Rt. 56 at Montebello, 20 July 1978, 1 male, JRV and TJV, VPI&SU. Pulaski Co.; Belspring, 12 July 1978, 1 male, P. J. Sieburth, VPI&SU. Roanoke Co.; Salem, 9 June 1973, 1 male, SWB, VPI&SU. Warren Co.; E. W. Surber's pd. off Rt. 634, 5 July 1975, 1 male, FLC. Washington Co.; Lodi, 30 Aug. 1953, 1 male, R. L. Hoffman, USNM. Westmoreland Co.; nr. Coles Point, 4 Aug. 1917, 1 female, J. E. Benedict, USNM; Meter, 19 Aug. 1916, 1 female, A. Holdridge, USNM. Wise Co.; N. Fork Reservoir at Rt. 834 at Phillips Cr. Recreation Area, 12 July 1980, 1 male, FLC. Wythe Co.; Wytheville, 29 June 1935, 1 male, 4 females, CA, (Det. CA).

Flight Season.--Apr. 11 (KY) to Oct. 14 (LA); in Virginia Apr. 29 (teneral) to Sept. 19. Known season in neighboring states are: District of Columbia-- May 20 to July 29; Kentucky-- Apr. 11 to Sept. 25; Maryland-- May 30 to Aug. 14; North Carolina-- May 28 to Sept. 13; Pennsylvania-- May 16 to Oct. 7; Tennessee-- Apr. 29 to Oct. 5; West Virginia-- June 13 to Aug. 13.

Biology.--*Libellula pulchella* inhabits slow-flowing streams, ponds, and marsh-bordered lakes. Adult males generally perch on branches or

dead vegetation near shore at from 0.5-2 m above water. The males only occasionally guard females with which they have mated.

Remarks.--This species is easily distinguished by its large basal, nodal, and apical wing spots which resemble the wing pattern of female *Plathemis lydia*.

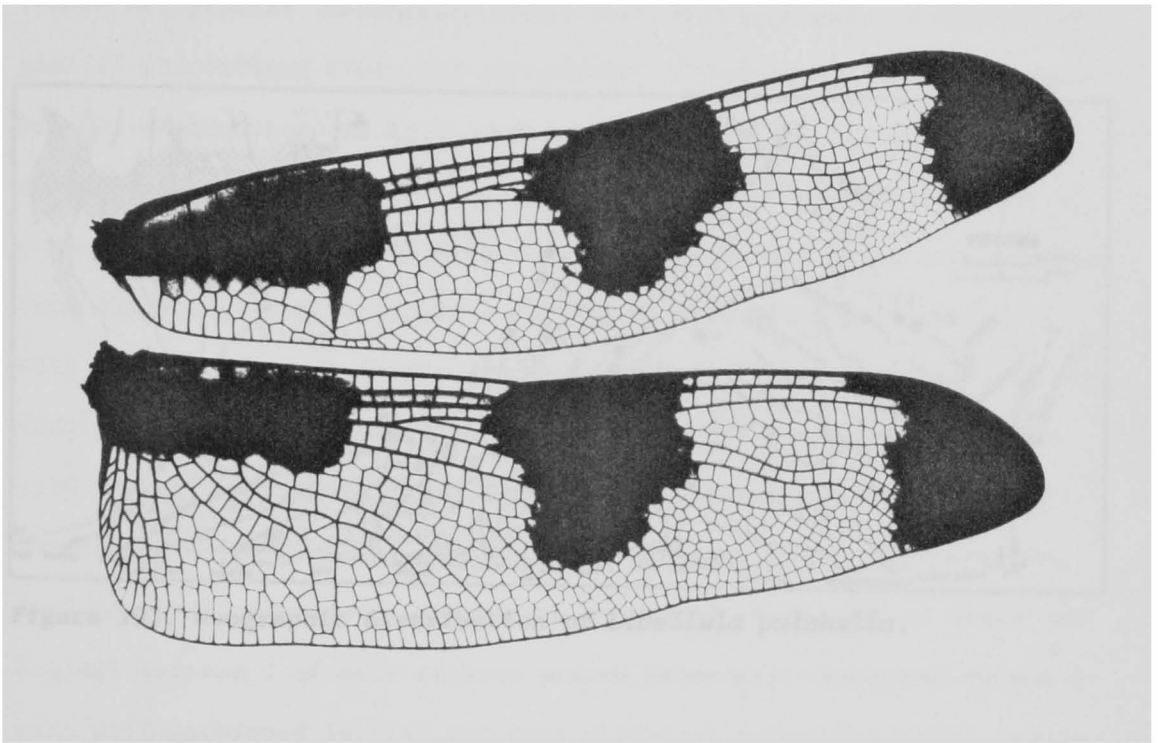


Figure 192. Wings of *Libellula (Neotetrum) pulchella* x3.

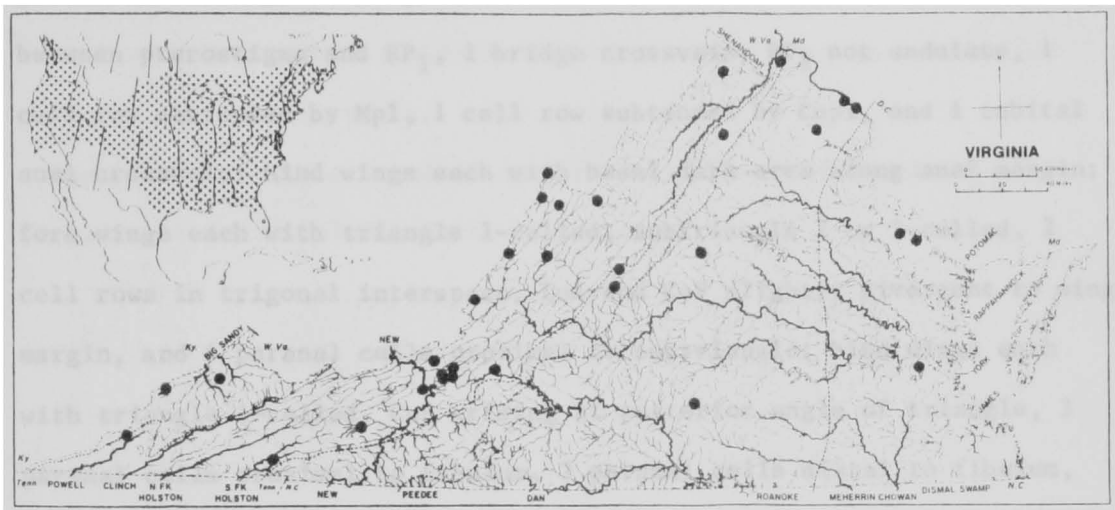


Figure 193. Geographic distribution of *Libellula pulchella*.

Genus *Macrodiplax* Brauer 1868

Brauer 1868. Verh. Zool.-Bot. Ges. Wien 18:366.

Type Species.--*Diplax cora* Brauer.

Diagnosis.--Posterior margin of pronotum directed posterodorsally without medial notch; apical 3 or 4 spines of outer spine row of hind femora not greatly lengthened; wings each with proximal and distal margins of pterostigma divergent anteriorly, 1 (occasionally 2) crossveins between pterostigma and RP_1 , 1 bridge crossvein, RP_2 not undulate, 1 cell row subtended by Mpl , 1 cell row subtended by $Cupl$, and 1 cubital anal crossvein; hind wings each with basal dark area along anal margin; fore wings each with triangle 1-celled, subtriangle 2 or 3-celled, 2 cell rows in trigonal interspace, CuA and CuP slightly divergent to wing margin, and 5 paranal cells proximal to subtriangle; hind wings each with triangle 1-celled, CuP arising at posterior angle of triangle, 3 paranal cells proximal to fibulum, 2 paranal cells distal to fibulum, anal loop well developed, and midrib angulated at ca. 30° at ankle; abdominal sternum 1 of male without paired processes; abdominal tergum 3 with well-developed lateral carinae; abdominal tergum 4 without supplementary transverse carina at antecostal suture; abdominal tergum 9 without well-developed lateral carinae.

Macrodiplax balteata (Hagen)

(Figures 194, 195)

Hagen 1861. Syn. Neur. N. Amer., p. 140 (in *Tetragoneuria*).

Length 37-42 mm; abdomen 26-29 mm; hind wings 28-35 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AZ, CA, FL, GA, LA, MS, NM, NC, SC, and TX, and also from Baja CA, Mexico, and from Cuba, Haiti, and Jamaica, and south to Venezuela. Known distribution among the counties of neighboring states include: North Carolina- Dare.

Flight Season.--Year-round southward. Known season in neighboring states are: North Carolina- Aug. 17.

Biology.--*Macrodiplox balteata* inhabits brackish pools and shallow ponds of the coastal plain.

Remarks.--This is a tropical species which has been collected near Virginia at Bodie Island, North Carolina.

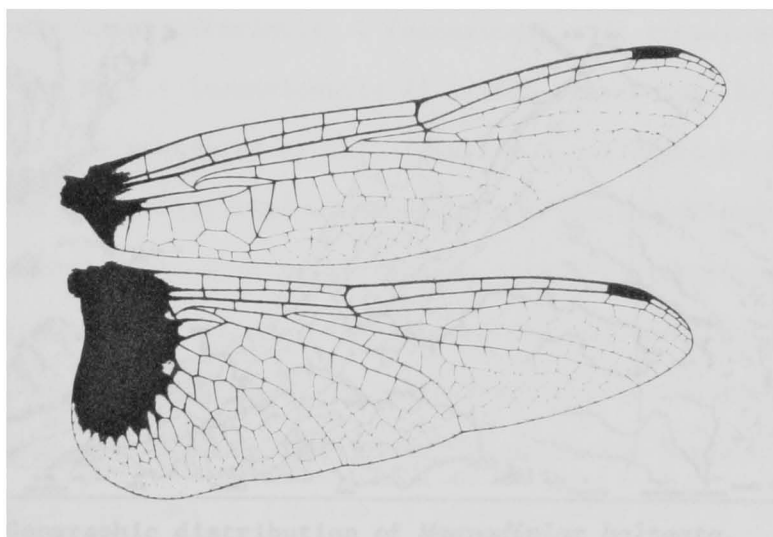


Figure 194. Wings of *Maerodiplax balteata* x3.

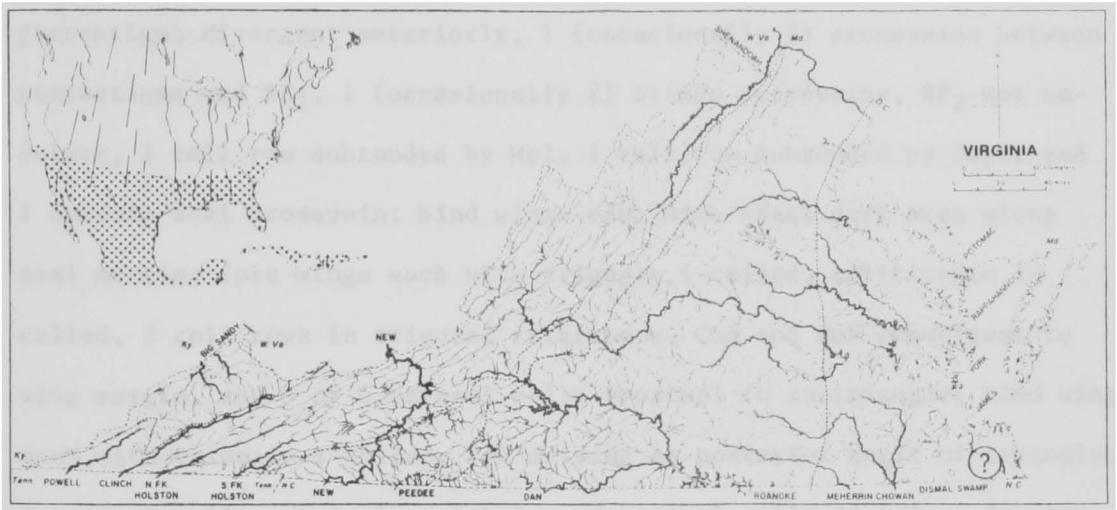


Figure 195. Geographic distribution of *Macrodiplax balteata*.

Genus *Miathyria* Kirby 1889Syn.: *Nothifixis* Navas

Kirby 1889. Ann. Nat. Hist. 14:258.

Type Species.--*Libellula simplex* Rambur.

Diagnosis.--Posterior margin of pronotum directed posterodorsally without medial notch; apical 3 or 4 spines of outer spine row of hind femora not greatly lengthened; wings each with proximal and distal margins of pterostigma divergent anteriorly, 1 (occasionally 2) crossveins between pterostigma and RP_1 , 1 (occasionally 2) bridge crossveins, RP_2 not undulate, 1 cell row subtended by Mpl , 1 cell row subtended by $Cupl$, and 1 cubital anal crossvein; hind wings each with basal dark area along anal margin; fore wings each with triangle 1-celled, subtriangle 1-celled, 2 cell rows in trigonal interspace, CuA and CuP convergent to wing margin, and 5 or 6 paranal cells proximal to subtriangle; hind wings each with triangle 1-celled, CuP arising at posterior angle of triangle, 3 paranal cells proximal to fibulum, 2 paranal cells distal to fibulum, anal loop well developed, and midrib angulated at ca. 40° at ankle; abdominal sternum 1 of male without paired processes; abdominal tergum 3 with well-developed lateral carinae; abdominal tergum 4 without supplementary transverse carina at antecostal suture; abdominal tergum 9 with weakly developed lateral carinae.

Remarks.--Both the genera *Miathyria* and *Tauriphila* may represent subgenera of *Macrodiplax*. These genera are primarily based on wing vein characteristics which apparently show a correlation with body size.

Miathyria marcella (Selys)

(Figure 196)

Selys 1857. In Sagra, Hist. Cuba, Ins., p. 452 (in *Libellula*).

Length 34-40 mm; abdomen 23-27 mm; hind wings 29-33 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of FL, LA, and TX, and also from Tamaulipas, Mexico, and from Cuba, Jamaica, and Puerto Rico, and south to Argentina.

Flight Season.--Year-round southward.

Biology.--*Miathyria marcella* inhabits ponds and marsh-bordered lakes.

Remarks.--This species doubtfully occurs in Virginia. However, it is abundant in Florida and occasional immigrants may enter eastern Virginia.

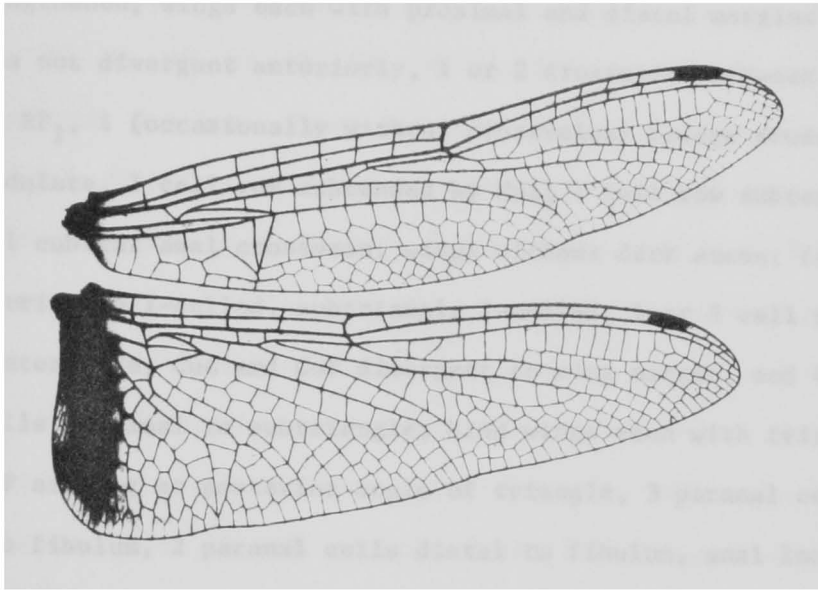


Figure 196. Wings of *Miathyria marcella* x3.

Genus *Nannothemis* Brauer 1868Syn.: *Aino* Kirby

Brauer 1868. Verh. Zool.-Bot. Ges. Wien 18:329.

Type Species.--*Nannophya bella* Uhler.

Diagnosis.--Posterior margin of pronotum directed posteriorly without medial notch; apical 3 or 4 spines of outer spine row of hind femora not greatly lengthened; wings each with proximal and distal margins of pterostigma not divergent anteriorly, 1 or 2 crossveins between pterostigma and RP_1 , 1 (occasionally without crossveins) bridge crossvein, RP_2 not undulate, 1 cell row subtended by Mpl , 1 cell row subtended by $Cupl$, and 1 cubital anal crossvein; wings without dark areas; fore wings each with triangle 1-celled, subtriangle 1-celled, 1 or 2 cell rows in trigonal interspace, CuA and CuP divergent to wing margin, and 4 or 5 paranal cells proximal to subtriangle; hind wings each with triangle 1-celled, CuP arising at posterior angle of triangle, 3 paranal cells proximal to fibulum, 2 paranal cells distal to fibulum, anal loop not well developed, and midrib angulated at ca. 35° at ankle; abdominal sternum 1 of male without paired processes; abdominal tergum 3 with well-developed lateral carinae; abdominal tergum 4 without supplementary transverse carina at antecostal suture; abdominal tergum 9 with well-developed lateral carinae.

Nannothemis bella (Uhler)Syn.: *puella* Kirby

(Figures 197, 198)

Uhler 1857. Proc. Acad. Phila., p. 87 (in *Nannophya*).

Length 17-21.5 mm; abdomen 11-14 mm; hind wings 14-16.5 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AL, CT, FL, GA, IN, KY, LA, ME, MD, MA, MI, MS, NH, NJ, NY, NC, OH, PA, SC, VA, and WI; and the provinces of Ont. and Que. Known from the Virginia county of Northumberland. Known distribution among the counties of neighboring states include: Kentucky- Edmonson, Hardin, and McCreary; Maryland- Prince Georges; North Carolina- Hoke, Montgomery, and Moore; Pennsylvania- Lehigh, Monroe, Philadelphia, and Pike.

Virginia Records.--Northumberland Co.; Great Wicomico R., 19 June 1890, 2 males, C. W. Johnson, (Det. C. W. Johnson), ANSP.

Flight Season.--Apr. 18 (MS) to Sept. 5 (NJ); in Virginia June 19. Known season in neighboring states are: Kentucky- May to June 9; Maryland- May 22 to Aug. 25; North Carolina- May to July 10; Pennsylvania- June 8 to July 23.

Biology.--*Nannothemis bella* inhabits shallow margins of marshes and bogs. Exuviae have been found to be most common where the water is less than 2 cm deep and emergent vegetation at a density of 1-4 stems per square decimeter. Exuviae are typically found on emergent vegetation 3-8 cm above water. Adults are weak flyers, seldom flying more than 15 cm above the water surface. Males typically perch on emergent vegetation

at from 5-15 cm above water. Females oviposit in the areas where the exuviae are found, but are more often found back from the shoreline.

Remarks.--This species is the smallest anisopterous dragonfly in North America. Although its distribution encompasses Eastern North America it is extremely local in occurrence, being reported only once from Virginia.

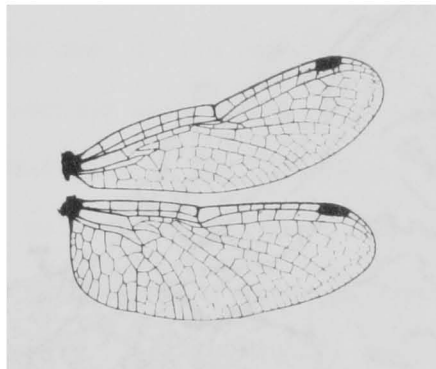


Figure 197. Wings of *Nannothemis bella* x3.

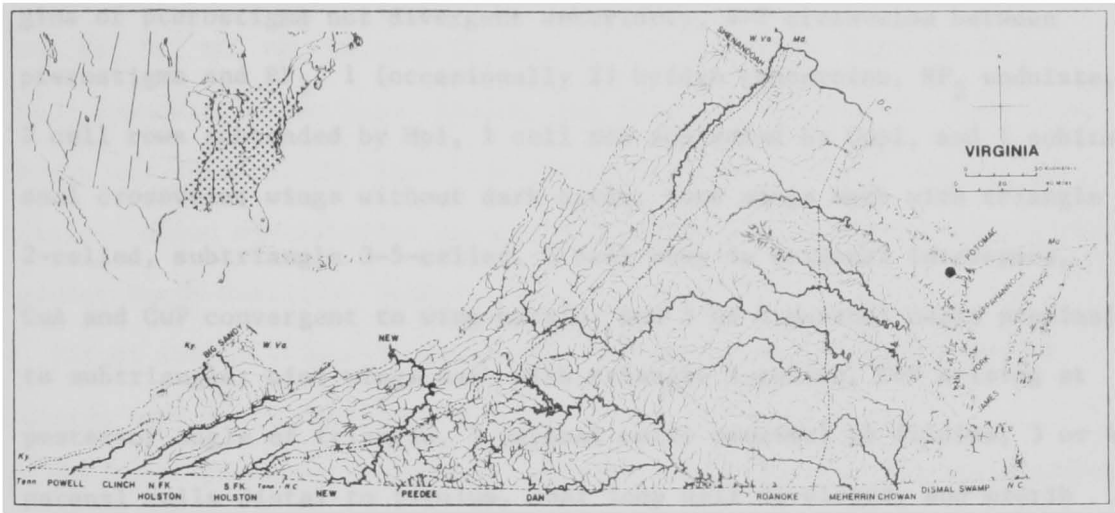


Figure 198. Geographic distribution of *Nannothemis bella*.

Genus *Orthemis* Hagen 1861Syn.: *Neocysta* Kirby

Hagen 1861. Syn. Neur. N. Amer., p. 160.

Type Species.--*Libellula ferruginea* Fabricius.

Diagnosis.--Posterior margin of pronotum directed posterodorsally without medial notch; apical 3 or 4 spines of outer spine row of hind femora not greatly lengthened; wings each with proximal and distal margins of pterostigma not divergent anteriorly, 4-7 crossveins between pterostigma and RP_1 , 1 (occasionally 2) bridge crossveins, RP_2 undulate, 2 cell rows subtended by Mpl , 1 cell row subtended by $Cup1$, and 1 cubital anal crossvein; wings without dark areas; fore wings each with triangle 2-celled, subtriangle 3-5-celled, 3 cell rows in trigonal interspace, CuA and CuP convergent to wing margin, and 5 or 6 paranal cells proximal to subtriangle; hind wings each with triangle 1-celled, CuP arising at posterior angle of triangle, 3 paranal cells proximal to fibulum, 3 or 4 paranal cells distal to fibulum, anal loop well developed, and midrib angulated at ca. 40° at ankle; abdominal sternum 1 of male without paired processes; abdominal tergum 3 with well-developed lateral carinae; abdominal tergum 4 without supplementary transverse carina at antecostal suture; abdominal tergum 9 with lateral carinae well developed in male and weakly developed in female.

Remarks.--If *Belonia*, *Ladona*, *Plathemis*, and *Platetrum* are considered subgenera of *Libellula* as suggested by Walker and Corbet (1975), then *Orthemis* should probably also be considered a subgenus of *Libellula*. *Orthemis* is similar to *Plathemis* and *Platetrum* in the shape of the posterior hamuli and in the development of lateral abdominal carinae.

Orthemis ferruginea (Fabricius)Syn.: *discolor* Burmeister, *macrostigma* Rambur

(Figures 199, 200)

Fabricius 1775. Syst. Entomol., p. 423 (in *Libellula*).

Length 48-55 mm; abdomen 32-39 mm; hind wings 37-44 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AL, AZ, AR, CA, FL, GA, LA, MS, NV, NM, NC, OK, TX, and UT, and also from Mexico- Baja CA, Chihuahua, Coahuila, Nuevo leon, Sonora, and Tamaulipas; Antilles- Cuba, Dom. Rep., and Jamaica; and also from Puerto Rico and south to Uruguay and Chile. Known distribution among the counties of neighboring states include: North Carolina- Pender.

Flight Season.--Year-round southward. Known season in neighboring states are: North Carolina- Aug. 5.

Biology.--*Orthemis ferruginea* inhabits ponds and slow-flowing streams. Adult males generally perch at from 1-3 m. This species is wary and swift of flight but will habitually return to favored perch sites after being disturbed.

Remarks.--This species is distinguished by the purplish red abdomen of mature males. It may occur as far north as eastern Virginia.

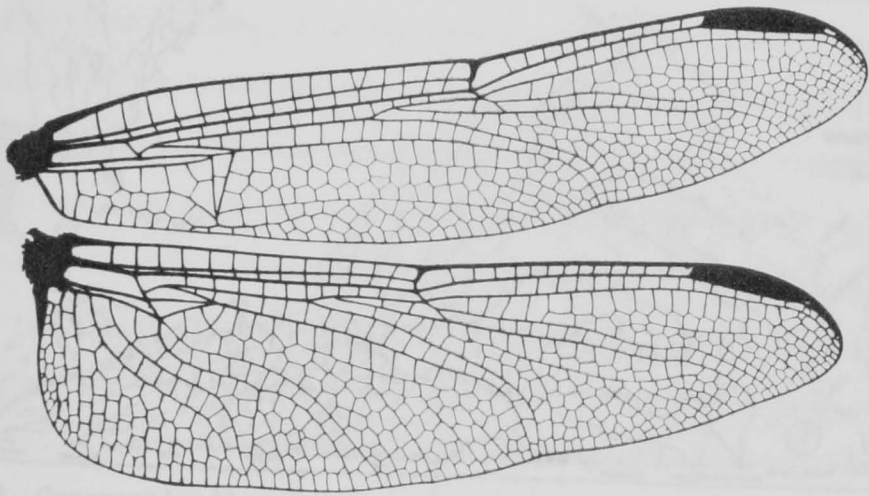


Figure 199. Wings of *Orthemis ferruginea* x3.

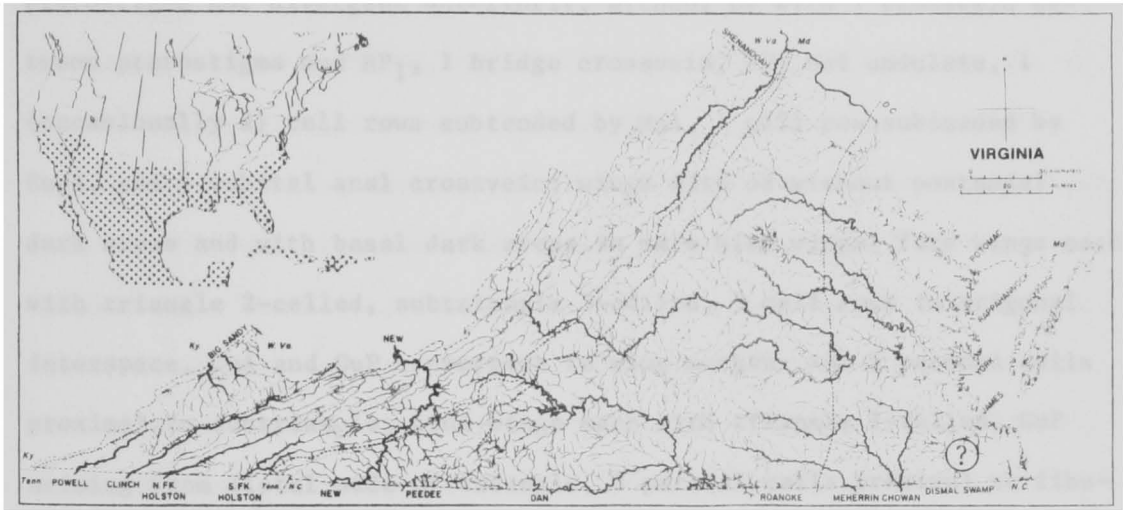


Figure 200. Geographic distribution of *Orthemis ferruginea*.

Genus *Pachydiplax* Brauer 1868

Brauer 1868. Verh. Zool.-Bot. Ges. Wien 18:368.

Type Species.--*Libellula longipennis* Burmeister.

Diagnosis.--Posterior margin of pronotum directed dorsally with small medial notch; apical 3 or 4 spines of outer spine row of hind femora not greatly lengthened; wings each with proximal and distal margins of pterostigma not divergent anteriorly, without or with 1 crossvein between pterostigma and RP_1 , 1 bridge crossvein, RP_2 not undulate, 1 (occasionally 2) cell rows subtended by Mpl , 1 cell row subtended by Cup_1 , and 1 cubital anal crossvein; wings with or without postnodal dark areas and with basal dark areas in male hind wings; fore wings each with triangle 2-celled, subtriangle 3-celled, 3 cell rows in trigonal interspace, CuA and CuP convergent to wing margin, and 5 paranal cells proximal to subtriangle; hind wings each with triangle 1-celled, CuP arising from distal side of triangle, 3 paranal cells proximal to fibulum, 3 paranal cells distal to fibulum, anal loop well developed, and midrib angulated at ca. 40° at ankle; abdominal sternum 1 of male without paired processes; abdominal tergum 3 with well-developed lateral carinae; abdominal tergum 4 without supplementary transverse carina at antecostal suture; abdominal tergum 9 with well-developed lateral carinae.

Pachydiplax longipennis (Burmeister)

(Figures 201, 202)

Burmeister 1839. Handb., p. 850 (in *Libellula*).

Length 31-45 mm; abdomen 20-36 mm; hind wings 26-42 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AL, AZ, AR, CA, CO, CT, DC, FL, GA, ID, IL, IN, IA, KS, KY, LA, ME, MD, MA, MI, MN, MS, MO, MT, NE, NV, NJ, NM, NY, NC, OH, OK, OR, PA, RI, SC, SD, TN, TX, UT, VA, WA, WV, WI, and WY, and the provinces of B.C., Man., and Ont., and also from Baja CA and Coahuila, Mexico, and from the Bermudas and Bahamas. Known from the Virginia counties of Albemarle, Alleghany, Augusta, Bedford, Charles City, Charlotte, Chesterfield, Craig, Culpeper, Essex, Fairfax, Giles, Goochland, Hanover, Henrico, Highland, James City, Lancaster, Lee, Loudoun, Louisa, Montgomery, Northampton, Pittsylvania, Powhatan, Prince William, Pulaski, Rockbridge, Russell, Spotsylvania, Sussex, Washington, Westmoreland, Wythe, and York, and the cities of Chesapeake, Newport News, Norfolk, Portsmouth, Richmond, Suffolk, and Virginia Beach. Known distribution among the counties of neighboring states include: Kentucky- Allen, Ballard, Barren, Bell, Breckinridge, Bullitt, Butler, Carter, Casey, Edmonson, Fayette, Floyd, Fulton, Green, Hardin, Harrison, Hart, Henderson, Hickman, Hopkins, Jefferson, Marion, McCreary, Meade, Metcalfe, Ohio, Oldham, Pike, Pulaski, Russell, Taylor, Todd, Trigg, Union, and Warren; Maryland- Wicomico and Worchester; North Carolina- Buncombe, Dare, Northampton, and Pamlico; Pennsylvania- Allegheny, Beaver, Berks, Bradford, Bucks, Butler, Cambria, Centre, Chester,

Clearfield, Clinton, Crawford, Delaware, Erie, Fayette, Franklin, Fulton, Greene, Huntingdon, Juniata, Lawrence, Lebanon, Lehigh, Luzerne, Monroe, Montgomery, Northampton, Northumberland, Perry, Philadelphia, Schuylkill, Somerset, Sullivan, Union, Venago, Warren, Westmoreland, and York; Tennessee-- Anderson, Blount, Campbell, Carroll, Coffee, Davidson, Dickson, Fentress, Hamblen, Hardin, Humphreys, Knox, Marion, Montgomery, Monroe, Obion, Rutherford, Sullivan, and Williamson; West Virginia-- Dodridge, Gilmer, Greenbrier, Pendleton, Putnam, Raleigh, and Ritchie.

Virginia Records.--Albemarle Co.; Charlottesville, 6 May 1948, 1 male, R. L. Hoffman, (Det. LKG); Huntley Hall in Charlottesville, 6 May 1948, 1 male, J. T. Calhoun, (Det. J. T. Calhoun), MZUM. Alleghany Co.; Griffith, 18 May 1950, 1 male, R. L. Hoffman, (Det. LKG); Griffith, 21 June 1951, 1 male, R. L. Hoffman, (Det. LKG); Jordan Mines, 20 July 1951, 1 male, R. L. Hoffman, (Det. LKG). Augusta Co.; Shenandoah Pd., 13 June 1980, 1 male, 2 females (pair in tandem), FLC; Shenandoah Pd., 17 July 1980, 2 males, 1 female, BCK. Bedford Co.; locality unknown, 14 June 1968, 1 male, S. Stephenson, VPI&SU. Charles City Co.; Marl pit on Rt. 5, 23 May 1938, 1 female, MED, VPI&SU; Harrison Lk. at Roxbury, 1 June 1938, 1 male, R. Hess, (Det. A. D. Hess), A. D. Hess Collection; Harrison Lk. at Roxbury, 12 June 1938, 5 males, R. Hess, (Det. A. D. Hess), A. D. Hess Collection; Herring Cr. Rd. on Rt. 5, 5 July 1938, 1 male, MED, VPI&SU; Marl pit on Rt. 5, 1 Aug. 1937, 2 males, 1 female, D. W. Davis and MED, VPI&SU; Berkeley Mills, 5 Sept. 1937, 6 males, MED, VPI&SU; Fish Hatchery Pd., 21 Sept. 1966, 1 male, MDR, VPI&SU. Charlotte Co.; Twittys Cr. at Rt. 642, 10 June 1975, 1 female,

FLC; Gee's Pd. at Keysville, 23 June 1938, 4 males, MED, VPI&SU; Twittys
 Cr. at Rt. 642, 22 July 1978, 1 female, FLC; Keysville pd., 10 Aug.
 1938, 2 males, J. T. Baldwin, VPI&SU; 1 mile W. of Keysville, 21 Aug.
 1938, 1 male, J. T. Baldwin, (Det. MED, MDR notes); Keysville pd., 24
 Aug. 1938, 5 males, J. T. Baldwin, VPI&SU. Chesterfield Co.; locality
 unknown, 20 June 1975, 3 males, R. H. Nugent, VCU; locality unknown, 24
 June 1968, 1 male, M. P. May, VCU; Pocahontas State Park, 24 June 1968,
 1 male, D. R. Good, VCU; locality unknown, 8 July 1975, 1 male, R. H.
 Nugent, VCU; locality unknown, 20 July 1973, 1 male, M. Lacy, VCU.
 Craig Co.; Johns Cr. at Rt. 311, 14 June 1974, 1 male, FLC; Broad Run,
 14 June 1960, 1 male, 1 female, E. M. Raff, VPI&SU. Culpeper Co.; lo-
 cality unknown, 12 June 1961, 1 female, RRM, VCU; Woodland Pd. off Rt.
 743, 15 July 1980, 2 males, 1 female, BCK. Essex Co.; Dunbrooke, 28
 July 1899, 1 male, RPC, USNM; Dunbrooke, 29 July 1899, 1 female, RPC,
 USNM. Fairfax Co.; Burke Lk. Park, 18 May 1965, 1 male, OSF, USNM;
 Great Falls, 26 May 1914, 1 male, 1 female, RPC, USNM; Great Falls, 2
 June 1914, 1 male, 1 female, RPC, USNM; Great Falls, 17 June 1914, 2
 males, RPC, USNM; Hunting Cr., 23 June 1973, 1 male, C. R. Parker,
 VPI&SU; Great Falls, 25 June 1914, 2 males, RPC, USNM; Great Falls, 8
 July 1914, 2 males, RPC, USNM; Great Falls, 8 July 1915, 1 male, V.
 Busck, USNM; Great Falls, 10 July 1914, 1 male, RPC, USNM; Great Falls,
 12 July 1915, 1 male, V. Busck, USNM; Great Falls, 12 July 1915, 1 male,
 1 female, F. Chestnut, USNM; Dyke, 16 July 1916, 1 male, W. L. McAtee,
 USNM; Great Falls, 23 July 1914, 1 male, BPC, USNM; Great Falls, 24
 Aug. 1915, 1 male, RPC, USNM. Giles Co.; Sinking Cr., 28 May 1975, 2
 males, FLC; Pembroke, 6 Aug. 1949, 1 male, C. F. Byers, (Det. C. F.

Byers, Byers 1951). Goochland Co.; locality unknown, 28 July 1969, 1 male, A. E. Davies, VCU. Hanover Co.; N. Anna R. at falls, 6 July 1977, 1 female, BCK; locality unknown, 29 July 1969, 1 male, C. Davis, VCU. Henrico Co.; locality unknown, 3 July 1975, 1 male, 2 females, C. Seranage, VCU. Highland Co.; Buck Run beaver pds., 3, 4 July 1971, 2 males, OSF, USNM. James City Co.; Jollys Pd., 16 May 1938, 1 male, MED, VPI&SU; Lily Pd. on Rt. 612, 27 May 1967, 1 male, MDR, VPI&SU; Kingsmill Pd., 4 June 1967, 2 males, 5 females, MDR, VPI&SU; Ewell Pd., 6 June 1967, 1 female, MDR, VPI&SU; Lk. Powell at Williamsburg, 7 June 1938, 1 female, MED, VPI&SU; Little Pd. on Jamestown Rd., 7 June 1938, 1 male, 1 female, MED, VPI&SU; Jamestown, 9 June 1938, 1 male, 1 female, MED, VPI&SU; Reservoir nr. Fort Eustis, 29 June 1938, 2 males, MED, VPI&SU; Lk. Matoaka, 1 July 1937, 1 male, CC, (Det. CC); Jamestown Island, 4 July 1937, 1 female, CC, (Det. CC); Lk. Powell at Williamsburg, 18 July 1937, 1 male, MED, VPI&SU; Lk. Powell at Williamsburg, 23 July 1937, 1 male, MED, VPI&SU; Lk. Powell at Williamsburg, 6 Aug. 1937, 1 male, V. M. Davis and MED, VPI&SU; Lk. Matoaka at Williamsburg, 15 Aug. 1937, 2 males, 2 females, MED, VPI&SU; Riverview at Norge, Sept. 1932, 5 nymphs, (Det. MED), CUC; Tutters Neck Pd., 15 Sept. 1966, 2 males, MDR, VPI&SU; Riverview Pd., 18 Sept. 1966, 1 male, MDR, VPI&SU; Pd. at Bassett Hall at Williamsburg, 22 Sept. 1966, 2 males, 1 female, MDR, VPI&SU. Lancaster Co.; locality unknown, 22 July 1977, 1 female, J. O'Hop, ODU. Lee Co.; Keokee Lk., 3 July 1977, 7 males, 2 females, FLC. Loudoun Co.; locality unknown, 12 Aug. 1971, 2 females, T. Muir, VPI&SU. Louisa Co.; N. Anna R. at Rt. 208, 1 nymph, collector unknown, (Det. S. S. Roback, Roback and Westfall, 1967); Lk. Anna backwater, 28 June 1973, 3 males,

C. M. Flint and OSF, USNM; S. Anna R. at Rt. 657, 5 July 1977, 1 male, BCK. Montgomery Co.; Blacksburg, 15 Apr. 1948, 1 male, T. K. Burton, VPI&SU; Blacksburg, 18 Apr. 1947, 1 male, A. B. Culbertson, VPI&SU; locality unknown, 26 Apr. 1974, 1 female, D. S. Stout, VPI&SU; Blacksburg, 3 May 1947, 1 male, M. A. Byrd, VPI&SU; Blacksburg, 6 May 1948, 1 male, Crist, VPI&SU; Blacksburg, 7 May 1948, 1 male, P. S. Smith, VPI&SU; locality unknown, 9 May 1958, 1 male, LeGallais, VPI&SU; Blacksburg, 10 May 1948, 1 male, 1 female, W. E. Ellis, VPI&SU; Blacksburg, 12 May 1953, 1 male, L. Scrmient, VPI&SU; Blacksburg, 15 May 1948, 1 male, E. C. Cockrell, VPI&SU; Blacksburg, 17 May 1948, 2 males, T. K. Burton, VPI&SU; Blacksburg, 17 May 1947, 1 male, J. M. Crockert, VPI&SU; Blacksburg, 18 May 1958, 1 male, D. Hubbell, VPI&SU; Blacksburg, 20 May 1948, 2 males, Boush, VPI&SU; Blacksburg, 21 May 1958, 1 female, N. T. Bardner, VPI&SU; Blacksburg, 21 May 1961, 1 male, H. Bolden, VPI&SU; Toms Cr. marsh 0.5 mile downstream from Rt. 655, 24 May 1973, 1 female, FLC; Blacksburg, 25 May 1965, 3 males, 1 female, B. Guthrie, VPI&SU; Blacksburg, 26 May 1958, 1 male, D. L. Farris, VPI&SU; Blacksburg, 26 May 1947, 1 male, N. C. Holbrook, VPI&SU; Blacksburg, 26 May 1958, 1 male, S. W. Bell, VPI&SU; Blacksburg, 26 May 1958, 1 male, A. J. Hart, VPI&SU; Blacksburg, 27 May 1948, 1 male, E. C. C., VPI&SU; Blacksburg, 29 May 1947, 1 male, R. F. Sutton, VPI&SU; oxbow of Toms Cr., 8 June 1974, 1 male, FLC; Toms Cr. at Rt. 655, 11 June 1978, 1 female, BCK; Pandapas Pd., 14 June 1974, 1 female, FLC; Blacksburg, 14 June 1975, 1 male, T. E. Bailey, VPI&SU; Blacksburg, 16 June 1952, 1 male, H. Jordan, VPI&SU; Blacksburg, 20 June 1948, 1 male, 1 female, G. M. Boush, VPI&SU; Poverty Valley, 25 June 1960, 3 males, RRM, VCU; Blacksburg, 25 June 1948, 5

males, 1 female, G. M. Boush, VPI&SU; Blacksburg, 30 June 1961, 1 male,
 B. Davis, VCU; Blacksburg, 3 July 1948, 1 male, G. M. Boush, VPI&SU;
 Pandapas Pd., 10 July 1977, 1 male, BCK; Pandapas Pd., 15 July 1974, 1
 male, FLC; Kelly's Pd. in Blacksburg, 18 July 1977, 1 male, S. Mudre,
 VPI&SU; Pandapas Pd., 28 July 1973, 1 male, FLC; VPI&SU Duck Pd., 30
 July 1948, 1 male, C. F. Byers, (Det. C. F. Byers, Byers 1951); Heath
 Pd. off Rt. 685 in Blacksburg, 1 Aug. 1977, 1 male, 1 female (in tandem),
 FLC; Blacksburg, 26 Sept. 1964, 1 female, Bobb, VPI&SU. Northampton
 Co.; Curtis Pd. at Savage Neck, 1 June 1937, 2 males, F. M. Jones, VPI&
 SU. Pittsylvania Co.; Johnson Farm pd. at Renan, 21 June 1980, 1 male,
 T. Williams, FLC Collection. Powhatan Co.; locality unknown, 27 June
 1975, 1 male, D. Custer, VCU; locality unknown, 27 June 1975, 3 males,
 R. Kelley, VCU; locality unknown, 27 June 1975, 2 males, M. Zimmerman,
 VCU; locality unknown, 9 July 1975, 1 female, R. H. Nugent, VCU. Prince
 William Co.; Prince William Forest Park, 19 Aug. 1973, 1 male, OSF,
 USNM. Pulaski Co.; Gatewood Reservoir, 29 June 1973, 1 female, FLC.
 Rockbridge Co.; Guys Run, 28 June 1978, 1 male, M. Meschter. Russell
 Co.; Laurel Bed Lk., 4 July 1977, 2 males, FLC. Spotsylvania Co.;
 swamp off Rt. 617, 7 July 1978, 1 male, FLC. Sussex Co.; locality un-
 known, 6 June 1975, 1 male, J. Hancock, ODU. Washington Co.; small pd.
 along Rt. 663, 15 June 1980, 1 male, FLC. Westmoreland Co.; nr. Coles
 Point, 27 June 1917, 1 male, 1 female, J. E. Benedict, USNM. Wythe Co.;
 Wytheville, 29 June 1935, 10 males, 5 females, CA, (Det. CA). York Co.;
 Jones Pd., 9 July 1938, 1 male, MED, VPI&SU; Yorktown, 7 Aug. 1948, 1
 male, R. L. Hoffman, (Det. LKG); Brackens Pd. on Colonial Parkway, 16
 Sept. 1966, 1 male, 3 females, MDR, VPI&SU; Jonesmill Pd. on Colonial

Parkway, 16 Sept. 1966, 1 male, 1 female, MDR, VPI&SU; Cr. at Wallers Pd., 17 Sept. 1966, 1 male, 3 females, MDR, VPI&SU; Upper Wallers Pd., 18 Sept. 1966, 2 females, MDR, VPI&SU; Newman Pd., 18 Sept. 1966, 2 males, 2 females, MDR, VPI&SU. City of Chesapeake; Dismal Swamp Wildlife Refuge, 5 Sept. 1974, 1 male, D. P. Chilos, VPI&SU; Lk. Drummond, 28 Sept. 1915, 1 female, H. S. Barber, USNM. City of Newport News; Warwick R. at Denbigh, 30 July 1938, 1 female, MED, (Det. MED, MDR notes). City of Norfolk; Airport, 25 May 1970, 2 males, 1 female, JFM, ODU; locality unknown, 11 June 1973, 2 males, 1 female, JFM, ODU; locality unknown, 13 June 1975, 1 male, FLC; Ocean View, 9 Aug., 1 individual, A. N. Caudell, (Det. A. N. Caudell), USNM. City of Portsmouth; Portsmouth City Park, 25 Aug. 1938, 1 male, 1 female, T. D. McCahill, VPI&SU. City of Richmond; Maymont Park, 29 May 1975, 1 female, J. Cook, VCU; James R., 17 June 1974, 1 male, M. Driscoll, VCU; Maymont Park, 25 June 1973, 2 males, N. G. Evenson, VCU; Maymont Park, 6 July 1975, 1 male, J. A. Florence, VCU; Maymont Park, 13 July 1973, 1 male, K. Beck, VCU; Maymont Park, 13 July 1973, 2 males, J. Krolak, VCU; Maymont Park, 13 July 1973, 1 male, T. Slate, VCU; Maymont Park, 13 July 1973, 2 males, 1 female, W. Smith, VCU; Maymont Park, 13 July 1973, 2 males, J. Verburg, VCU; Maymont Park, 15 July 1973, 1 male, J. Gainer, VCU; Maymont Park, 20 July 1969, 1 male, Droppleman, VCU; Maymont Park, 26 July 1969, 1 male, Droppleman, VCU. City of Suffolk; locality unknown, 10 May 1973, 1 male, P. W. Larkins, VPI&SU; Jericho Ditch in Dismal Swamp Wildlife Refuge, 1 June 1970, 1 male, JFM, ODU; Jericho Lane in Dismal Swamp Wildlife Refuge, 22 June 1975, 1 female, FLC; Dismal Swamp Wildlife Refuge, 2 July 1973, 6 males, 1 female, JFM, ODU; ditch nr. Holland, 15

July 1975, 1 male, J. W. Jenkins, VPI&SU; Dismal Swamp Wildlife Refuge, 29 July 1974, 2 males, J. Hancock, ODU; Holland, 24 July 1975, 1 female, J. W. Jenkins, VPI&SU; Dismal Swamp Wildlife Refuge, 12 Aug. 1974, 4 males, J. Hancock, ODU; Green Acres nr. Churchland, 27 Aug. 1938, 1 male, T. D. McCahill, (Det. T. D. McCahill); Cypress Chapel, 13, 14 Sept. 1934, 5 males, 1 female, LKG, (Det. LKG, Gloyd 1951). City of Virginia Beach; White Lk. at Seaside State Park, 22 May 1977, 1 male, 3 females (teneral), FLC; Back Bay Refuge, 25 May 1975, 2 females, J. O'Hop, ODU; Fort Story, 2 June 1970, 4 females, JFM, ODU; Cape Henry at Seashore State Park, 11 June 1974, 2 males, D. Davis and M. Davis, USNM; Back Bay Refuge, 26 June 1973, 2 males, 5 females, JFM, ODU; Cape Henry at Seashore State Park, 26 June 1971, 6 males, 4 females, R. H. Perry, VPI&SU; Cape Henry, 9 July 1962, 3 males, OSF, USNM; Cape Henry, Aug. 1916, 1 female, M. Carmody, USNM; Back Bay at Sand Bridge Rd., 14 Aug. 1977, 1 male, JRV, VPI&SU; White Lk. at Seashore State Park, 16 Sept. 1974, 1 male, JFM, ODU.

Flight Season.--Year-round (FL); in Virginia Apr. 15 to Sept. 28. Known season in neighboring states are: District of Columbia- July 8; Kentucky- Apr. 12 to Oct. 6; Maryland- July 10 to Sept. 5; North Carolina- Apr. to Oct. 15; Pennsylvania- May 1 to Sept. 30; Tennessee- May 5 to Sept. 5; West Virginia- June 22 to Aug. 20.

Biology.--*Pachydiplax longipennis* inhabits swamps, marshes, slow-flowing streams, ponds, and lakes. The males perch near the nymphal habitat with the wings characteristically inclined downward.

Remarks.--This species is distinguished by the absence of crossveins under the proximal 3/4 of the pterostigma. It is a wide-ranging species.

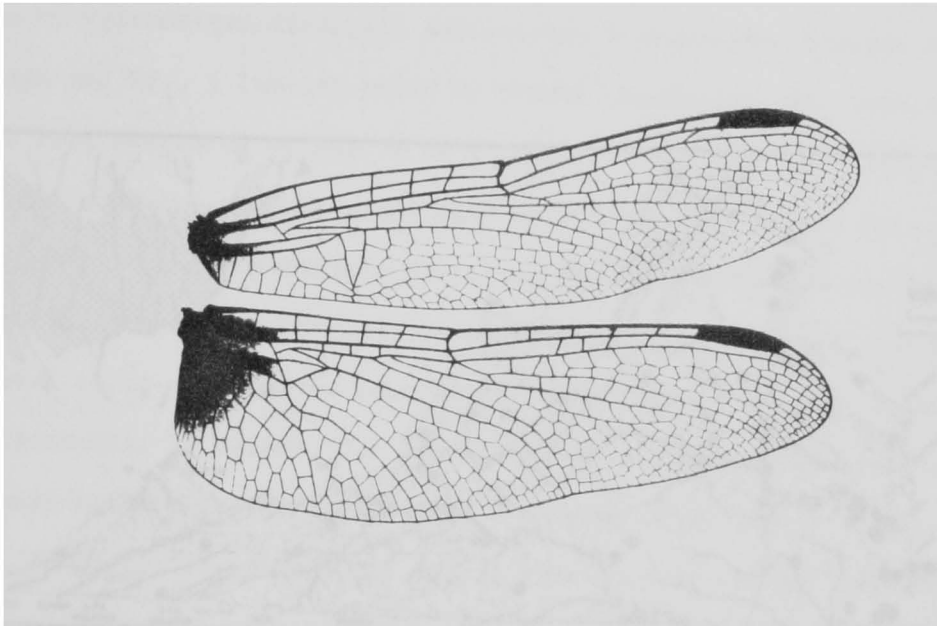


Figure 201. Wings of *Pachydiplax longipennis* x3.

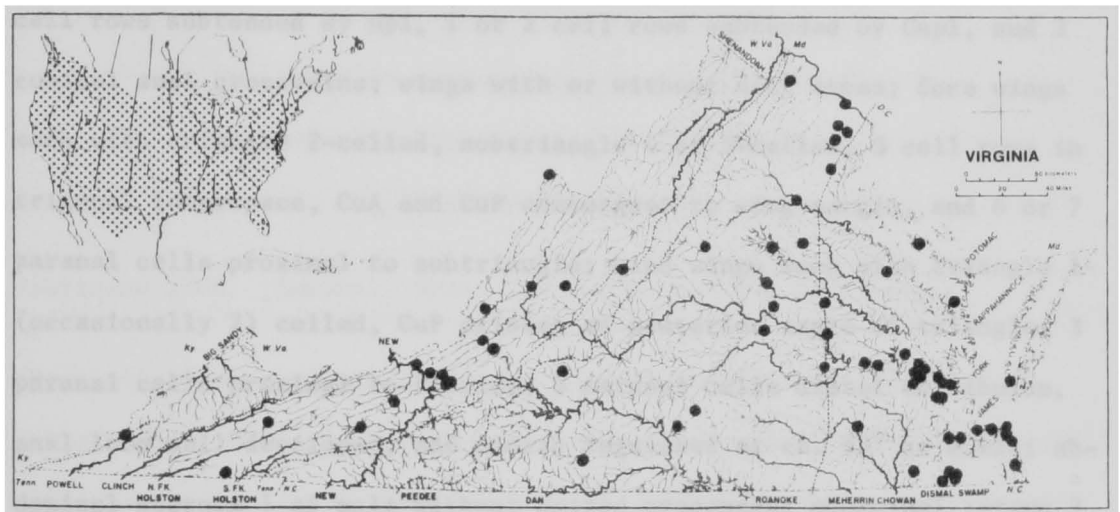


Figure 202. Geographic distribution of *Pachydiplax longipennis*.

Genus *Pantala* Hagen 1861

Hagen 1861. Syn. Neur. N. Amer., p. 141.

Type Species.--*Libellula flavescens* Fabricius.

Diagnosis.--Posterior margin of pronotum directed posterodorsally without medial notch; apical 3 or 4 spines of outer spine row of hind femora not greatly lengthened; wings each with proximal and distal margins of pterostigma divergent anteriorly, 2 crossveins between pterostigma and RP_1 , 1 (occasionally 2) bridge crossveins, RP_2 undulate, 2 cell rows subtended by Mpl , 1 or 2 cell rows subtended by Cup_1 , and 2 cubital anal crossveins; wings with or without dark areas; fore wings each with triangle 2-celled, subtriangle 4 or 5-celled, 3 cell rows in trigonal interspace, CuA and CuP convergent to wing margin, and 6 or 7 paranal cells proximal to subtriangle; hind wings each with triangle 1- (occasionally 2) celled, CuP arising at posterior angle of triangle, 3 paranal cells proximal to fibulum, 3 paranal cells distal to fibulum, anal loop well developed, and midrib angulated at ca. 35° at ankle; abdominal sternum 1 of male without paired processes; abdominal tergum 3 without well-developed lateral carinae; abdominal tergum 4 and 5 with supplementary transverse carina at antecostal suture; abdominal tergum 9 with well-developed lateral carinae.

Species Key to Adult *Pantala*

1. Hind wings each without opaque brown spot near anal angle; middorsal carinae of abdominal segment 5 longer than posterolateral carinae of segment 6 *P. flavescens* p. 858

Hind wings each with opaque brown spot near anal angle; middorsal carinae of abdominal segment 5 ca. as long as posterolateral carinae of segment 6 *P. hymenaea* p. 860

Pantala flavescens (Fabricius)

Syn.: *analisis* Burmeister, *sparshallii* Curtis,

terminalis Burmeister, *viridula* Beauvais

(Figures 203a, 204a)

Fabricius 1798. Entomol. Syst. Suppl., p. 285 (in *Libellula*).

Length 44-50 mm; abdomen 27-34 mm; hind wings 36-43 mm.

Diagnosis.--Wings each with costa yellow and brown; fore wings each with pterostigma ca. 5 times as long as wide; hind wings each without opaque brown spot near anal angle; abdomen golden-yellow with transverse carinae not brown, ventral surface of terga generally with brown markings; abdominal segment 5 longer than high in lateral view; cerci mostly brown, male cerci each with ventral angulation; male epiproct ca. 3/5 length of cerci, apical teeth not contiguous.

Distribution.--Known from the states of AL, AZ, AR, CA, DC, FL, GA, IL, IN, IA, KS, KY, LA, ME, MD, MA, MI, MS, MO, NE, NV, NH, NJ, NY, NC, OH, OK, PA, RI, SC, TN, TX, VT, VA, WV, and WI, and the provinces of

Man., Nfld., Ont., and Que., and also from Baja CA and Chihuahua, Mexico, and from the Antilles of Cuba, Dom. Rep., Haiti, Jamaica, and Puerto Rico. Known from the Virginia counties of Bath, Charlotte, Henrico, James City, Louisa, and Montgomery, and the cities of Norfolk, Portsmouth, Suffolk, and Virginia Beach. Known distribution among the counties of neighboring states include: Kentucky- Bullitt, Butler, Edmonson, Fulton, Green, Harrison, Hickman, Jefferson, Kenton, Marshall, Ohio, Pike, Pulaski, Taylor, Trigg, Union, and Warren; Maryland- Worchester; North Carolina- Dare and Wake; Pennsylvania- Allegheny, Beaver, Bucks, Butler, Cambria, Centre, Clearfield, Cumberland, Delaware, Erie, Huntingdon, Lancaster, Montgomery, Perry, Philadelphia, Schuylkill, Somerset, Warren, Westmoreland, Wyoming, and York; Tennessee- Anderson, Blount, Cumberland, Davidson, Greene, Jackson, Knox, Obion, Sevier, and Sullivan.

Virginia Records.--Bath Co.; Pd. along Rt. 678 nr. Rt. 627, 2 Oct. 1977, 1 female (teneral), FLC. Charlotte Co.; Twittys Cr. at Rt. 642, 14 June 1975, 1 male, FLC. Henrico Co.; locality unknown, 17 Oct. 1970, 1 male, C. Rowe, VPI&SU. James City Co.; Williamsburg, 30 Sept. 1936, 1 female, collector unknown, (Det. MED, MDR notes); Williamsburg, 11 Oct. 1937, 1 male, MED, VPI&SU; Williamsburg, 12 Oct. 1911, 1 male, collector unknown, VPI&SU. Louisa Co.; N. Anna R. at Rt. 208, date unknown, nymph, S. S. Roback, (Det. S. S. Roback, Roback and Westfall, 1967); N. Anna R. at Rt. 601, 19 Aug. 1977, 1 male, BCK. Montgomery Co.; Pandapas Pd., 15 July 1974, 1 male, FLC; building on Rt. 653, 23 July 1978, 1 female, BCK; Heath Pd. off Rt. 685 in Blacksburg, 1 Aug. 1977, 1 male, FLC; Toms Cr. oxbow, 12 Aug. 1973, 1 male, FLC, VPI&SU;

Heath Pd. off Rt. 685 in Blacksburg, 12 Aug. 1973, 5 males, FLC. City of Norfolk; locality unknown, 2 July 1974, 1 male, 2 females, J. Hancock, ODU; locality unknown, 12 Sept. 1973, 1 male, A. Cambell, ODU. City of Suffolk; Dismal Swamp Wildlife Refuge, 12 Aug. 1974, 1 male, 1 female, J. Hancock, ODU; Dismal Swamp Wildlife Refuge, 19 Aug. 1974, 1 male, J. Hancock, ODU; Cypress Chapel, 14 Sept. 1934, 1 male, LKG, (Det. LKG, Gloyd 1951). City of Portsmouth; Craney Island, 13 Aug. 1973, 2 males, 2 females, D. Laist, ODU. City of Virginia Beach; locality unknown, 14 Sept. 1974, 1 female, Leggett, ODU.

Flight Season.--Year-round southward; in Virginia June 14 to Oct. 17. Known season in neighboring states are: District of Columbia- July 23; Kentucky- June to Sept. 16; Maryland- Aug. 22; North Carolina- May 6 to Oct. 15; Pennsylvania- July 1 to Oct. 15; Tennessee- June 19 to Oct. 16.

Biology.--*Pantala flavescens* inhabits temporary and artificial ponds, and shallow lakes. This is a migratory species which is occasionally observed feeding in large numbers. Adult males patrol near shore at from 1-3 m. Adults are often observed feeding over fields at from 1-5 m.

Remarks.--This species is distinguished by its golden yellow abdomen and lack of a basal brown spot in the wings. It is the only cosmopolitan dragonfly.

Pantala hymenaea (Say)

(Figures 203b, 204b)

Say 1839. J. Acad. Phila., p. 19 (in *Libellula*).

Length 43-50 mm; abdomen 27-34 mm; hind wings 36-42 mm.

Diagnosis.--Wings each with costa brown; fore wings each with pterostigma 6 or 7 times as long as wide; hind wings each with opaque brown spot near anal angle; abdomen brown with transverse carinae brown, ventral surface of terga generally without brown markings; abdominal segment 5 ca. as long as high in lateral view; cerci mostly yellow, male cerci each without ventral angulation; male epiproct ca. $3/4$ length of cerci, apical teeth contiguous.

Distribution.--Known from the states of AL, AZ, AR, CA, CO, DC, FL, GA, IL, IN, IA, KS, KY, LA, ME, MD, MI, MS, MO, NE, NV, NH, NJ, NM, NC, OH, OK, OR, PA, SC, SD, TN, TX, VA, WV, and WI, and the provinces of Man., N.B., and Ont., and also from Baja CA and Coahuila, Mexico, and from Cuba, and also south to Chile. Known from the Virginia counties of Hanover, Henrico, Montgomery, Pulaski, Southampton, and Spotsylvania, and the cities of Norfolk, Portsmouth, and Virginia Beach. Known distribution among the counties of neighboring states include: Kentucky- Breckinridge, Cumberland, Edmonson, Green, Harrison, Henderson, Jefferson, McCreary, Trigg, Wayne, and Whitley; North Carolina- Durham and Wake; Pennsylvania- Allegheny, Centre, Delaware, Erie, Montgomery, and Philadelphia; Tennessee- Davidson, Knox, Obion, Rutherford, and Sullivan; West Virginia- Randolph.

Virginia Records.--Hanover Co.; Rt. 1, 7 July 1978, 1 male, FLC. Henrico Co.; Richmond, 2 Aug. 1931, 1 female, C. F. Byers, FSCA. Montgomery Co.; Heath Pd. off Rt. 685 in Blacksburg, 8 July 1978, 1 male, FLC. Pulaski Co.; Claytor Lk. State Park, 28 June 1973, 2 males, FLC; Claytor Lk. State Park, 2 Aug. 1973, 3 males, FLC. Southampton Co.; Nottoway R. at Rt. 753, 10 Oct. 1978, 1 male (teneral), FLC. Spotsyl-

vania Co.; Rt. 3 nr. Fredericksburg, 16 July 1980, 1 female, BCK. City of Norfolk; locality unknown, 25 Sept. 1974, 1 male, D. P. Childs, ODU. City of Portsmouth; locality unknown, 29 Sept. 1974, 1 female, M. G. Burch, ODU. City of Virginia Beach; locality unknown, 21 Sept. 1974, 1 male, C. Roberts, ODU.

Flight Season.--Apr. 2 (FL) to Dec. 4 (TX); in Virginia June 28 to Oct. 10 (teneral). Known season in neighboring states are: District of Columbia- Sept. 15; Kentucky- June 5 to Aug.; North Carolina- July 7 to Aug. 11; Pennsylvania- May 16 to Sept. 23; Tennessee- June 29 to Aug. 31; West Virginia- July 4.

Biology.--*Pantala hymenea* inhabits temporary and artificial ponds, and lake margins. This is a migratory species. Adult males patrol near shore at from 1-3 m. Adults are frequently observed feeding over fields at from 1-5 m.

Remarks.--This species is distinguished by its brown abdomen and brown spot near the anal angle of the hind wings. It is found throughout Virginia but is less common than *P. flavescens* in the western mountains.

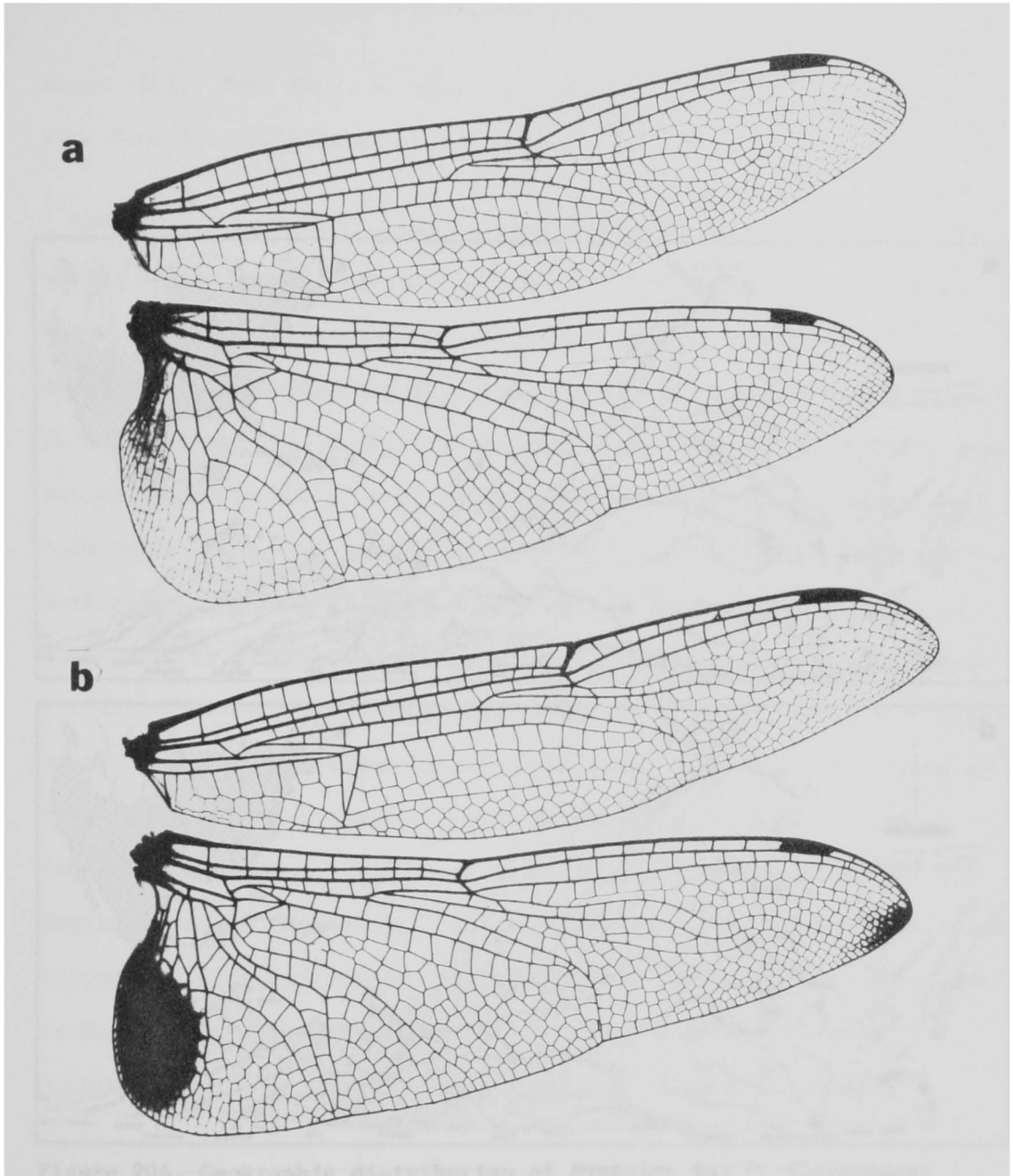


Figure 203. Wings of *Pantala* x3: (a) *P. flavescens*; (b) *P. hymenaea*.

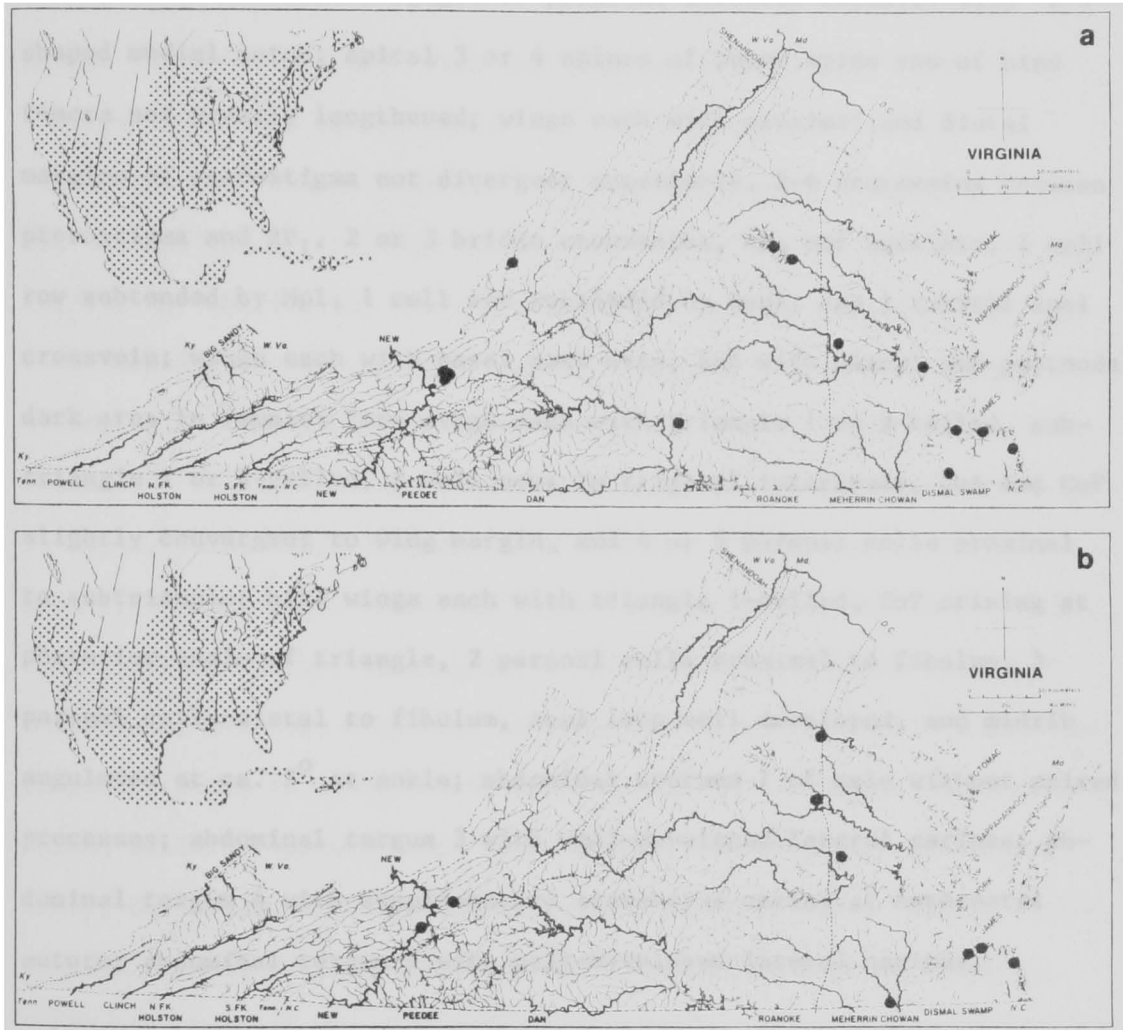


Figure 204. Geographic distribution of *Pantala*: (a) *P. flavescens*; (b) *P. hymenaea*.

Genus *Perithemis* Hagen 1861

Hagen 1861. Syn. Neur. N. Amer., p. 185.

Type Species.--*Libellula domitia* Drury.

Diagnosis.--Posterior margin of pronotum directed dorsally with "V"-shaped medial notch; apical 3 or 4 spines of outer spine row of hind femora not greatly lengthened; wings each with proximal and distal margins of pterostigma not divergent anteriorly, 2-4 crossveins between pterostigma and RP_1 , 2 or 3 bridge crossveins, RP_2 not undulate, 1 cell row subtended by Mpl , 1 cell row subtended by $Cup1$, and 1 cubital anal crossvein; wings each with basal dark area, and with discal and postnodal dark area in female; fore wings each with triangle 1 or 2-celled, sub-triangle 1 or 2-celled, 2 cell rows in trigonal interspace, CuA and CuP slightly convergent to wing margin, and 4 or 5 paranal cells proximal to subtriangle; hind wings each with triangle 1-celled, CuP arising at posterior angle of triangle, 2 paranal cells proximal to fibulum, 3 paranal cells distal to fibulum, anal loop well developed, and midrib angulated at ca. 5° at ankle; abdominal sternum 1 of male without paired processes; abdominal tergum 3 with well-developed lateral carinae; abdominal tergum 4 with supplementary transverse carina at antecostal suture; abdominal tergum 9 with well-developed lateral carinae.

Perithemis tenera (Say)Syn.: *chlora* Rambur, *tenuiseta* Say

(Figures 205, 206)

Say 1839. J. Acad. Phila. 8:31 (in *Libellula*).

Length 20-25 mm; abdomen 12-15 mm; hind wings 16-21 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AL, AR, CT, DC, DE, FL, GA, IL, IN, IA, KS, KY, LA, MD, MA, MI, MS, MO, NE, NH, NJ, NY, NC, OH, OK, PA, RI, SC, TN, TX, VA, WV, and WI, and the province of Ont., and also from Coahuila, Mexico. Known from the Virginia counties of Albemarle, Arlington, Bedford, Charles City, Charlotte, Chesterfield, Cumberland, Dickenson, Essex, Fairfax, Goochland, Hanover, Henrico, Highland, Isle of Wight, James City, King William, Loudoun, Louisa, Mecklenburg, Montgomery, Nelson, Page, Powhatan, Prince George, Prince William, Pulaski, Spotsylvania, Warren, Washington, Wythe, and York, and the cities of Chesapeake, Norfolk, Richmond, Suffolk, and Virginia Beach. Known distribution among the counties of neighboring states include: Kentucky-Allen, Ballard, Barren, Bell, Breckinridge, Bullitt, Butler, Carter, Casey, Christian, Clinton, Cumberland, Edmonson, Fayette, Floyd, Fulton, Grayson, Green, Hardin, Harrison, Hart, Henderson, Hickman, Hopkins, Jefferson, Letcher, Marion, McCreary, Metcalfe, Ohio, Oldham, Pike, Powell, Pulaski, Robertson, Russell, Taylor, Todd, Trigg, Warren, and Wayne; Maryland- Baltimore, Montgomery, Prince Georges, Wicomico, and Worcester; North Carolina- Dare, Guilford, and New Hanover; Pennsylvania- Allegheny, Beaver, Bucks, Cambria, Centre, Chester, Clearfield,

Columbia, Crawford, Cumberland, Dauphin, Delaware, Erie, Franklin, Fulton, Greene, Huntingdon, Indiana, Jefferson, Lebanon, Luzerne, Monroe, Montgomery, Northumberland, Perry, Philadelphia, Pike, Schuylkill, Washington, Wayne, Westmoreland, Wyoming, and York; Tennessee- Blount, Campbell, Carroll, Cumberland, Davidson, Fentress, Giles, Greene, Knox, Monroe, Montgomery, Obion, Rutherford, Sullivan, and Washington; West Virginia- Mason, Pendleton, Putnam, Raleigh, Ritchie, and Summers.

Virginia Records.--Albemarle Co.; Charlottesville, 31 Aug. 1937, 5 males, 2 females (1 pair), MED, (Det. MED, MDR notes); Charlottesville, 1 Sept. 1937, 1 female, MED, (Det. MED, MDR notes). Arlington Co.; Potomac R. at Gravely Point and Roosevelt Island, "June 4 to Sept. 15", (Donnelly 1961); locality unknown, 8 June 1914, 1 female, A. W. J. Pomeroy, USNM. Bedford Co.; locality unknown, 19 June 1968, 1 male, S. Stephenson, VPI&SU; 8 miles W. of Lynchburg, 20 June 1948, 1 male, 2 females, R. L. Hoffman, (Det. LKG); Peaks of Otter Lk., 22 July 1978, 1 male, 1 female (in tandem). Charles City Co.; Harrison Lk. at Roxbury, 12 June 1938, 1 male, R. Hess, (Det. A. D. Hess), A. D. Hess Collection; Harrison Lk. at Roxbury, 28 June 1938, 1 female, R. Hess, (Det. A. D. Hess), A. D. Hess Collection; Berkeley Mills, 5 July 1938, 1 pair, MED, (Det. MED, MDR notes); Fish Hatchery Pds., 21 Sept. 1966, 5 males, MDR, VPI&SU; Harrison Lk. at Fish Hatchery, 21 Sept. 1966, 1 male, MDR, VPI&SU. Charlotte Co.; Twittys Cr. at Rt. 642, 14 June 1975, 1 female, FLC; Twittys Cr. Dam, 18 June 1975, 1 male, 3 females, FLC; 1.5 miles N.W. of Keysville, 10 July 1938, 2 males, J. T. Baldwin, (Det. MED, MDR notes); Keysville Pd., 24 Aug. 1938, 2 females, J. T. Baldwin, (Det. MED, MDR notes). Chesterfield Co.; Pocahontas State Park, 20 June 1974,

1 male, J. Kittrell, VCU; Pocahontas State Park, 24 June 1968, 1 female, H. Gilpin, VCU; nr. Richmond, 25 June 1971, 4 males, R. H. Perry, VPI&SU; Pocahontas State Park, 20 July 1973, 1 male, 1 female, K. Beck, VCU. Cumberland Co.; Bear Cr. Lk., 23 May 1977, 1 male, 1 female (teneral), 1 male (in emergence), 12 nymphal exuviae, FLC. Dickenson Co.; John W. Flannagan Reservoir at Rt. 755, 1 male, FLC. Essex Co.; Hewerton's Farm pd., 8 Aug. 1978, 1 male, R. L. Hoffman, VPI&SU. Fairfax Co.; Dyke, "June 4 to Sept. 15", (Donnelly 1961); Great Falls, 4 July 1899, 1 male, W. R. Maxon and G. N. Collins, USNM; Four Mile Run, 13 July 1913, 1 female, A. Wetmore, USNM; Mt. Vernon, 13 Aug. 1916, 1 male, W. L. McAtee, USNM. Goochland Co.; locality unknown, 28 July 1969, 1 male. F. Wyatt, VCU. Hanover Co.; locality unknown, 3 July 1975, 1 female, N. G. Evenson, VCU. Henrico Co.; James R. Canal at Richmond, 1 Aug. 1937, 1 male (observed), (Det. MED, MDR notes); nr. Richmond, 20 Sept. 1935, 1 male, A. Walker, (Det. A. Walker), VSEC. Highland Co.; Buck Run beaver pds., 8 Aug. 1978, 1 female, FLC; Buck Run beaver pds., 31 Aug. to 2 Sept. 1973, 1 male, C. M. Flint and OSF, USNM. Isle of Wight Co.; locality unknown, JFM and J. Hancock, 1 June 1975, 1 male, 2 females, ODU. James City Co.; Lk. Matoaka at Williamsburg, 23 May 1938, 1 female, MED, (Det. MED, MDR notes); Jamestown Island Pd., 27 May 1938, 1 male, MED, VPI&SU; Jamestown Island Pd., 27 May 1938, 1 male, MED, (Det. MED, MDR notes); Reservoir nr. Fort Eustis, 29 June 1938, 1 male, 1 female, MED, VPI&SU; Lk. Matoaka at Williamsburg, 1 July 1937, 1 male, 1 female, CC, (Det. CC); Lightfoot, 2 July 1970, 1 male, B. Davidson, VPI&SU; Williamsburg, 12 July 1937, 1 female, collector unknown, (Det. MED, MDR notes); Lk. Matoaka at Williamsburg, 15 Aug. 1937, 1 male, 1

female, MED, VPI&SU; Lk. Matoaka at Williamsburg, 15 Aug. 1937, 2 males, 1 female, MED, (Det. MED, MDR notes); Riverview at Norge, Sept. 1932, nymph, MED, (Det. MED), CUC; College Cr. at Williamsburg, 15 Sept. 1966, 1 male, 6 females, MDR, VPI&SU. King William Co.; locality unknown, 9 June 1975, 2 males, J. O'Hop, ODU. Loudoun Co.; locality unknown, 12 Aug. 1971, 1 male, 1 female, T. Muir, VPI&SU. Louisa Co.; Lk. Anna backwater, 28 June 1973, 2 males, C. M. Flint and OSF, USNM; Lk. Anna at Env. Lab., 6 July 1977, 2 females, BCK; N. Anna R. at Rt. 719, 27 July 1970, 1 male, G. M. Simmons, VCU. Mecklenburg Co.; Chase City, 19 June 1976, 1 female, J. Steiner, VCU. Montgomery Co.; VPI&SU campus, 3 June 1975, 1 female, SWB, VPI&SU; Blacksburg, 25 June 1948, 2 males, 1 female, G. M. Boush, VPI&SU; Blacksburg, 30 June 1961, 1 male, B. Davis, VCU; Blacksburg, 3 July 1948, 1 male, E. W. King, VPI&SU; Pandapas Pd., 4 July 1974, 1 male, T. Bailey, VPI&SU; Heath Pd. off Rt. 685 in Blacksburg, 8 July 1978, 1 nymphal exuviae, FLC; Blacksburg, 10 July 1948, 1 male, G. M. Boush, (Det. LKG, Gloyd 1951); VPI&SU campus, 16 July 1978, 1 male, FLC; Blacksburg, 22 July 1948, 1 female, G. M. Boush, (Det. LKG, Gloyd 1951); Blacksburg, 25 July 1951, 1 male, 1 female, J. Jurdan, VPI &SU; Toms Cr. marsh 0.5 miles downstream from Rt. 655, 25 July 1973, 1 male, 2 females, FLC; VPI&SU Duck Pd., 30 July 1948, 1 male, C. F. Byers, (Det. C. F. Byers, Byers 1951); Blacksburg, 6 Aug. 1972, 1 male, I. M. Beisler, VPI&SU; Pandapas Pd., 15 Aug. 1978, 1 male, FLC; VPI&SU Duck Pd., 20 Aug. 1978, 3 males, P. J. Sieburth, VPI&SU; Stroubles Cr. 0.1 mile downstream from VPI&SU Duck Pd., 12 Sept. 1977, 2 females, FLC; Stroubles Cr., 20 Sept. 1976, 1 female, BCK, VPI&SU. Nelson Co.; 20 July 1978, 4 males, 1 female, JRV, VPI&SU. Page Co.; L. Jackson, 15

Aug. 1980, 1 male, BCK. Powhatan Co.; locality unknown, 27 June 1975, 1 male, R. H. Nugent, VCU; locality unknown, 27 June 1975, 1 male, R. Kelley, VCU. Prince George Co.; Hopewell, 8 Aug. 1969, 1 female, R. Eichmann, VCU. Prince William Co.; Broad Run at Lk. Jackson, "June 4 to Sept. 15", (Donnelly 1961); Broad Run at Lk. Jackson, 15 Aug. 1953, observation, TWD, (Det. TWD, TWD field notes). Pulaski Co.; Gatewood Reservoir, 29 June 1973, 1 female, FLC. Spotsylvania Co.; beaver dam off Rt. 617, 7 July 1978, 1 male, FLC. Warren Co.; Surber's Pd. off Rt. 634, 6 June 1977, 1 male, FLC; Surber's Pd. off Rt. 634, 5 July 1975, 1 female, FLC; S. Fork Indian Hollow Br., 21 Aug. 1970, 1 male, E. W. Surber, VPI&SU. Washington Co.; small pd. along Rt. 663, 15 June 1980, 1 male, FLC; swamp at junction of Rts. 663 and 665, 4 July 1978, 1 male, 1 female, G. Anderson, VPI&SU. Wythe Co.; Chitwood Pd. on Pine Ridge Rd., 30 June 1970, 1 male, W. R. Chitwood, VPI&SU. York Co.; Upper Waller Pd., 27 May 1967, 1 male, 1 female, MDR, VPI&SU; Yorktown, 27 June 1976, 1 male, J. Steiner, VCU; Jones Pd., 9 July 1938, 1 female, MED, VPI&SU; Bracken's Pd. on Colonial Parkway, 16 Sept. 1966, 2 females, MDR, VPI&SU; Wallers Pd., 17 Sept. 1966, 3 males, MDR, VPI&SU. City of Chesapeake; Stumpy Lk., 31 May 1970, 2 males, 2 females, JFM, ODU. City of Norfolk; locality unknown, 16 May 1969, 1 female, K. R. H., ODU; locality unknown, 3 June 1973, 1 male, D. Laist, ODU; locality unknown, 12 June 1962, 2 females, C. V. Corell, VPI&SU; locality unknown, 10 Aug. 1973, 1 male, P. W. Larkins, VPI&SU; locality unknown, 3 Nov. 1975, 1 male, M. Burkeh, ODU. City of Richmond; Maymont Park, 9 June 1976, 1 male, P. Thomas; James River, 17 June 1974, 1 male, G. Catrin, VCU; Maymont Park, 26 June 1974, 1 female, J. Kittrell, VCU; Maymont

Park, 26 June 1975, 1 male, N. G. Evenson, VCU; Maymont Park, 27 June 1975, 1 male, Y. Wallace, VCU; Maymont Park, 29 June 1975, 1 male, 1 female, L. A. Runge, VCU; West End, 10 July 1972, 1 male, M. Haralson, VCU; Maymont Park, 13 July 1973, 1 male, J. Krolak, VCU; Maymont Park, 13 July 1973, 1 male, W. Smith, VCU; Maymont Park, 13 July 1973, 1 male, J. Verburg, VCU; Maymont Park, 8 Aug. 1975, 1 female, M. Lao, VCU; Maymont Park, 26 Aug. 1969, 1 male, Droppleman, VCU; Maymont Park, 27 Aug. 1969, 1 male, Droppleman, VCU; Maymont Park, 8 Sept. 1974, 1 male, D. P. Chilos, VPI&SU. City of Suffolk; Holland, 2 July 1954, 1 male, collector unknown, VPI&SU; Cypress Chapel, 14 Sept. 1934, 1 female, LKG, (Det. LKG, Gloyd 1951); City of Virginia Beach; Back Bay Refuge, 31 May 1975, 3 males, 2 females, ODU; locality unknown, 21 June 1973, 1 female, D. Simonet, VPI&SU; locality unknown, 15 Aug. 1974, 1 female, M. Paris, VPI&SU.

Flight Season.--Apr. (TX) to Nov. 3 (VA); in Virginia May 16 to Nov. 3. Known season in neighboring states are: District of Columbia- June 7 to Aug. 1; Kentucky- May 22 to Oct. 3; Maryland- June 4 to July 31; North Carolina- May 24 to Oct. 15; Pennsylvania- June 1 to Sept. 15; Tennessee- May 5 to Sept. 25; West Virginia- July 7 to Aug. 13.

Biology.--*Perithemis tenera* inhabits ditches, ponds, and marsh-bordered lakes. Adult males generally perch on emergent vegetation near floating algae or other floating vegetation. Copulation occurs in flight and males guard their mates during oviposition. The males also exhibit a mock ovipositing behavior, generally over floating algae, when females approach their territory. This behavior apparently reduces predation on ovipositing females by assuring the absence of predators

near the oviposition site. The adults seldom fly more than 15 cm above the water.

Remarks.--This is a small dragonfly distinguished by the amber wings of the male and the banded wings of the female.

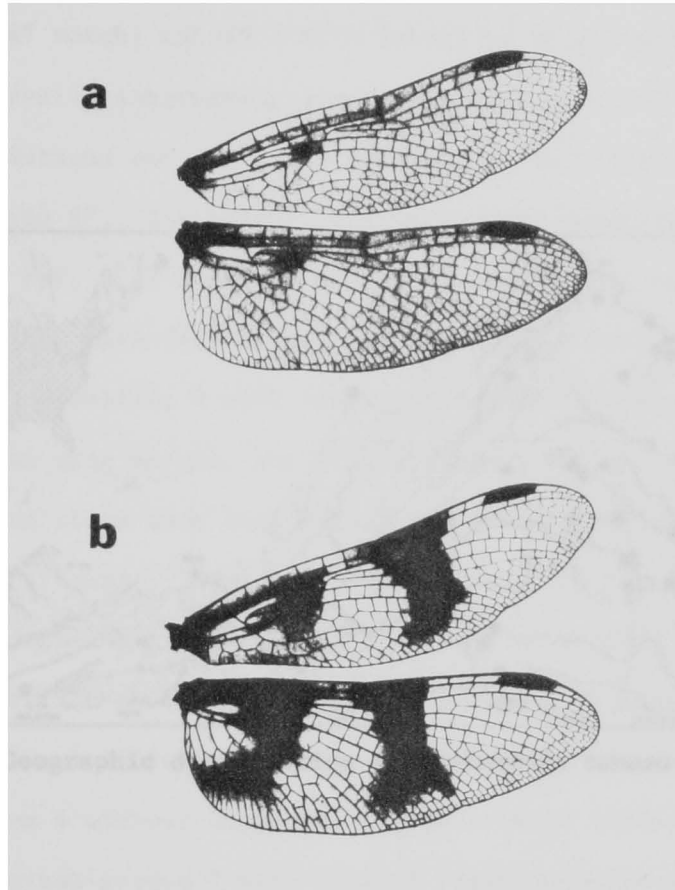


Figure 205. Wings of *Perithemis tenera* x3: (a) male; (b) female.

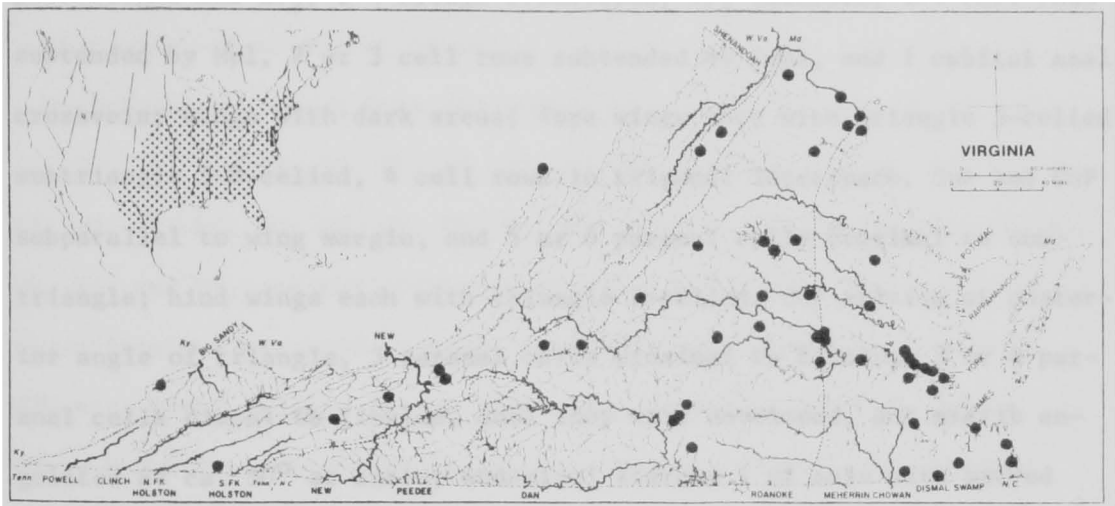


Figure 206. Geographic distribution of *Perithemis tenera*.

Genus *Plathemis* Hagen 1861

Hagen 1861. Syn. Neur. N. Amer., p. 149.

Type Species.--*Libellula lydia* Drury.

Diagnosis.--Posterior margin of pronotum directed posterodorsally without medial notch; apical 3 or 4 spines of outer spine row of hind femora not greatly lengthened; wings each with proximal and distal margins of pterostigma not divergent anteriorly, 3-5 crossveins between pterostigma and RP_1 , 2-4 bridge crossveins, RP_2 undulate, 2-4 cell rows subtended by Mpl , 2 or 3 cell rows subtended by Cup_1 , and 1 cubital anal crossvein; wings with dark areas; fore wings each with triangle 3-celled, subtriangle 5-8-celled, 4 cell rows in trigonal interspace, CuA and CuP subparallel to wing margin, and 5 or 6 paranal cells proximal to subtriangle; hind wings each with triangle 2-celled, CuP arising at posterior angle of triangle, 3 paranal cells proximal to fibulum, 3 or 4 paranal cells distal to fibulum, anal loop well developed, and midrib angulated at ca. 50° at ankle; abdominal sternum 1 of male with paired processes; abdominal tergum 3 with well-developed lateral carinae; abdominal tergum 4 without supplementary transverse carina at antecostal suture; abdominal tergum 9 with lateral carinae weakly developed in male and well developed in female.

Remarks.--This genus is most closely related to the Palearctic genus *Platetrum* with which it shares several unique characteristics including the ventral processes of abdominal segment 1, the accessory latch involving the third segment of the penis and the anterior lamina, and the presence of a lateral carinae on abdominal segment 9. Although the wing

venation, wing color pattern, and abdominal shape are different, *Plathemis* may reasonably be considered a subgenus of *Platetrum*.

Plathemis lydia (Drury)

Syn.: *trimaculata* DeGeer

(Figures 207, 208)

Drury 1770. Ill. Exot. Ins. 1:112 (in *Libellula*).

Length 37-48 mm; abdomen 23-32 mm; hind wings 28-35 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AL, AR, CA, CO, CT, DC, FL, GA, ID, IL, IN, IA, KS, KY, LA, ME, MD, MA, MI, MN, MS, MO, NE, NV, NH, NJ, NM, NY, NC, ND, OH, OK, OR, PA, RI, SC, SD, TN, TX, UT, VT, VA, WA, WV, WI, and WY, and the provinces of B.C., N.B., N.S., Ont., and Que.

Known from the Virginia counties of Albemarle, Alleghany, Arlington, Augusta, Bath, Bedford, Bland, Buchanan, Campbell, Carroll, Charles City, Charlotte, Chesterfield, Clarke, Craig, Culpeper, Dickenson, Essex, Fairfax, Floyd, Giles, Goochland, Grayson, Greene, Halifax, Hanover, Henry, Highland, Isle of Wight, James City, King William, Lee, Louisa, Montgomery, Nelson, New Kent, Patrick, Pittsylvania, Powhatan, Prince George, Roanoke, Rockbridge, Rockingham, Russell, Scott, Southampton, Spotsylvania, Tazewell, Warren, Washington, Wise, Wythe, and York, and the cities of Chesapeake, Hampton, Newport News, Norfolk, Richmond, Suffolk, and Virginia Beach. Known distribution among the counties of neighboring states include: Kentucky- Allen, Barren, Bell, Boyle, Breckinridge, Bullitt, Butler, Carter, Casey, Cumberland, Edmonson,

Fayette, Floyd, Fulton, Grayson, Green, Hardin, Harrison, Hart, Henderson, Hickman, Hopkins, Jefferson, Kenton, Letcher, Lincoln, Marion, McCreary, Metcalfe, Monroe, Ohio, Oldham, Pike, Powell, Pulaski, Robertson, Russell, Taylor, Todd, Trigg, Union, Warren, and Wayne; Maryland- Calvert, Caroline, Charles, Garrett, Montgomery, Prince Georges, Talbot, Wicomico, and Worcester; North Carolina- Brunswick and Wake; Pennsylvania- Allegheny, Armstrong, Beaver, Bedford, Berks, Blair, Bradford, Bucks, Butler, Cambria, Carbon, Centre, Chester, Clearfield, Clinton, Columbia, Crawford, Dauphin, Delaware, Elk, Erie, Fayette, Forest, Franklin, Fulton, Greene, Huntingdon, Indiana, Jefferson, Lancaster, Lawrence, Lebanon, Lehigh, Luzerne, Lycoming, Mercer, Monroe, Montgomery, Northampton, Perry, Philadelphia, Pike, Potter, Schuylkill, Snyder, Somerset, Sullivan, Susquehanna, Tioga, Union, Venango, Warren, Washington, Wayne, Westmoreland, and York; Tennessee- Anderson, Carter, Campbell, Carroll, Coffee, Cumberland, Davidson, Fentress, Greene, Hawkins, Humphreys, Jefferson, Johnson, Marion, Montgomery, Obion, Robertson, Rutherford, Sevier, Sullivan, and Williamson; West Virginia- Hampshire, Hancock, Pendleton, Pocahontas, Raleigh, Randolph, Ritchie, and Taylor.

Virginia Records.--Albemarle Co.; Charlottesville, 8 May 1948, 1 female, R. L. Hoffman, (Det. LKG), INHS; Charlottesville, 11 May 1968, 1 male, R. L. Hoffman, FSCA; old reservoir in Charlottesville, 20 May 1948, 3 males, C. H. Leys, (Det. LKG), MZUM; Charlottesville, 10 July 1948, 1 female, H. L. Bobb, VPI&SU. Alleghany Co.; Jordan Mines, 15 May 1951, 1 male, R. L. Hoffman, (Det. LKG); Griffith, 30 May 1953, 1 female, R. L. Hoffman, INHS; Griffith, 21 June 1953, 1 male, R. L.

Hoffman, (Det. LKG), INHS; Simpson Cr. at Longdale Furnace, 18 Sept. 1934, 1 female, LKG, (Det. LKG, Gloyd 1951); pd. at Lowmoor, 19 Sept. 1934, 1 male, 1 female, LKG, (Det. LKG, Gloyd 1951). Arlington Co.; Rosslyn, 22 June 1909, 1 female, collector unknown, (MDR notes), USNM. Augusta Co.; Shenandoah Pd., 13 June 1980, 1 female, FLC; Todd Lk., 30 June 1973, 1 male, SWD; Hearthstone Lk. and stream, 30 June 1973, 1 male, SWD. Bath Co.; beaver pd. along Rt. 600, 18 June 1978, 7 males, 3 females (2 pair in tandem), FLC; Douthat Lk. at Rt. 629, 27 June 1973, 1 male, SWD. Bedford Co.; 8 miles W. of Lynchburg, 20 June 1948, 1 male, C. H. Leys, (Det. LKG), MZUM; 8 miles W. of Lynchburg, 20 June 1948, 1 male, R. L. Hoffman, (Det. LKG), INHS. Bland Co.; South Gap, 26 June 1955, 1 male, R. L. and R. B. Hoffman, VPI&SU. Buchanan Co.; Russell Prater Cr. along Rt. 83, 12 July 1978, 1 male, FLC. Campbell Co.; Lynchburg, 6 June 1942, 1 female, collector unknown, VPI&SU. Carroll Co.; New R. at Rt. 58 nr. Galax, 19 June 1977, 1 male, 1 female, FLC. Charles City Co.; Herring Cr., 5 July 1938, 1 female, MED, VPI&SU; Fish Hatchery pds., 21 Sept. 1966, 1 male, MDR, VPI&SU. Charlotte Co.; Twittys Cr. 1 mile upstream from Drakes Br., 23 May 1977, 1 female, FLC; Twittys Cr. at Rt. 642, 23 May 1977, 1 male, FLC; Gees Pd. at Keysville, 23 June 1938, 1 male, MED, VPI&SU; 1.5 miles N.W. of Keysville, 10 July 1938, 1 male, J. T. Baldwin, (Det. MED, MDR notes); Keysville pd., 24 Aug. 1938, 1 male, J. T. Baldwin, (Det. MED, MDR notes). Chesterfield Co.; Chester, 17 June 1976, 1 female, J. Steiner, VCU; locality unknown, 21 June 1975, 1 male, R. H. Nugent, VCU; Gregory Pd. Rd., 26 June 1971, 1 female, JRV, VPI&SU; Presquile National Wildlife Refuge, 8 July 1969, 1 female, A. E. Pries, VCU. Clarke Co.; Longmeadow Farm, 18 July 1976,

1 female, J. N. Clore, VCU. Craig Co.; Tub Run, 13 July 1975, 2 males, SWB, VPI&SU; locality unknown, 19 July 1973, 1 male, E. C. Turner, VPI&SU; farm pd. 1.5 miles S.W. of Paint Bank at Rt. 635, 15 Oct. 1977, 1 female, FLC. Culpeper Co.; Rappahannock R. 0.5 mile N. of Rt. 683, 15 July 1980, 1 female, BCK; Rapidan R. 1.5 miles S. of Rt. 681, 15 July 1980, 2 females, BCK. Dickenson Co.; John W. Flannagan Reservoir at Rt. 755, 12 July 1980, 1 male, FLC. Essex Co.; Dunbrooke, 29 July 1899, 1 male, 1 female, RPC, USNM. Fairfax Co.; Potomac R. 0.5 mile above Great Falls, 17 Apr. 1978 (emerged 19 May 1978), 1 male nymph, FLC; Pohick Cr. at Gunston Cove, "May 1 to Sept. 8", (Donnelly 1961); Great Falls, 4 June 1898, 1 male, W. R. Maxon, USNM; pd. at Rt. 7 nr. Danbury, 30 June 1977, 1 male, J. Schmidt, VPI&SU; Great Falls, 4 July 1898, 1 male, W. R. Maxon, USNM; Great Falls, 8 July 1915, 1 male, V. Busck, USNM; Great Falls, 12 July 1905, 1 male, D. H. Clemons, USNM; Great Falls, 23 July 1979, 1 male, RPC, USNM; Great Falls, 24 July 1900, 1 male, BPC, USNM; Great Falls, 26 July 1898, 1 male, W. R. Maxon, USNM; Great Falls, 27 July 1907, 1 male, RPC, USNM; Great Falls, 27 July 1898, 1 male, 1 female, W. R. Maxon, USNM; Bull Run Creek, 14 Aug. 1980, 2 females, BCK, (Det. BCK); pd. along Potomac R. at Difficult Run, 19 Sept. 1978, 1 male, FLC. Floyd Co.; Little R. at Rt. 615, 27 May 1977, 1 male (teneral), FLC; Little R. at Rt. 615, 3 June 1977, 1 female, FLC; Little R. at Rt. 682, 10 June 1978, 1 female, FLC; seep entering Camp Cr. at Rt. 615, 10 June 1978, 3 males, 1 female, FLC. Giles Co.; Sylvatica Pd. at Mtn. Lk. Bio. Sta., 16 Apr. 1977 (emerged 30 Apr. 1977), 1 male, P. K. Powell, VPI&SU; Farrier Farm at Newport, 7 May 1938, (observation), MED, (MDR notes); pd. off Rt. 460, 24 May 1978, 1 male,

1 female nymph (emerged 28 May 1978), D. E. Minnick, VPI&SU; pd. nr. Newport church on Rt. 42, 28 May 1977, 1 male, FLC; Sylvatica Pd. at Mtn. Lk. Bio. Sta., 26 June 1977, 1 male, BCK; Riopel Pd. at Mtn. Lk. Bio. Sta., 26 June 1977, 1 female, FLC; Riopel Pd. at Mtn. Lk. Bio. Sta., 2 July 1977, 1 male, P. K. Powell, VPI&SU; Sylvatica Pd. at Mtn. Lk. Bio. Sta., 25 Sept. 1977, 1 female, FLC. Goochland Co.; Win Free Farm, 21 July 1976, 1 male, J. N. Clore, VCU. Grayson Co.; New R. at Rt. 810, 19 June 1977, 1 female, FLC. Greene Co.; Celt, 1 May 1938, 1 female, (Det. MED, MDR notes). Halifax Co.; Rt. 360, 8 June 1978, 2 females (observed), BCK, personal communication. Hanover Co.; locality unknown, 28 Apr. 1970, 1 female, Fearington, ODU; locality unknown, 9 June 1975, 1 female, J. O'Hop, ODU; Ashland, 21 June 1975, 1 female, C. Serange, VCU; Luk Pd., 3 July 1975, 1 male, C. Lee, VCU; N. Anna R. 1 mile W. of Rt. 1, 2 Aug. 1978, 2 males, 1 female, BCK; S. Anna R. at Rt. 657, 2 Aug. 1978, 1 female, BCK; Mechanicsville, 11 Aug. 1969, 1 female, R. R. Griffin, VCU. Henry Co.; Horsepasture Cr. 0.8 mile N. of Spencer, 23 May 1979, 1 male, R. L. Hoffman, VPI&SU. Highland Co.; Bullpasture R. at head of gorge, 30 May 1977, 1 male, FLC; Back Cr. at Rt. 250, 4 June 1977, 1 male, FLC; Buck Run beaver pds., 18 June 1978, 1 male, FLC; small pd. on Rt. 250 E. of Monterey, 23 June 1978, 1 male, FLC; Buck Run beaver pds., 1 July 1972, 1 male, 3 females, C. M. Flint and OSF, USNM; Buck Run beaver pds., 3, 4 July 1971, 2 males, OSF, USNM; Long Run beaver pd., 8 Aug. 1978, 1 male, JRV, VPI&SU; farm pd. at Rts. 250 and 640, 8 Aug. 1978, 1 male, 1 female, JRV, VPI&SU; Buck Run beaver pds., 8 Aug. 1978, 1 male, FLC; Buck Run beaver pds., 31 Aug. to 2 Sept. 1973, 2 males, C. M. Flint and OSF, USNM. Isle of Wight Co.; locality

unknown, 1 June 1975, 2 males, 2 females, JFM and J. Hancock, ODU.
 James City Co.; Lk. Matoaka at Williamsburg, 13 Apr. 1938, 1 female,
 MED and D. T. R., (Det. MED, MDR notes); Lk. Matoaka at Williamsburg,
 3 May 1937, 1 female, collector unknown, (Det. MED, MDR notes): Lk.
 Matoaka at Williamsburg, 4 May 1938, 1 male, 1 female, MED, (Det. MED,
 MDR notes); Lk. Matoaka at Williamsburg, 4 May 1938, 1 male, 1 female,
 T. D. M., (Det. MED, MDR notes); Williamsburg, 10 May 1939, 1 male,
 collector unknown, VPI&SU; Jollys Pd., 24 May 1966, 1 male, MDR, VPI&
 SU; W&M campus pd., 5 June 1938, 1 female, F. B. Koss, (Det. MED, MDR
 notes); Ewell Pd., 6 June 1967, 2 males, MDR, VPI&SU; Jamestown, 9 June
 1938, 1 male, MED, MDR notes; Williamsburg, 23 June 1937, 1 male, MED,
 VPI&SU; Lk. Matoaka at Williamsburg, 1 July 1937, 2 males, 1 female,
 CC, (Det. CC); Jamestown, 9 July 1938, 1 male, MED, VPI&SU; Williams-
 burg, 25 July 1937, 1 male, MED, VPI&SU; Lk. Powell at Williamsburg, 6
 Aug. 1937, 1 female, V. M. Davis and MED, (Det. MED, Davis 1938);
 Riverview at Norge, Sept. 1932, nymph, MED, (Det. MED, CUC; Williamsburg,
 17 Sept. 1929, 1 male, MED, VPI&SU; Kingsbill Pd., 18 Sept. 1966, 1 fe-
 male, MDR, VPI&SU. King William Co.; locality unknown, 9 June 1975, 1
 male, J. O'Hop, ODU. Lee Co.; Keokee Lk., 3 July 1977, 4 males, FLC;
 Cumberland Mtns., 5 July 1905, 1 male, Hubbard and Schwarz, (MDR notes),
 USNM. Louisa Co.; Rt. 601, 2 June 1977, 1 female, BCK; S. Anna R. at
 Rt. 522, 3 June 1977, 1 female, BCK. Montgomery Co.; Blacksburg, 12
 Apr. 1958, 1 male, G. Rock, VPI&SU; Kelly's Pd. on Rt. 655, 2 May 1978,
 1 female, K. Loyd, VPI&SU; Hall farm pd. on Rt. 705, 3 May 1979, 1 fe-
 male, J. Clarke, VPI&SU; Blacksburg, 13 May 1948, 1 male, P. H. Smith,
 VPI&SU; VPI&SU Dairy sewage pd., 14 May 1977, 2 males, 1 female, C.

Sheppard, VPI&SU; Blacksburg, 15 May 1948, 1 male, E. C. Cockrell, VPI&SU; VPI&SU Dairy sewage pd., 16 May 1977, 1 male, 1 female, R. Southwick, VPI&SU; Blacksburg, 17 May 1976, 1 male, H. Mathews, VPI&SU; Craig Cr. beaver pd. on Rt. 621, 17 May 1977, 1 female, J. Schmidt, VPI&SU; VPI&SU campus pd. at Blacksburg, 18 May 1937, 1 male, "W&M students", (Det. MED, MDR notes); Blacksburg, 18 May 1948, 1 male, Cochran, VPI&SU; Blacksburg, 20 May 1948, 3 males, 2 females, G. M. Boush, VPI&SU; Toms Cr. oxbow 0.5 mile S. of Rt. 655, 24 May 1973, 1 male, 1 female, FLC, VPI&SU; Smith Cr. at Rts. 615 and 674, 24 May 1978, 1 male, G. D. Hutton, VPI&SU; Blacksburg, 25 May 1959, 1 female, L. B. Nolen, VPI&SU; Blacksburg, 25 May 1963, 1 female, T. Lloyd, VPI&SU; Blacksburg, 25 May 1959, 1 female, Martin, VPI&SU; Blacksburg, 26 May 1958, 1 male, J. W. Berry, VPI&SU; Blacksburg, 27 May 1948, 1 female, P. Smith, VPI&SU; Poverty Cr., 27 May 1962, 1 male, D. Innes, VPI&SU; Blacksburg, 27 May 1948, 1 female, E. C. Cockrall, VPI&SU; locality unknown, 27 May 1963, 1 male, collector unknown, VPI&SU; Blacksburg, 28 May 1948, 1 male, E. C. Cockrall, VPI&SU; Blacksburg, 30 May 1961, 1 male, C. R. Moore, VPI&SU; Blacksburg, 2 June 1960, 1 male, W. I. Strength, VPI&SU; VPI&SU Duck Pd., 5 June 1975, 1 male, SWB, VPI&SU; Blacksburg, 9 June 1958, 1 female, Le Gallais, VPI&SU; Pedlar Hollow at Rt. 603, 13 June 1978, 1 female, FLC; Blacksburg, 14 June 1975, 1 male, T. E. Bailey, VPI&SU; Blacksburg, 23 June 1960, 1 male, RRM, VCU; Blacksburg, 23 June 1948, 1 male, 1 female, Boush, VPI&SU; Blacksburg, 25 June 1948, 2 males, Boush, VPI&SU; Blacksburg, 30 June 1961, 1 male, E. Lindamoor, VCU; Blacksburg, 8 July 1948, 1 female, Boush, VPI&SU; Hickory Hill on Brush Mtn., 9 July 1978, 1 male, P. J. Sieburth, VPI&SU; Blacksburg, 10 July 1948, 2

males, 1 female, G. M. Boush, VPI&SU; Blacksburg, 12 July 1967, 1 male,
 E. C. Turner, VPI&SU; Blacksburg, 17 July 1970, 1 male, R. H. Perry,
 VPI&SU; VPI&SU Duck Pd., 24 July 1937, 1 female, collector unknown,
 (Det. MED, MDR notes); Heath Pd. off Rt. 685 at Blacksburg, 1 Aug. 1977,
 1 male, 1 female, FLC; Pd. at Dori-Del Equine Center, 1 Aug. 1976, 1
 male, R. Akers, VPI&SU; Blacksburg, 5 Aug. 1961, 1 male, 1 female, C.
 V. Covell, VPI&SU; VPI&SU Duck Pd., 8 Aug. 1937, 1 male, 1 female,
 "W&M students", (Det. MED, MDR notes); Pandapas Pd., 15 Aug. 1978, 1
 male, FLC; VPI&SU Duck Pd., 20 Aug. 1978, 1 male, P. J. Sieburth, VPI&
 SU; VPI&SU, 30 Aug. 1976, 1 female, BCK, VPI&SU; Poverty Hollow, 11
 Sept. 1977, 1 female, A. F. Beck, VPI&SU; Blacksburg, 21 Sept. 1940, 1
 male, J. M. Grayson, VPI&SU; Pandapas Pd., 25 Sept. 1977, 1 female,
 FLC; locality unknown, 30 Sept. 1968, 1 female, T. Mullins, VPI&SU;
 locality unknown, 3 Oct. 1975, 1 female, C. Castilla, VPI&SU. Nelson
 Co.; Afton, 26 July 1973, 1 female, M. Lau, VCU. New Kent Co.; Plum
 Point, 30 Apr. 1970, observation, C. Shiffer, personal communication;
 locality unknown, 22 July 1974, 1 male, JFM, ODU. Patrick Co.; Rock
 Castle Cr. at Rt. 605, 21 May 1978, 1 male, FLC; seepage area along
 Rock Castle Cr. at Rt. 605, 11 June 1978, 1 male, FLC. Pittsylvania
 Co.; locality unknown, 27 Apr. 1963, 1 female, G. Edwards, VPI&SU; Rt.
 874 at McGuff Cr., 21 May 1978, 1 male, FLC; marshy area in field along
 Rt. 880, 21 May 1978, 1 male, FLC. Powhatan Co.; locality unknown, 27
 June 1975, 1 male, D. Custer, VCU; locality unknown, 27 June 1975, 1
 male, H. Zimmerman, VCU. Prince George Co.; Hopewell, 20 June 1976, 1
 male, P. Thomas. Roanoke Co.; Salem, 23 June 1973, 1 female, SWB, VPI&
 SU; Blue Ridge Parkway, 29 June 1975, 1 female, SWB, VPI&SU. Rockbridge

Co.; Guys Run, 2 June 1978, 1 male, M. Meschter; Guys Run, 28 June 1978, 1 male, M. Meschter; locality unknown, 27 May 1965, 1 male, McClanahan, VPI&SU; Hone Quarry Lake and stream, 1 July 1973, 1 male, SWD. Russell Co.; Little Bottom, 26 May 1962, 2 males, D. Innes, VPI&SU; Laurel Bed Lk., 4 July 1977, 2 males, FLC. Scott Co.; locality unknown, 4 May 1974, 1 male, D. Simonet, VPI&SU. Southampton Co.; Delzell farm 9 miles N.W. of Windsor off Rt. 635, 5 May 1979, 1 female, S. Brown, VPI&SU. Spotsylvania Co.; small tributary of Matta R. at Rt. 617, 29 May 1978, 1 female, FLC; 0.25 mile from Fredericksburg, 18 June 1889, 1 male, W. D. Richardson, (Det. P. P. Calvert, Calvert 1890), ANSP. Tazewell Co.; locality unknown, 7 June 1915, 1 male, 1 female (in tandem), L. O. Jackson, USNM; small tributary of Cove Cr. along Rt. 662, 10 June 1978, 1 female, BCK, FLC Collection; E. Fork of Cove Cr. along Rt. 662, 10 June 1978, 1 male, BCK; Station Spring Cr. at Rt. 623, 10 June 1978, 1 female, BCK; Cove branch Bog at Beartown Mtn., 11 July 1977, 1 male, BCK; Burk's Garden at Rt. 623, 30 July 1973, 1 female, SWB, VPI&SU; Maiden Mtn. Bog, 16 Aug. 1977, 1 male, 1 female, FLC. Warren Co.; Surber's Pd. at Rt. 634, 6 June 1977, 1 male, 1 female, FLC. Washington Co.; small pd. along Rt. 663, 15 June 1980, 1 male, FLC; farm pd. at Rt. 633, 2 July 1978, 2 males, 1 female, G. Anderson, VPI&SU; locality unknown, 17 July 1977, 1 male, G. Anderson, VPI&SU; Straight Br. beaver pds. below Beartree campground, 28 July 1979, 2 females, JRV, VPI&SU; Emory, 15 Aug. 1959, 1 male, D. Kennon, VCU; pd. at Lodi, 30 Aug. 1953, 1 male, R. L. Hoffman, USNM. Wise Co.; Big Stone Gap, 20 July 1936, 1 male, collector unknown, (Det. MED, MDR notes). Wythe Co.; Chitwood's Pd. on Pine Ridge Rd., 10 June 1970, 1 female, W. R. Chitwood, VPI&SU;

Pine Ridge Rd., 17 June 1970, 1 male, W. R. Chitwood, VPI&SU; Wytheville, 30 June 1935, 3 females, CA, (Det. CA). York Co.; seepage below dam at Wallers Pd., 19 May 1966, 1 male, 1 female, MDR, VPI&SU; Cr. at Wallers Pd., 17 Sept. 1966, 1 female, MDR. VPI&SU. City of Chesapeake; Stumpy Lk., 31 May 1970, 2 males, 1 female, JFM, ODU. City of Hampton; locality unknown, 21 May 1970, 1 male, F. Causey, ODU. City of Newport News; locality unknown, 16 May 1969, 1 female, Cas, ODU. City of Norfolk; locality unknown, 9 July 1974, 1 male, JFM, ODU; locality unknown, 7 Sept. 1973, 1 male, P. W. Larkins, VPI&SU; locality unknown, 9 Sept. 1973, 1 female, P. W. Larkins, VPI&SU. City of Richmond; locality unknown, 18 June 1974, 1 female, E. F. Fox, VCU; Maymont Park, 21 June 1974, 1 male, D. H. Beals, VCU; Maymont Park, 29 June 1968, 1 female, P. A. Bayeman, VCU; Maymont Park, 13 July 1973, 2 males, J. Verburg, VCU; Maymont Park, 13 July 1973, 1 male, 1 female, J. Krolak, VCU; Maymont Park, 13 July 1973, 1 male, J. Gainer, VCU; Maymont Park, 13 July 1973, 1 male, K. Beck, VCU; Maymont Park, 16 July 1975, 1 male, N. G. Evenson, VCU; Maymont Park, 26 July 1969, 1 female, Droppleman, VCU; Maymont Park, 8 Aug. 1973, 1 male, M. Lacy, VCU. City of Suffolk; Dismal Swamp Wildlife Refuge, 22 Apr. 1974, 1 male, 2 females, JFM, ODU; Dismal Swamp Wildlife Refuge, 10 May 1970, 1 female, F. Causey, ODU; Dismal Swamp Wildlife Refuge, 11 May 1970, 1 female, J. C. Steere, ODU; Lk. Drummond in Dismal Swamp Wildlife Refuge, 16 May 1970, 3 males, 3 females, JFM, ODU; Washington Ditch in Dismal Swamp Wildlife Refuge, 21 May 1977, 2 males, 3 females, FLC; Dismal Swamp Wildlife Refuge, 2 July 1973, 1 male, 1 female, JFM, ODU; Holland, 4 July 1975, 1 female, J. W. Jenkins, VPI&SU; Dismal Swamp Wildlife Refuge, 20 July 1974, 2 males, 1

female, J. Hancock, ODU: Dismal Swamp Wildlife Refuge, 5 Aug. 1974, 1 male, J. Hancock, ODU; Dismal Swamp Wildlife Refuge, 12 Aug. 1974, 1 female, J. Hancock, ODU: Holland, 12 Sept. 1976, 1 male, J. W. Jenkins, VPI&SU; Dismal Swamp Wildlife Refuge, 25 Oct. 1970, 1 male, 1 female, JFM, ODU. City of Virginia Beach; locality unknown, 20 June 1974, 1 male, E. F. Fox, VCU.

Flight Season.--Mar. 8 (TX) to Oct. 25 (VA); in Virginia Apr. 12 to Oct. 25. Known season in neighboring states are: District of Columbia-- June 13 to July 8; Kentucky-- Apr. 13 to Sept.; Maryland-- May 1 to Aug. 25; North Carolina-- Apr. 22 to Oct.; Pennsylvania-- May 1 to Sept. 15; Tennessee-- Apr. 24 to Oct. 16; West Virginia-- June 13 to Aug. 13.

Biology.--*Plathemis lydia* inhabits seepage pools, ponds, slow-flowing streams, and marsh-bordered lakes. Adult males perch on flat surfaces near shore. Adults are often encountered perching on fallen trees along the margin of fields. Near water the adults seldom fly higher than 1 m above the water. Males often guard females with which they have mated during oviposition, and occasionally exhibit a mock oviposition when a female enters their territory.

Remarks.--Distinguished by its relatively wide abdomen and banded wings, this species is characterized by a pronounced sexual dimorphism in wing pattern in which the female wing pattern resembles that of *L. pulchella*.

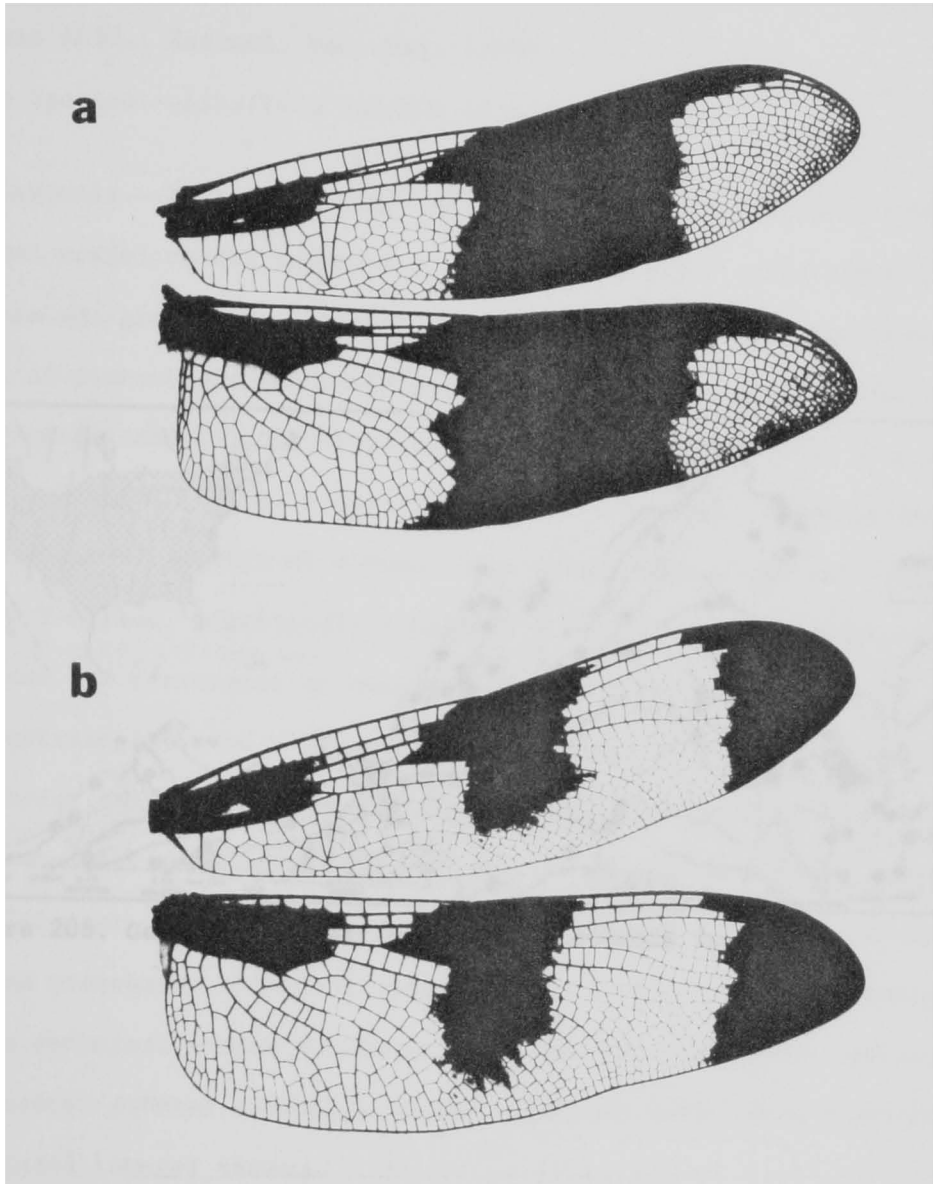


Figure 207. Wings of *Plathemis lyliu* x3: (a) male; (b) female.

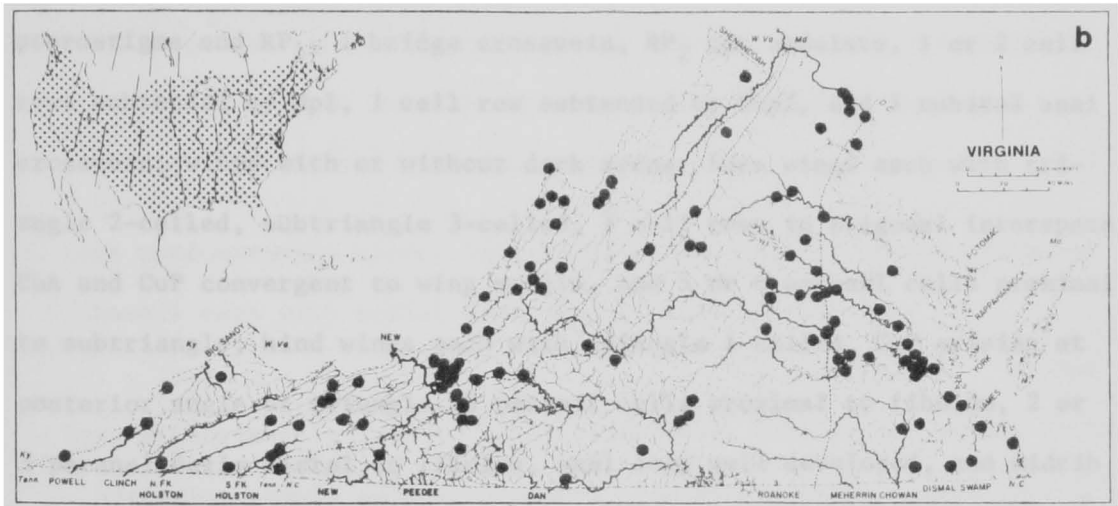


Figure 208. Geographic distribution of *Plathemis lydia*.

Genus *Sympetrum* Newman 1833Syn.: *Diplax* Charpentier

Newman 1833. Entomol. Mon. Mag. 1:511.

Type Species.--*Libellula vulgata* Linnaeus.

Diagnosis.--Posterior margin of pronotum directed dorsally with "v"-shaped medial notch; apical 3 or 4 spines of outer spine row of hind femora not greatly lengthened; wings each with proximal and distal margins of pterostigma not divergent anteriorly, 1 or 2 crossveins between pterostigma and RP_1 , 1 bridge crossvein, RP_2 not undulate, 1 or 2 cell rows subtended by Mpl , 1 cell row subtended by $Cupl$, and 1 cubital anal crossvein; wings with or without dark areas; fore wings each with triangle 2-celled, subtriangle 3-celled, 3 cell rows in trigonal interspace, CuA and CuP convergent to wing margin, and 5 or 6 paranal cells proximal to subtriangle; hind wings each with triangle 1-celled, CuP arising at posterior angle of triangle, 3 paranal cells proximal to fibulum, 2 or 3 paranal cells distal to fibulum, anal loop well developed, and midrib angulated at ca. 45° at ankle; abdominal sternum 1 of male without paired processes; abdominal tergum 3 with weakly developed lateral carinae; abdominal tergum 4 without supplementary transverse carina at antecostal suture; abdominal tergum 9 without (with in *S. vicinum*) well-developed lateral carinae.

Species Key to Adult *Sympetrum* of Virginia

1. Male cerci each with prominent ventral tooth, posterior hamuli each directed posteriorly; vulvar lamina bilobate 4
 Male cerci each without prominent ventral tooth, posterior hamuli each directed posteroventrally; vulvar lamina entire 2
2. Hind wings each transparent saffron over basal half; abdominal segment 9 with lateral carinae; posterior hamuli each with lateral lobe directed posteriorly *S. semicinctum* p. 903
 Hind wings each predominantly hyaline over basal half; abdominal segment 9 without lateral carinae; posterior hamuli each with lateral lobe directed posteroventrally 3
3. Legs predominantly black; lateral abdominal carinae black; posterior hamuli each with medial hook shorter than lateral lobe
 *S. costiferum* p. 894
 Legs predominantly yellow; lateral abdominal carinae not black; posterior hamuli each with medial hook longer than lateral lobe .
 *S. vicinum* p. 905
4. Tibiae predominantly yellowish brown; posterior surface of head without ridges lateral to occiput; posterior hamuli each with dorsal lobe shelflike and rounded apically in ventral view; vulvar lamina ca. 4 times as wide as long *S. ambiguum* p. 892
 Tibiae predominantly black; posterior surface of head with ridges lateral to occiput; posterior hamuli each with dorsal lobe not shelflike and not rounded apically in ventral view; vulvar lamina ca. as wide as long 5

5. Costa yellow with black spines; hind wings each with 4 cell rows between fibulum and wing margin; face yellowish red at maturity; vulvar lamina with ventral ridges curved posterolaterally
 *S. internum* p. 895
- Costa not yellow with black spines; hind wings each with 3 cell rows between fibulum and wing margin; face not yellowish red at maturity; vulvar lamina with ventral ridges directed posteriorly . . . 6
6. Posterior hamuli each without mesal processes on dorsal lobe; vulvar lamina inflated, ca. as high as long; female femora not predominantly black *S. rubicundulum* p. 899
- Posterior hamuli each with mesal processes on dorsal lobe; vulvar lamina not inflated, ca. 1/2 as high as long; female femora predominantly black 7
7. Posterior hamuli each with dorsal lobe acuminate apically and obtuse-angulate medially, and with ventral hook extended posteriorly beyond dorsal lobe; ventral surface of vulvar lamina convexly curved to blunt posterodorsally directed apices . . . *S. janeae* p. 896
- Posterior hamuli each with dorsal lobe truncate apically and tuberculate medially, and with ventral hook not extended posteriorly beyond dorsal lobe; ventral surface of vulvar lamina flatly tapered to acute posteriorly directed apices
 *S. obtrusum* p. 897

Sympetrum ambiguum (Rambur)

Syn.: *albifrons* Charpentier

(Figures 209a, 212a, 215a)

Rambur 1842. Ins. Neur., p. 106 (in *Libellula*).

Length 33-38 mm; abdomen 21-25 mm; hind wings 25-28 mm.

Diagnosis.--Face white at maturity; posterior surface of head without ridgelike elevation lateral to occiput; tibiae predominantly brownish yellow, femora predominantly brownish yellow; wings hyaline, costa brown with medial yellow stripe; hind wings each with 3 cell rows between fibulum and wing margin; posterior hamuli each directed posteriorly, each with dorsal lobe rounded apically in ventral view, and ventral hook not extended beyond apex of dorsal lobe; vulvar lamina bilobate; abdominal segment 9 without lateral carinae; male cerci with ventral teeth, dorsal surface concave.

Distribution.--Known from the states of AL, AR, FL, GA, IL, IN, IA, KS, KY, LA, ME, MD, MA, MI, MN, MS, MO, NE, NJ, NC, OH, OK, PA, SC, TN, TX, and VA, and the province of Ont. Known from the Virginia counties of Albemarle, Charles City, Fairfax, James City, Loudoun, and Mecklenburg, and the cities of Chesapeake, Norfolk, Suffolk, and Virginia Beach. Known distribution among the counties of neighboring states include: Kentucky- Bullitt, Carter, Edmonson, Fayette, Fulton, Green, Harrison, Hart, Jefferson, Ohio, Oldham, Rockcastle, Taylor, Trigg, Union, Warren, and Washington; Maryland- Prince Georges; North Carolina- Craven, Moore, and Wake; Pennsylvania- Allegheny, Delaware, and Philadelphia; Tennessee- Blount, Davidson, Greene, Hawkins, Marshall, and Williamson.

Virginia Records.--Albemarle Co.; Charlottesville, 1 Sept. 1937, 2 males, MDE, VPI&SU. Charles City Co.; Fish Hatchery, 21 Sept. 1966, 2 males, MDR, VPI&SU. Fairfax Co.; Great Falls, 4 July 1899, 1 female, W. R. Maxon and G. N. Collins, USNM. James City Co.; Williamsburg, 30 Sept. 1936, 1 male, MED, VPI&SU; Williamsburg, 12 Oct. 1936, 1 female, MED, VPI&SU. Loudoun Co.; Hillsboro, 22 Aug. 1898, 1 female, RPC, USNM. Mecklenburg Co.; boat landing at John H. Kerr Reservoir nr. Rt. 58, 9 Oct. 1978, 1 male, FLC. City of Chesapeake; Lk. Drummond, 28 Aug. 1948, 2 males, collector unknown, VPI&SU. City of Norfolk; locality unknown, 24 Sept. 1975, 1 male, Rhodes, ODU; locality unknown, 5 Oct. 1974, 1 male, Leggett, ODU. City of Suffolk; Dismal Swamp Wildlife Refuge, 20 Sept. 1975, 1 male, R. S. Hertz, ODU; Dismal Swamp Wildlife Refuge, 20 Sept. 1975, 1 male, E. Green, ODU; Dismal Swamp Wildlife Refuge, 20 Sept. 1975, 2 males, J. Hancock, ODU; Dismal Swamp Wildlife Refuge, 21 Sept. 1975, 1 male, M. Burkett, ODU; Dismal Swamp Wildlife Refuge, 27 Sept. 1959, 1 male, 1 female, N. Neighbors, VPI&SU; Dismal Swamp Wildlife Refuge, 28 Sept. 1975, 3 males, J. Hancock, ODU; Dismal Swamp Wildlife Refuge, 1 Oct. 1974, 1 female, T. M. G., ODU. City of Virginia Beach; locality unknown, 12 Sept. 1975, 1 male, A. Cambell, ODU; locality unknown, 15 Sept. 1975, 1 female, J. F. B., ODU.

Flight Season.--May 3 (AL) to Nov. 10 (FL); in Virginia July 4 to Oct. 12. Known season in neighboring states are: Kentucky- May 20 to Oct. 16; Maryland- Sept. 16 to 24; North Carolina- June to Sept. 28; Pennsylvania- Aug. 8 to Sept. 7; Tennessee- Aug. 23 to Sept. 30.

Biology.--*Sympetrum ambiguum* inhabits marshes, ditches, and ponds.

Remarks.--This species is distinguished by the black apical rings of

the abdominal segments. *Sympetrum ambiguum* apparently does not occur in the western mountains of Virginia.

Sympetrum costiferum (Hagen)

(Figures 209b, 212b, 215b)

Hagen 1861. Syn. Neur. N. Amer., p. 174 (in *Diplax*).

Length 31-40 mm; abdomen 21-28 mm; hind wings 23-30 mm.

Diagnosis.--Face yellowish brown at maturity; posterior surface of head without ridgelike elevation lateral to occiput; tibiae predominantly black, femora predominantly black; wings hyaline with saffron costal streak in female, costa reddish yellow with black spines; hind wings each with 3 or 4 cell rows between fibulum and wing margin; posterior hamuli each directed posteroventrally, each with mesal hook not extended beyond lateral lobe; vulvar lamina entire, slightly protruding from sternum; abdominal segment 9 without lateral carinae; male cerci without ventral teeth, dorsal surface convex.

Distribution.--Known from the states of CA, CT, ID, IA, ME, MA, MI, MO, MT, NE, NV, NH, NY, OH, OR, PA, RI, SD, UT, VT, WA, WI, and WY, and the provinces of Alta., B.C., Man., N.B., Nfld., N.W. Terr., N.S., Ont., Que., and Sask. Known distribution among the counties of neighboring states include: Pennsylvania- Tioga.

Flight Season.--July 7 (Nfld.) to Nov. 1 (B.C.). Known season in neighboring states are: Pennsylvania- Aug. 13 to 14.

Biology.--*Sympetrum costiferum* inhabits marshes, bogs, ponds, and marsh-bordered lakes. Oviposition generally occurs while in tandem with

the male.

Remarks.--*Sympetrum costiferum* is distinguished by the dark face of the male and a saffron costal streak of the female. This species may possibly occur in the bog ponds of western Virginia.

Sympetrum internum Montgomery

(Figures 210a, 213a, 216a)

Montgomery 1943. Can. Entomol. 75:57.

Length 28-36 mm; abdomen 19-25 mm; hind wings 21-29 mm.

Diagnosis.--Face yellowish red at maturity; posterior surface of head with ridgelike elevation lateral to occiput; tibiae predominantly black, femora predominantly black; wings hyaline with basal half occasionally saffron in female, costa yellow with black spines; hind wings each with 4 (occasionally 3) cell rows between fibulum and wing margin; posterior hamuli each directed posteriorly, each with dorsal lobes acuminate in lateral view with mesal lobe tuberculate and subapical, ventral hook extended slightly beyond apex of dorsal lobe; vulvar lamina bilobate, ca. as wide as long, ca. twice as long as high, ventral surface flatly tapered to acute posteriorly directed apices; abdominal segment 9 without lateral carinae; male cerci with ventral teeth, dorsal surface concave.

Distribution.--Known from the states of AK, CA, CO, ID, IL, IN, IA, KS, KY(?), MI, MN, MO, MT, NE, NV, ND, OK, OR, PA(?), SD, UT, WA, WI, and WY, and the provinces of Alta., B.C., Man., N.W. Terr., Ont., Que(?), and Sask. Known distribution among the counties of neighboring

states include: Kentucky(?)— Bell, Carter, Edmonson, Green, Hart, Ohio, Trigg, and Union; Pennsylvania(?)— Allegheny, Centre, Clinton, Delaware, Erie, and Monroe.

Flight Season.--June 15 (Ont.) to Oct. 8 (B.C.). Known season in neighboring states are: Kentucky(?)— Aug. to Oct.; Pennsylvania(?)— July 1 to Sept. 30.

Biology.--*Sympetrum internum* inhabits marshes, bogs, ponds, and marsh-bordered lakes.

Remarks.--*Sympetrum internum* is distinguished by the yellow costa and in mature individuals by the bright red face. This species doubtfully occurs in Virginia but it is included because it has been previously confused with *S. janeae* and *S. obtrusum*.

Sympetrum janeae n. sp.

(Figures 209c, 212c, 215c)

Length 32-36 mm; abdomen 22-25 mm; hind wings 24-27 mm.

Diagnosis.--Face yellowish white at maturity; posterior surface of head with ridgelike elevation lateral to occiput; tibiae predominantly black, femora predominantly black; wings hyaline, costa black with medial yellow stripe; hind wings each with 3 cell rows between fibulum and wing margin; posterior hamuli each directed posteriorly, each with dorsal lobe acuminate in lateral view with mesal process obtuseangulate and ventral hook extended beyond apex of dorsal lobe; vulvar lamina bilobate, ca. as wide as long, ca. twice as long as high, ventral surface convexly curved to blunt posterodorsally directed apices; abdominal segment 9 without lateral carinae; male cerci with ventral teeth, dorsal

surface concave.

Distribution.--Known from the states of CT, DE, ME, MD, MA, NH, NJ, NY, PA, VT, and VA, and the provinces of N.B., Nfld., N.S., P.E.I., and Que. Known from the Virginia city of Suffolk. Known distribution among the counties of neighboring states include: Maryland- Montgomery; Pennsylvania- Pike.

Virginia Records.--City of Suffolk; Dismal Swamp Wildlife Refuge, 20 Sept. 1975, 1 male, C. A. Carlson, ODU.

Flight Season.--Aug. 19 (PA) to Sept. 20 (VA); in Virginia Sept. 20. Known season in neighboring states are: Pennsylvania- Aug. 19.

Biology.--*Sympetrum janeae* inhabits marshes, bogs, ponds, and marsh-bordered lakes. Oviposition generally occurs in tandem.

Remarks.--*Sympetrum janeae* is distinguished by the white face and long ventral hook of the male hamuli. This species has been most often confused with the males of *S. rubicundulum* and the females of *S. obtrusum*. The distribution of this species in Virginia is apparently limited to the coastal plain.

Sympetrum obtrusum (Hagen)

Syn.: *decisum* Hagen

(Figures 210b, 213b, 216b)

Hagen 1867. Stettin Entomol. Ztg. 28:95 (in *Diplac*).

Length 30-38 mm; abdomen 21-26 mm; hind wings 21-29 mm.

Diagnosis.--Face white at maturity; posterior surface of head with ridgelike elevation lateral to occiput; tibiae predominantly black,

femora predominantly black; wings hyaline, costa black with medial yellow stripe; hind wings each with 3 cell rows between fibulum and wing margin; posterior hamuli each directed posteriorly, each with dorsal lobe truncate in lateral view with mesal lobe tuberculate and apical, ventral hook not extended beyond apex of dorsal lobe; vulvar lamina bilobate, ca. as wide as long, ca. twice as long as high, ventral surface flatly tapered to acute posteriorly directed apices; abdominal segment 9 without lateral carinae; male cerci with ventral teeth, dorsal surface concave.

Distribution.--Known from the states of CA, CO, ID, IL, IN, IA, KS, KY, ME, MD, MA, MI, MN, MT, NE, NH, NJ, NY, NC, ND, OH, OR, PA, RI, SD, UT, VT, VA, WA, WV, WI, and WY, and the provinces of Alta., B.C., Man., N.B., N.S., NW. Terr., Ont., P.E.I., Que., and Sask. Known from the Virginia counties of Giles and Highland. Known distribution among the counties of neighboring states include: Kentucky- Breckinridge, Edmonson, Hart, and Ohio; Maryland- Alleghany, Garrett, Montgomery, and Prince Georges; North Carolina- Watauga; Pennsylvania- Allegheny, Beaver, Bucks, Butler, Centre, Clearfield, Clinton, Crawford, Delaware, Elk, Erie, Fayette, Jefferson, McKean, Mercer, Somerset, and Warren; West Virginia- Jefferson, Preston, Randolph, and Tucker.

Virginia Records.--Giles Co.; *Sylvatica* Pd. at Mtn. Lk. Bio. Sta., 27 Oct. 1978, 1 male, FLC. Highland Co.; Bearwallow Run beaver pds., 8 Aug. 1978, 1 female, JRV, VPI&SU; spring seep nr. Laurel Fork at Rt. 642, 8 Aug. 1978, 1 male, 1 female, JRV, VPI&SU; Buck Run beaver ponds, 8 Aug. 1978, 4 males, FLC; beaver pds. at headwaters of Slab Camp Run, 2 Oct. 1977, 1 male, FLC.

Flight Season.--Apr. 14 (IN) to Oct. 27 (VA); in Virginia Aug. 8 to Oct. 27. Known season in neighboring states are: Kentucky- Aug. to Oct.; Maryland- Aug. 23 to Oct. 3; North Carolina- July; Pennsylvania- July 1 to Oct. 15; West Virginia- Aug. 8 to Sept. 15.

Biology.--*Sympetrum obtrusum* inhabits marshes, bogs, ponds, and marsh-bordered lakes.

Remarks.--*Sympetrum obtrusum* is distinguished by its white face and the truncate dorsal lobe of male hamuli. This species apparently does not occur east of the western mountains in Virginia.

Sympetrum rubicundulum (Say)

Syn.: *assimilatum* Uhler

(Figures 210c, 213c, 216c)

Say 1839. J. Acad. Phila. 8:26 (in *Libellula*).

Length 31-39 mm; abdomen 21-27 mm; hind wings 24-30 mm.

Diagnosis.--Face yellowish white at maturity; posterior surface of head with ridgelike elevation lateral to occiput; tibiae predominantly black, femora predominantly black in male, yellowish brown in female; wings hyaline, occasionally saffron basally, costa black with medial yellow stripe; hind wings each with 3 cell rows between fibulum and wing margin; posterior hamuli each directed posteriorly, each with dorsal lobe acuminate in lateral view, without mesal process, and with ventral hook extended beyond apex of dorsal lobe; vulvar lamina bilobate, ca. as wide at base as long, inflated ca. as long as high, ventral surface convexly curved to blunt posterodorsally directed apices; abdominal

segment 9 without lateral carinae; male cerci with ventral teeth, dorsal surface concave.

Distribution.--Known from the states of CO, CT, DC, GA, ID, IL, IN, IA, KS, KY, MD, MA(?), MI, MN, MO, NE, NV, NJ, NY, NC, OH, PA, SD, TN, UT, VA, WV, WI, and WY, and the provinces of Ont. and Que.(?). Known from the Virginia counties of Alleghany, Arlington, Augusta, Bath, Botetourt, Charlotte, Craig, Fairfax, Giles, Highland, Montgomery, Pulaski, Rockbridge, Rockingham, Russell, Washington, and Wythe. Known distribution among the counties of neighboring states include: Kentucky- Bullitt, Edmonson, Fayette, Green, Harrison, Hart, Jefferson, McCreary, Ohio, Taylor, and Trigg; Maryland- Montgomery and Prince Georges; North Carolina- Du ham, Haywood, Jackson, Wake, Wilkes, and Yadkin; Pennsylvania- Allegheny, Beaver, Berks, Bradford, Bucks, Butler, Cambria, Carbon, Centre, Chester, Clearfield, Clinton, Crawford, Delaware, Elk, Erie, Fayette, Franklin, Fulton, Huntingdon, Indiana, Lancaster, Lawrence, Lebanon, Lehigh, Luzerne, Mercer, Monroe, Montgomery, Perry, Philadelphia, Pike, Schuylkill, Somerset, Sullivan, Tioga, Union, Venango, Warren, Washington, Wayne, Westmoreland, and Wyoming; Tennessee- Fentress; West Virginia- Greenbrier, Jefferson, Kanawha, Mason, Monroe, Pendleton, Raleigh, and Ritchie.

Virginia Records.--Alleghany Co.; Boiling Springs, 20 July 1951, 3 males, R. L. Hoffman, (Det. LKG); Griffith, 1 Aug. 1953, 2 males, R. L. Hoffman, (Det. LKG); marsh along Rt. 159, 28 Aug. 1973, 1 male, 1 female (in tandem), FLC; Pd. Flat Marsh off Rt. 600, 10 Sept. 1978, 1 male, FLC. Arlington Co.; Potomac R. at Gravelly Point, "June 6 to Oct. 12", (Donnelly 1961). Augusta Co.; Shenandoah Pd., 17 July 1980,

2 males, BCK; Maple Flat Pds., 2 Oct. 1977, 1 male, SWB, FLC Collection. Bath Co.; spring-fed marsh on Rt. 601 3.5 miles from Rt. 39, 11 Sept. 1979, 2 males, JRV, VPI&SU; spring-fed marsh on Rt. 601 3.5 miles from Rt. 39, 11 Sept. 1979, 1 male, 1 female, BCK; pd. along Rt. 678 nr. Rt. 627, 2 Oct. 1977, 2 males, FLC. Botetourt Co.; Craig Cr. at Rt. 706 nr. Oriskany, 17 June 1978, 1 female, FLC. Charlotte Co.; Twittys Cr. at Rt. 642, 14 June 1975, 1 male, FLC. Craig Co.; Johns Cr., 28 June 1975, 1 male, SWB, VPI&SU; pd. 1 mile S. of Paint Bank at Rt. 635, 9 Aug. 1978, 7 males, 1 female, FLC; Johns Cr. at Rt. 311, 12 Aug. 1973, 1 male, FLC; farm pd. at Rt. 611 0.2 miles from Rt. 311, 14 Aug. 1974, 1 female, FLC; Johns Cr. 4.2 miles W. of Newcastle, 26 Aug. 1953, 2 females, R. H. Gibbs, USNM. Fairfax Co.; Hunting Meadows in Fairfax Park Authority, 23 July 1975, 1 female, C. R. Parker, VPI&SU. Giles Co.; Sylvatica Pd. at Mtn. Lk. Bio. Sta., 26 June 1977, 1 male, BCK; Mtn. Lk. at Pond Drain Cr., 5 July 1973, 1 male, FLC; Sylvatica Pd. at Mtn. Lk. Bio. Sta., 27 Oct. 1978, 1 male, FLC. Highland Co.; small beaver pd. nr. Back Cr., 1 Aug. 1973, 1 male, 1 female (in tandem), FLC; Buck Run beaver pds., 8 Aug. 1978, 1 male, FLC. Montgomery Co.; New R. at McCoy-Longbranch, 12 June 1977, 4 males, 1 female, BCK; New R. at McCoy; 12 June 1977, 2 males, 8 females, R. Baer, FLC Collection; Blacksburg, 25 June 1948, 1 male, G. M. Boush, VPI&SU; Toms Cr. oxbow below Rt. 655 bridge, 26 June 1973, 3 males, 2 females, FLC; Toms Cr. marsh 0.5 miles downstream from Rt. 655, 29 June 1973, 1 male, 1 female (in tandem), FLC; locality unknown, July 1947, 1 male, E. A. Smyth, USNM; Blacksburg, 2 July 1948, 1 female, J. M. Grayson, VPI&SU; Heath Pd. off Rt. 685 in Blacksburg, 8 July 1978, 1 male, FLC; Toms Cr. marsh 0.5 miles downstream

from Rt. 655, 10 July 1973, 3 males, 3 females (3 pair in tandem), FLC; Craig Cr. beaver pd. at Rt. 621 0.8 mile from Rt. 460, 15 July 1978, 3 males, BCK; Blacksburg, 18 July 1974, 1 male, T. Bailey, VPI&SU; Blacksburg, 22 July 1948, 2 males, G. M. Boush, VPI&SU; Toms Cr. marsh 0.5 miles downstream from Rt. 655, 25 July 1973, 2 males, 2 females (in tandem), FLC; Heath Pd. off Rt. 685 in Blacksburg, 1 Aug. 1977, 2 males, 1 female (1 pair in tandem), FLC; locality unknown, 9 Aug. 1901, 2 males, E. A. Smyth, USNM; Poverty Hollow, 17 Aug. 1961, 1 male, C. V. Covell, VPI&SU; Craig Cr. beaver pd. at Rt. 621, 22 Aug. 1978, 3 males, BCK, FLC Collection; Craig Cr. beaver pd. at Rt. 621, 22 Aug. 1978, 1 male, 1 female (in tandem); Poverty Cr., 23 Sept. 1977, 1 male, BCK; Pandapas Pd., 5 Oct. 1980, 1 female, FLC, VPI&SU. Pulaski Co.; Gatewood Reservoir, 29 June 1973, 2 males, 2 females (2 pair in tandem), FLC; Belspring, 12 July 1978, 1 male, BCK; Belspring, 12 July 1978, 1 male, J. Trumble, VPI&SU. Rockbridge Co.; Guys Run, 28 June 1978, 1 male, M. Meschter. Rockingham Co.; small grassy pd. on crest of Shenandoah Mtn., 18 Aug. 1978, 2 males, R. L. Hoffman, VPI&SU. Russell Co.; Laurel Bed Lk., 4 July 1977, 4 males, 1 female (all teneral), 32 nymphal exuviae, FLC; beaver pds. and sphagnum bog at upper end of Laurel Bed Lk., 28 Aug. 1979, 7 males, 5 females, JRV and BCK, VPI&SU; Laurel Bed Lk. at entrance of Laurel Bed Cr., 25 Sept. 1977, 8 males, 5 females, BCK; Laurel Bed Lk., 25 Sept. 1977, 13 males, 10 females (10 pair in tandem), FLC. Washington Co.; Straight Br. beaver pds., 14 Aug. 1979, 1 male, BCK. Wythe Co.; Wytheville, 27 June 1935, 11 males, 3 females, CA, (Det. CA); Wytheville, 27 June 1935, 4 males, CA, (Det. CA), MZUM.

Flight Season.--May 5 (OH) to Nov. 13 (NC); in Virginia June 12 to

Oct. 27. Known season in neighboring states are: Kentucky- July to Oct. 29; Maryland- July 16 to Oct. 12; North Carolina- July 27 to Nov. 13; Pennsylvania- June 1 to Oct. 23; Tennessee- July 1; West Virginia- June 20 to Sept. 30.

Biology.--*Sympetrum rubicundulum* inhabits marshes, ditches, ponds, and marsh-bordered lakes.

Remarks.--Distinguished by its clear wings and absence of mesal process on male hamuli, this species is common in Virginia.

Sympetrum semicinctum (Say)

(Figures 211a, 214a, 217a)

Say 1839. J. Acad. Phila. 8:27 (in *Libellula*).

Length 24-31 mm; abdomen 15-20 mm; hind wings 18-24 mm.

Diagnosis.--Face yellowish brown at maturity; posterior surface of head without ridgelike elevation lateral to occiput; tibiae predominantly dark brown, femora predominantly black; wings saffron over basal 1/2, costa black with medial yellow stripe; hind wings each with 4 (occasionally 3) cell rows between fibulum and wing margin; posterior hamuli each directed ventrally, each with mesal hook extended to ca. level of lateral lobe; vulvar lamina entire, slightly protruding from sternum; abdominal segment 9 with lateral carinae; male cerci without or with small subapical ventral teeth, dorsal surface convex.

Distribution.--Known from the states of CT, DC, IL, IN, IA, KY, ME, MD, MA, MI, MN(?), NH, NJ, NY, NC, OH, PA, RI, TN, VT, VA, WV, and WI, and the provinces of N.B., N.S., Ont., and Que. Known from the Virginia

counties of Augusta, Bath, Charlotte, Giles, Grayson, Highland, Montgomery, Tazewell, and Wythe. Known distribution among the counties of neighboring states include: Kentucky- Carter and Harrison; Maryland- Prince Georges; North Carolina- Buncombe; Pennsylvania- Allegheny, Beaver, Berks, Bucks, Butler, Cambria, Centre, Chester, Clearfield, Clinton, Crawford, Delaware, Erie, Fayette, Franklin, Fulton, Huntingdon, Indiana, Lehigh, Lycoming, Monroe, Montgomery, Perry, Philadelphia, Schuylkill, Somerset, Venango, Washington, Wayne, and Westmoreland; Tennessee- Carter, Hawkins, Johnson, Sevier, and Smith.

Virginia Records.--Augusta Co.; Shenandoah Pd., 29 Oct. 1978, 1 male, 1 female (in tandem), FLC. Bath Co.; spring-fed marsh on Rt. 601 3.5 miles from Rt. 39, 11 Sept. 1979, 2 males, 2 females, BCK; spring-fed marsh on Rt. 601 3.5 miles from Rt. 39, 11 Sept. 1979, 2 males, 1 female, JRV, VPI&SU. Charlotte Co.; Twittys Cr. at Rt. 642, 22 July 1978, 1 female, FLC; Horsepen Cr. at Rt. 637, 23 July 1974, 1 male, FLC. Giles Co.; Eggleston, 2 Sept. 1965, 1 male, G. Straley, VPI&SU. Grayson Co.; spring seep at Rt. 603, 14 Aug. 1979, 1 male, JRV, VPI&SU. Highland Co.; Buck Run beaver pds., 8 Aug. 1978, 1 female, FLC; Buck Run beaver pds., 12 Sept. 1979, 1 male, BCK. Montgomery Co.; Toms Cr. marsh 0.5 miles downstream from Rt. 655, 25 June 1973, 1 male, 1 female (in tandem), FLC; Pandapas Pd., 25 June 1973, 1 male, 1 female, FLC; Toms Cr. oxbow below Rt. 655 bridge, 26 June 1973, 1 male, 1 female (in tandem), FLC; Toms Cr. marsh 0.5 mile downstream from Rt. 655, 29 June 1973, 1 male, FLC; Blacksburg, 8 July 1948, 1 male, G. M. Boush, VPI&SU; Toms Cr. oxbow, 15 July 1973, 1 male, FLC, VPI&SU; Toms Cr. marsh 0.5 mile downstream from Rt. 655, 20 July 1973, 1 male, 1 female (in tandem)

FLC; Heath Pd. off Rt. 685 in Blacksburg, 1 Aug. 1977, 1 male, 1 female (in tandem), FLC; Toms Cr. marsh 0.5 miles downstream from Rt. 655, 5 Aug. 1974, 1 female, FLC; locality unknown, 9 Aug. 1901, 2 males, collector unknown, USNM; Toms Cr. at Rt. 655, 11 Sept. 1977, 2 males, FLC; Stroubles Cr. 0.1 mile downstream from VPI&SU Duck Pd., 12 Sept. 1977, 1 male, 1 female, FLC; Stroubles Cr. downstream from VPI&SU Duck Pd., 13 Sept. 1977, 1 male, 1 female, FLC. Tazewell Co.; Tazewell, 20 July 1935, 1 female, CA, (Det. CA). Wythe Co.; Wytheville, 28 June 1935, 7 males, 1 female, CA, (Det. CA); Max Meadows, 3 Aug. 1938, 1 male, A. H. Clark, USNM.

Flight Season.--June 19 (Ont.) to Oct. 29 (VA); in Virginia June 25 to Oct. 29. Known season in neighboring states are: District of Columbia- July 16; Kentucky- Sept.; Maryland- July 21 to Sept. 24; North Carolina- Aug. 2; Pennsylvania- June 24 to Oct. 23; Tennessee- July 14 to Sept. 3.

Biology.--*Sympetrum semicinotum* inhabits seepage pools and spring-fed marshes. Oviposition generally occurs in tandem with the male.

Remarks.--*Sympetrum semicinotum* is distinguished by broad saffron areas of the wings. This species is widely distributed in Virginia but is seldom abundant, apparently because of the limited nature of the nymphal habitat.

Sympetrum vicinum (Hagen)

(Figures 211b, 214b, 217b)

Hagen 1861. Syn. Neur. N. Amer., p. 175 (in *Diplax*).

Length 26-35 mm; abdomen 18-24 mm; hind wings 20-26 mm.

Diagnosis.--Face reddish brown at maturity; posterior surface of head without ridgelike elevation lateral to occiput; tibiae predominantly yellowish brown, femora predominantly yellow; wings hyaline or tinged with red, costa reddish yellow with black spines; hind wings each with 3 or 4 cell rows between fibulum and wing margin; posterior hamuli each directed ventrally, each with mesal hook extended beyond apex of lateral lobe; vulvar lamina entire, greatly protruding from sternum; abdominal segment 9 without lateral carinae; male cerci without or with small sub-apical ventral teeth, dorsal surface convex.

Distribution.--Known from the states of AL, AR, CO, CT, DC, DE, FL, GA, ID, IL, IN, IA, KS, KY, LA, ME, MD, MA, MI, MN, MS, MO, NE, NH, NJ, NY, NC, OH, OK, PA, RI, SC, TN, TX, VT, VA, WA, WV, WI, and WY, and the provinces of B.C., N.B., N.S., Ont., and Que. Known from the Virginia counties of Albemarle, Alleghany, Arlington, Augusta, Bath, Charles City, Charlotte, Chesterfield, Craig, Essex, Fairfax, Fauquier, Frederick, Giles, Hanover, Highland, James City, Loudoun, Louisa, Montgomery, Prince William, Roanoke, Rockbridge, Russell, Spotsylvania, Warren, Wise, Wythe, and York, and the city of Suffolk. Known distribution among the counties of neighboring states include: Kentucky- Allen, Bell, Bullitt, Butler, Carter, Edmonson, Green, Hardin, Harrison, Hart, Jefferson, Marion, McCreary, Ohio, Pulaski, Rockcastle, Taylor, and Whitley; Maryland- Anne Arundel, Montgomery, Prince Georges, and Talbot; North Carolina- Camden, Macon, McDowell, Moore, and Wake; Pennsylvania- Adams, Allegheny, Beaver, Bradford, Bucks, Butler, Cambria, Carbon, Centre, Chester, Clarion, Clearfield, Clinton, Columbia, Crawford,

Delaware, Elk, Erie, Fayette, Forest, Franklin, Fulton, Greene, Huntingdon, Indiana, Jefferson, Lebanon, Luzerne, McKean, Mercer, Monroe, Montgomery, Perry, Philadelphia, Pike, Schuylkill, Somerset, Union, Venango, Warren, Washington, Wayne, Westmoreland, Wyoming, and York; Tennessee-- Carroll, Cumberland, Davidson, Obion, Sullivan, and Unicoi; West Virginia-- Gilmer, Kanawha, Mason, Nicholas, Raleigh, Randolph, and Ritchie.

Virginia Records.--Albemarle Co.; Charlottesville, 1 Sept. 1937, 1 male, 1 female, MED, (Det. MED, MDR notes). Alleghany Co.; Griffith, 1 Aug. 1953, 4 males, 2 females, R. L. Hoffman, (Det. LKG); Pd. Flat Marsh off Rt. 600, 10 Sept. 1978, 1 female, 4 nymphal exuviae, FLC; Lowmoor, 19 Sept. 1934, 8 males, LKG and H. K. Gloyd, (Det. LKG, Gloyd 1951). Arlington Co.; Chain Bridge, "June 25 to Nov. 11", (Donnelly 1961). Augusta Co.; Green Pd. at Big Levels, 9 Oct. 1977, 1 male, FLC; Shenandoah Pd., 29 Oct. 1978, 7 males, 5 females (2 pair in tandem), FLC. Bath Co.; Pd. along Rt. 678 nr. Rt. 627, 2 Oct. 1977, 9 males, FLC; beaver pds. along Rt. 600, 27 Oct. 1978, 2 males, 2 females, FLC. Charles City Co.; Harrison Lk. at Roxbury, 28 May 1938, 1 female, R. Hess, (Det. A. D. Hess), A. D. Hess Collection; Harrison Lk. at Roxbury, 1 June 1938, 1 female, R. Hess, (Det. A. D. Hess), A. D. Hess Collection; Harrison Lk. at Roxbury, 13 June 1938, 3 females, R. Hess, (Det. A. D. Hess), A. D. Hess Collection; Herring Cr. Pd. at Rt. 5, 5 July 1938, 1 male, 2 females, MED, (Det. MED, MDR notes); Sawmill Swamp, 5 July 1938, 1 male, MED, (Det. MED, MDR notes); Fish Hatchery, 21 Sept. 1966, 9 males, 7 females, MDR, VPI&SU. Charlotte Co.; Twittys Cr. Dam, 10 June 1975, 1 female, FLC. Chesterfield Co.; Chester, 8 July 1976, 1 male,

S. Steiner, VCU. Craig Co.; pd. at Rt. 635 1 mile S. of Paint Bank, 9 Aug. 1978, 1 male (teneral), FLC; pd. at Rt. 635 1 mile S. of Paint Bank, 15 Oct. 1977, 1 male, FLC; roadside marsh at Rt. 635 1.5 miles S. of Paint Bank, 15 Oct. 1977, 5 males, FLC; roadside marsh at Rt. 635 2 miles S. of Paint Bank, 27 Oct. 1978, 2 males, 2 females (1 pair in tandem), FLC. Essex Co.; Dunbrooke, 28 July 1899, 1 male, RPC, USNM. Fairfax Co.; Great Falls, 25 June 1914, 1 female, RPC, USNM; Mallory House Pd. at George Mason Univ., 12 July 1975, 1 male, 4 females, K. A. and C. R. Parker; Falls Church, 15 July 1917, 1 male, I. N. Gabrielson, USNM; Great Falls, 27 July 1907, 2 males, RPC, USNM; Great Falls, 1 Aug. 1916, 1 female, W. L. McAtee, USNM; Great Falls, 18 Aug. 1917, 2 females, W. L. McAtee, USNM; Great Falls, 17 Sept. 1920, 1 male, H. O'Connor, USNM; Great Falls, 20 Sept. 1917, 1 male, BPC, USNM; Difficult Run, 28 Oct. 1917, 1 male, W. L. McAtee, USNM; opposite Plummers Island, 7 Nov. 1901, 2 males, RPC, USNM; Great Falls, 12 Nov. 1905, 2 males, D. H. Clemons, USNM. Fauquier Co.; 4 Sept. 1916, 1 female, R. A. Emmons, USNM. Frederick Co.; Turkey Run at Rt. 671, 27 Oct. 1978, 1 male, FLC. Giles Co.; Sylvatica Pd. at Mtn. Lk. Bio. Sta., 25 Sept. 1977, 1 male, FLC; Bailey Gap Pd. at Rt. 714, 25 Sept. 1977, 4 males, 1 female (1 pair in tandem), FLC; Sylvatica Pd. at Mtn. Lk. Bio. Sta., 27 Oct. 1978, 1 female (teneral), FLC. Hanover Co.; N. Anna R. at Rt. 738, 28 July 1976, 1 male, 1 female (teneral), JRV, BCK Collection. Highland Co.; Buck Run beaver pds., 8 Aug. 1978, 1 female (teneral), FLC; Buck Run beaver pds., 20 Aug. 1978, 1 female (teneral), FLC; Buck Run beaver pds., 31 Aug. to 2 Sept. 1973, 1 male, OSF, USNM; Buck Run beaver pds., 4 Sept. 1974, 1 male, OSF, USNM; Buck Run beaver pds., 12 Sept. 1979, 2 males, 1 female,

BCK; Buck Run beaver pds., 19 Sept. 1976, 2 males, JFM, ODU. James City Co.; Lk. Powell at Williamsburg, 1 July 1937, 1 female, CC, (Det. CC); Lk. Matoaka at Williamsburg, 12 July 1937, 1 female, CC, (Det. CC); Bassett Hall Pd. at Williamsburg, 22 Sept. 1966, 1 male, 1 female, MDR, VPI&SU; Toano, 8 Oct. 1937, 1 male, R. W. Menzel, (Det. MED, MDR notes); Lk. Matoaka at Williamsburg, 12 Oct. 1936, 1 male, 1 female, MED, (Det. MED, Davis 1938); Williamsburg, 19 Oct. 1936, 1 female, collector unknown, (Det. MED, MDR notes); Lk. Matoaka at Williamsburg, 22 Oct. 1936, 1 female, MED, (Det. MED, Davis 1938); Williamsburg, 25 Oct. 1936, 1 female, collector unknown, (Det. MED, MDR notes). Loudoun Co.; locality unknown, 12 Aug. 1971, 1 male, 1 female, T. Muir, VPI&SU. Louisa Co.; S. Anna R. at Rt. 522, 1 Sept. 1977, 1 female, BCK; Elk Cr. at Rt. 652, 22 Nov. 1968, 1 female, G. M. Simmons, VPI&SU. Montgomery Co.; 20 July 1973, 1 female, FLC; Pandapas Pd., 15 Aug. 1978, 1 male, FLC; locality unknown, 25 Aug. 1976, 2 males, T. Bailey, VPI&SU; Stroubles Cr. downstream from VPI&SU Duck Pd., 13 Sept. 1977, 3 males, FLC; locality unknown, 25 Sept. 1968, 1 male, T. Mullins, VPI&SU; Stroubles Cr., 25 Sept. 1976, 2 males, BCK, VPI&SU; Blacksburg, 25 Sept. 1976, 1 male, M. Phitteason, VPI&SU; locality unknown, 1 Oct. 1964, 1 male, K. Webb, VPI&SU; VPI&SU Duck Pd., 3 Oct. 1963, 1 male, Riffe, VPI&SU; locality unknown, 5 Oct. 1974, 1 male, L. A. Saussy, VPI&SU; Pandapas Pd., 5 Oct. 1980, 3 males, JRV. VPI&SU; locality unknown, 13 Oct. 1970, 1 male, R. Peterson, VPI&SU; locality unknown, 15 Oct. 1968, 2 males, D. Vaughan, VPI&SU. Prince William Co.; Quantico, 20 Sept. 1975, 1 male, N. Legere, ODU. Roanoke Co.; locality unknown, 21 Sept. 1974, 1 female, VPI&SU. Rockbridge Co.; Guys Run, 15 Nov. 1977, 1 male, M. Meschter. Russell

Co.; Laurel Bed Lk. at bog at entrance of Laurel Bed Cr., 25 Sept. 1977, 1 male, 1 female, BCK. Spotsylvania Co.; locality unknown, 18 June 1888, 1 female, W. D. Richardson, (Det. P. P. Calvert), ANSP; beaver dam off Rt. 617, 7 July 1978, 1 female (teneral), FLC. Warren Co.; Surber's Pd. nr. Browntown, 5 Sept. 1970, 2 males, E. W. Surber, VPI&SU. Wise Co.; Big Stone Gap, 10 July 1936, 1 female, collector unknown, VPI&SU; Big Stone Gap, 7 Oct. 1963, collector unknown, (Det. MED, MDR notes). Wythe Co.; Wytheville, 30 June 1935, 6 males, 4 females, CA, (Det. CA). York Co.; Cr. at Wallers Pd., 17 Sept. 1966, 1 male, MDR, VPI&SU. City of Suffolk; Cypress Chapel, 14 Sept. 1934, 1 female, LKG, (Det. LKG, Gloyd 1951); Western Br. Lk., 20 Sept. 1975, 1 male, J. O' Hop, ODU.

Flight Season.--May 28 (VA) to Dec. 13 (SC); in Virginia May 28 to Nov. 22. Known season in neighboring states are: District of Columbia- July 31 to Nov. 7; Kentucky- June 2 to Oct. 27; Maryland- July 20 to Nov. 10; North Carolina- June to Dec.; Pennsylvania- July 8 to Nov. 23; Tennessee- June 14 to Dec. 6; West Virginia- June 30 to Oct. 15.

Biology.--*Sympetrum vicinum* inhabits marshes, ditches, ponds, and marsh-bordered lakes. Oviposition occurs in tandem with the male.

Remarks.--Distinguished by the lack of black abdominal markings, this species is the most common species of *Sympetrum* in Virginia.

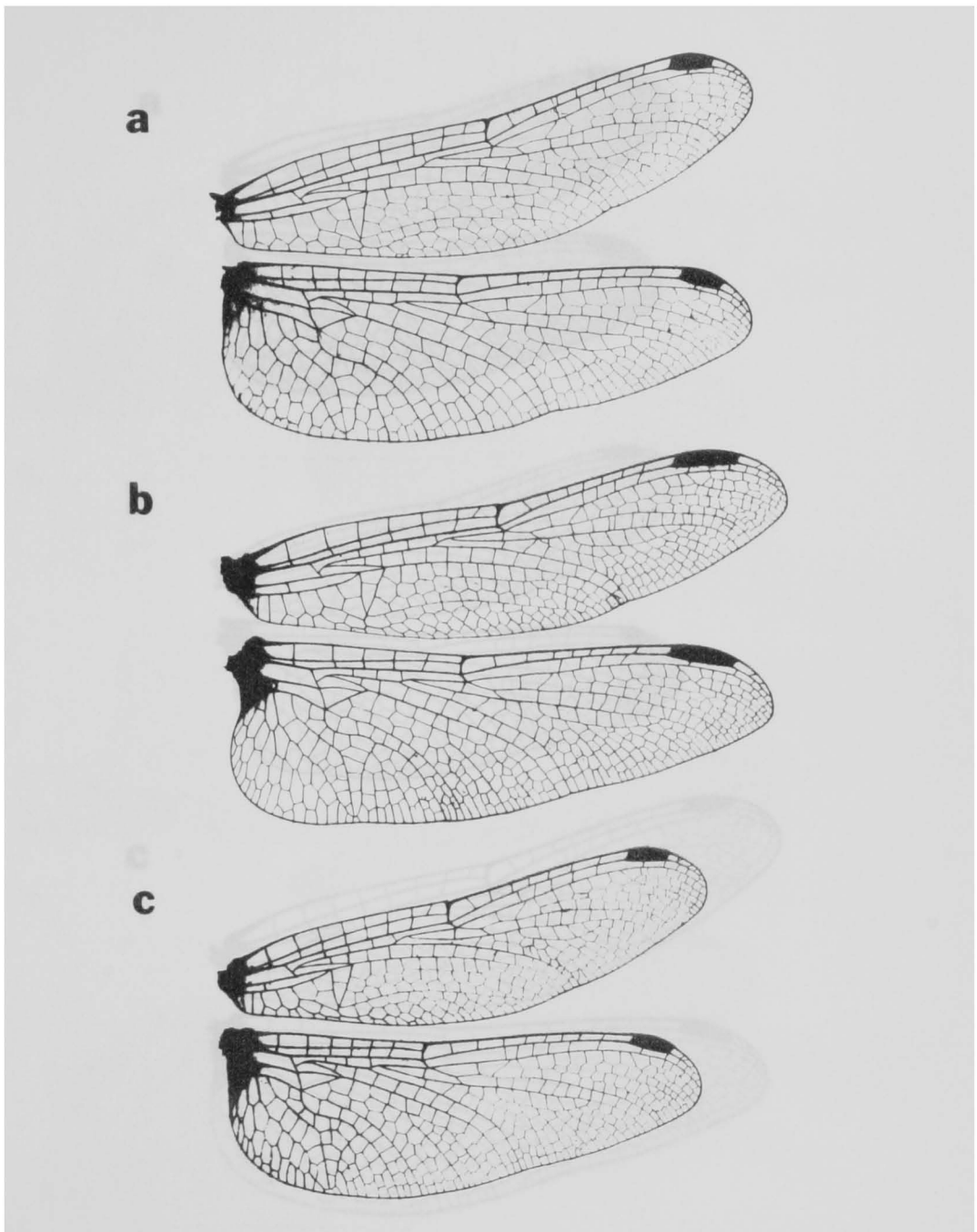


Figure 209. Wings of *Sympetrum* x3: (a) *S. ambiguum*; (b) *S. costiferum*; (c) *S. janeae*.

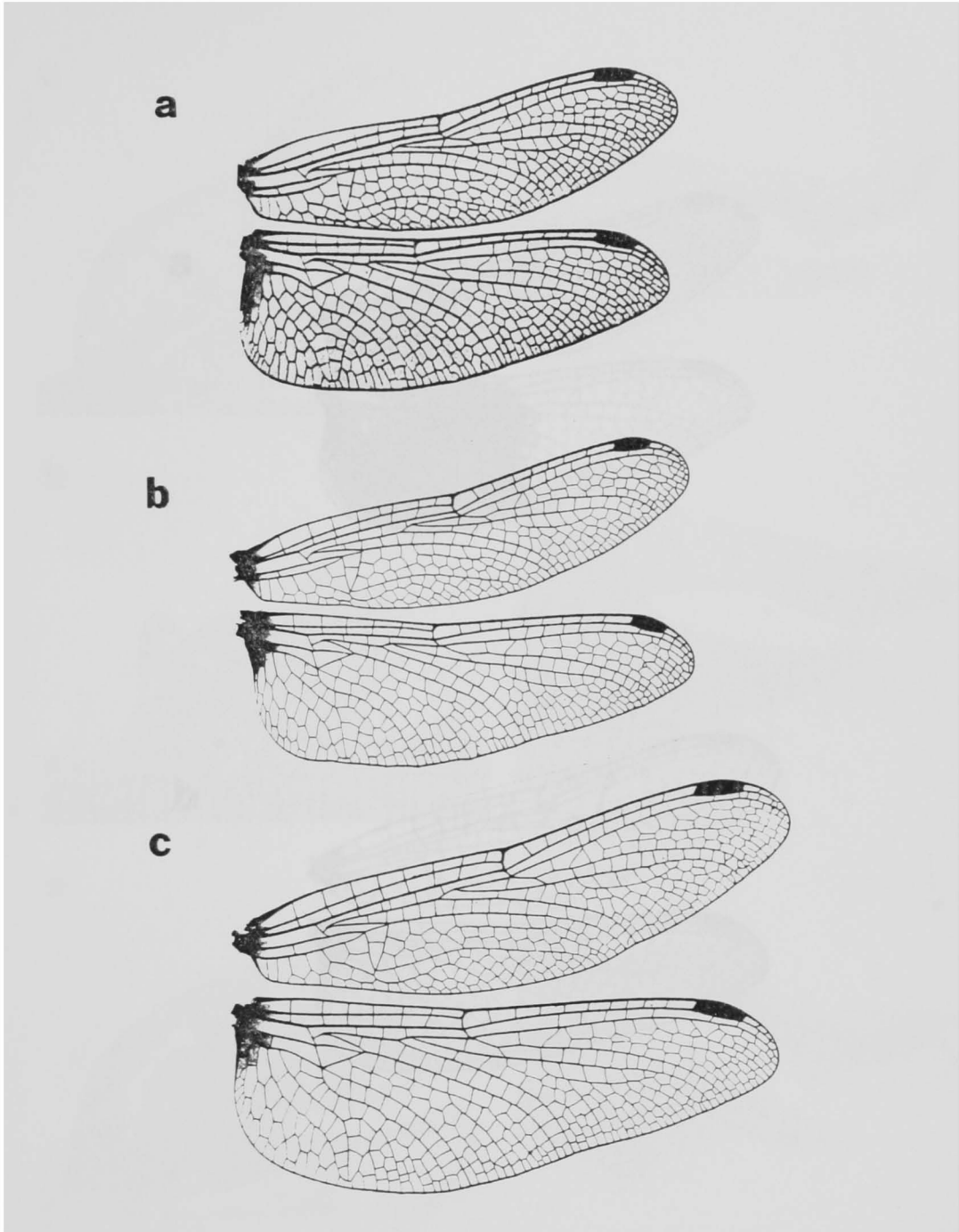


Figure 210. Wings of *Sympetrum* x3: (a) *S. internum*; (b) *S. obtrusum*; (c) *S. rubicundulum*.

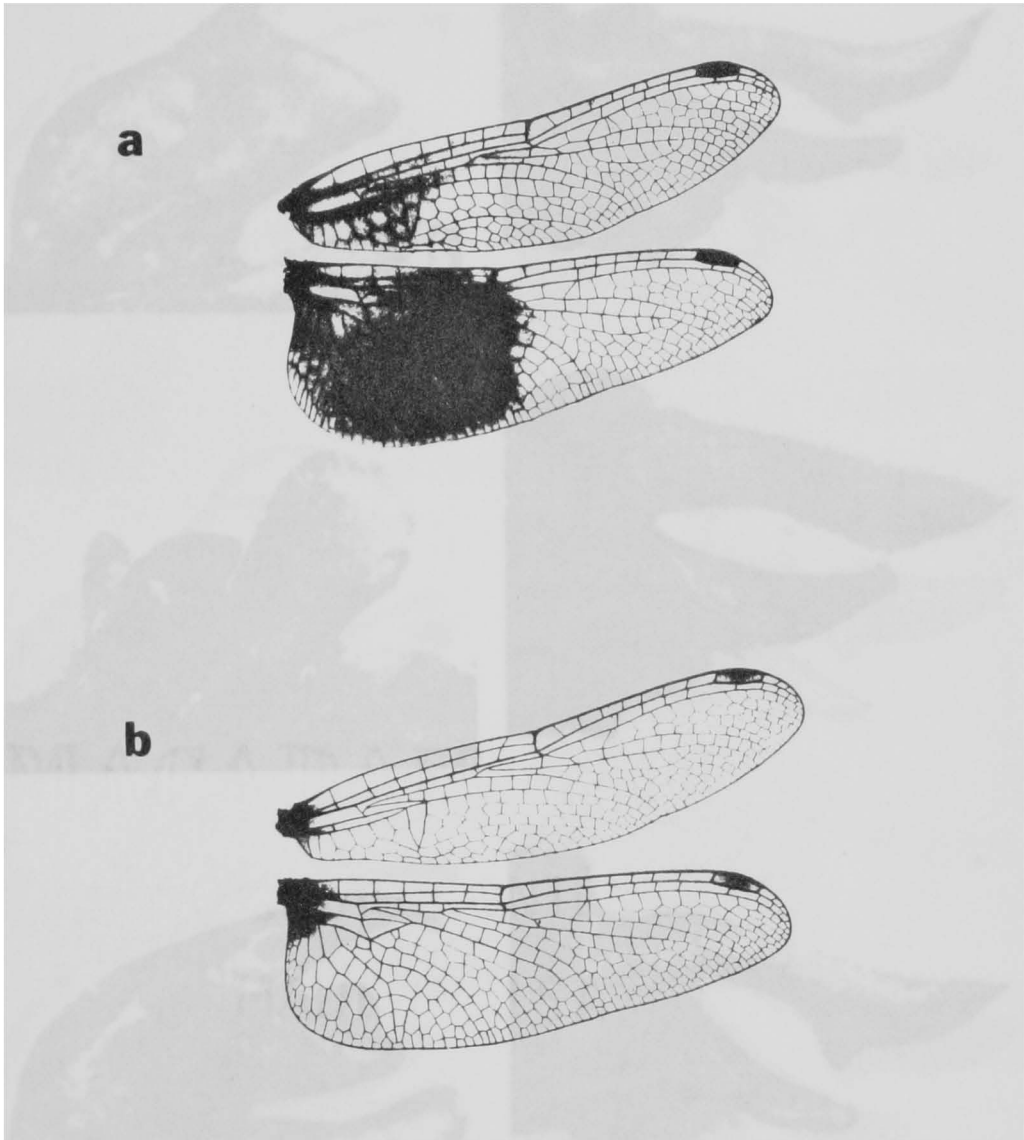


Figure 211. Wings of *Sympetrum* x3: (a) *S. semisinctum*; (b) *S. virinum*.

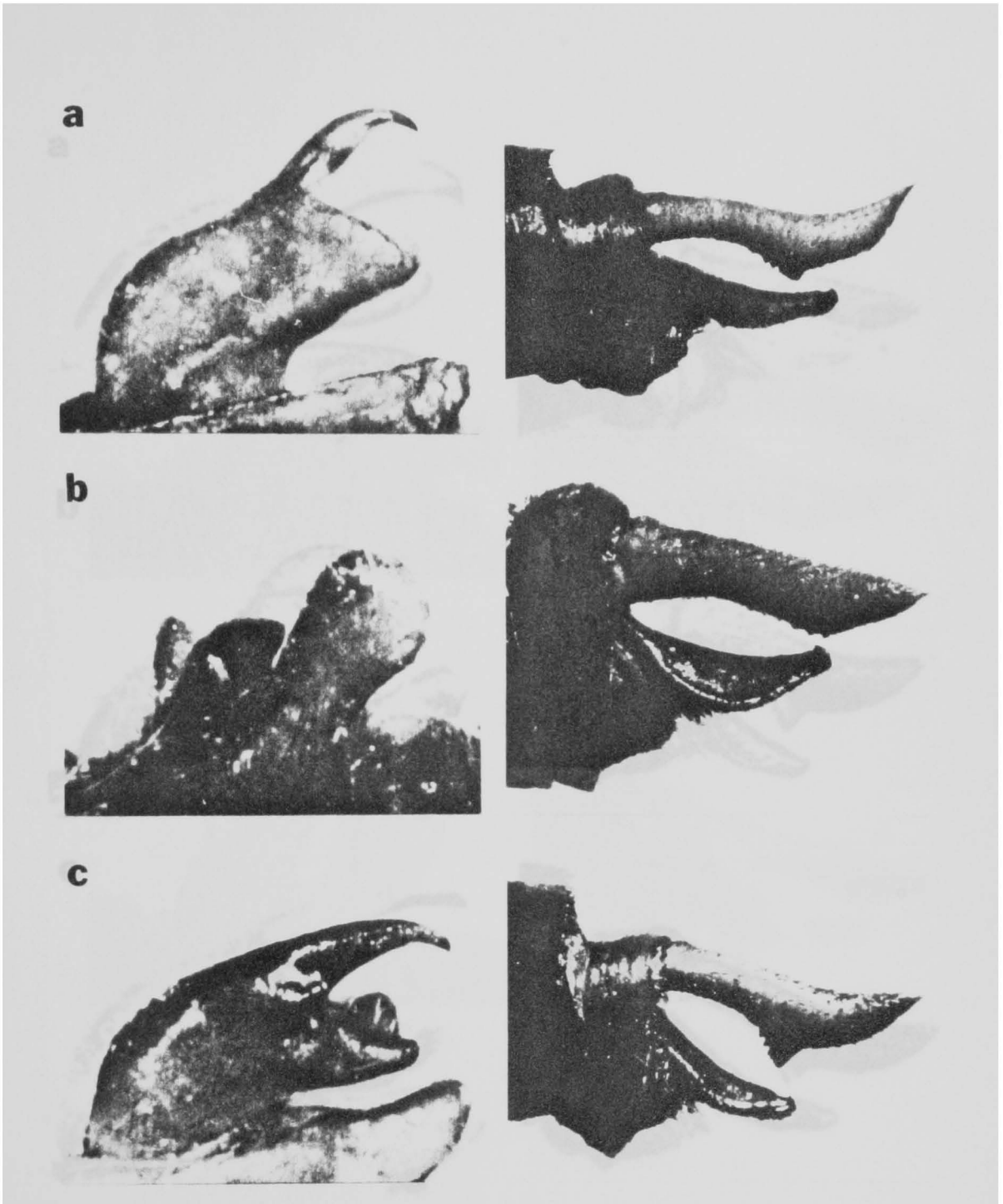


Figure 212. Posterior hamuli x50 and male terminalia x30 in lateral view of *Sympetrum*: (a) *S. ambiguus*; (b) *S. costiferum*; (c) *S. janeae*.

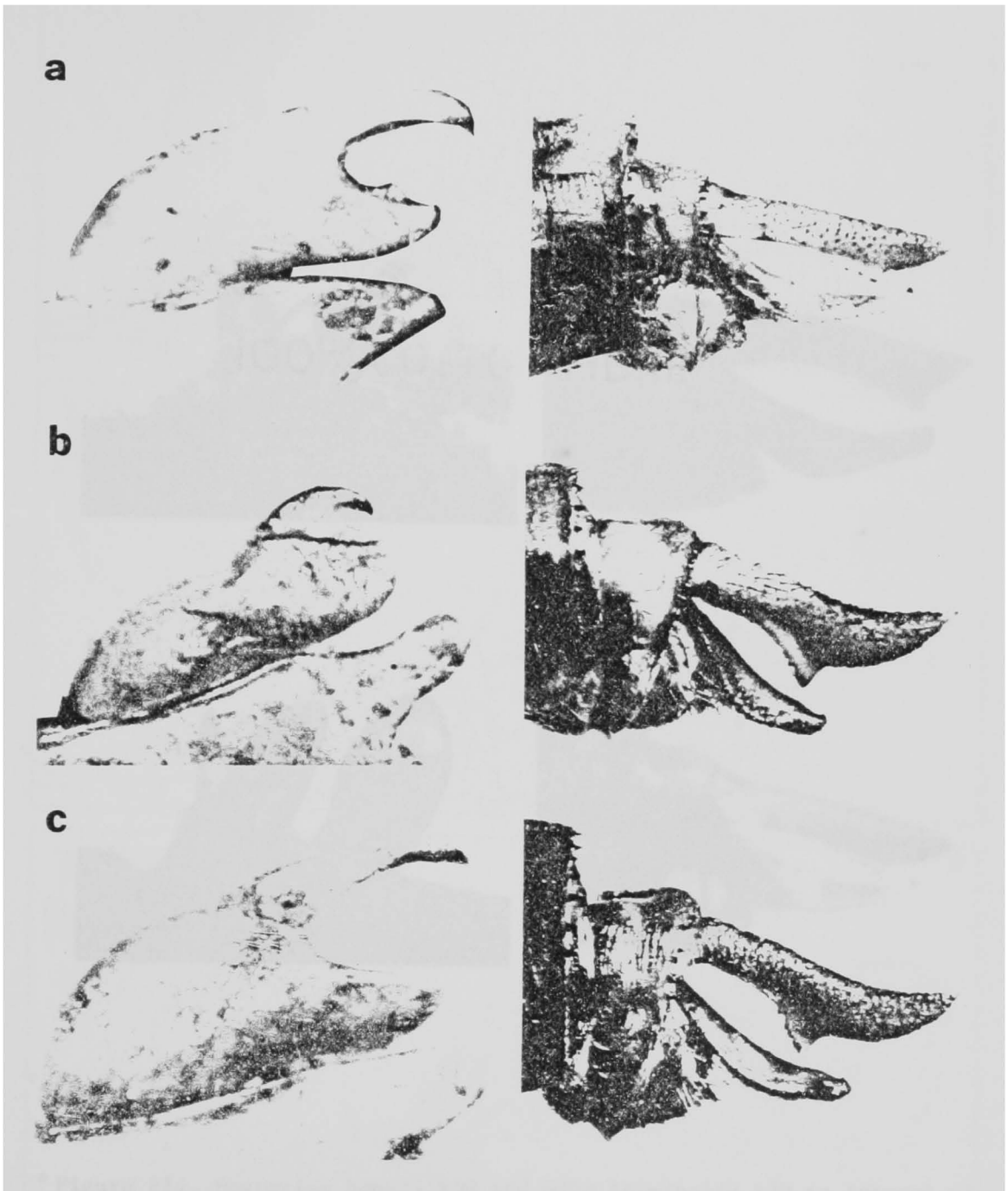


Figure 213. Posterior hamuli x50 and male terminalia x30 in lateral view of *Sympetrum*: (a) *S. internum*; (b) *S. obtusum*; (c) *S. rubicundulum*.

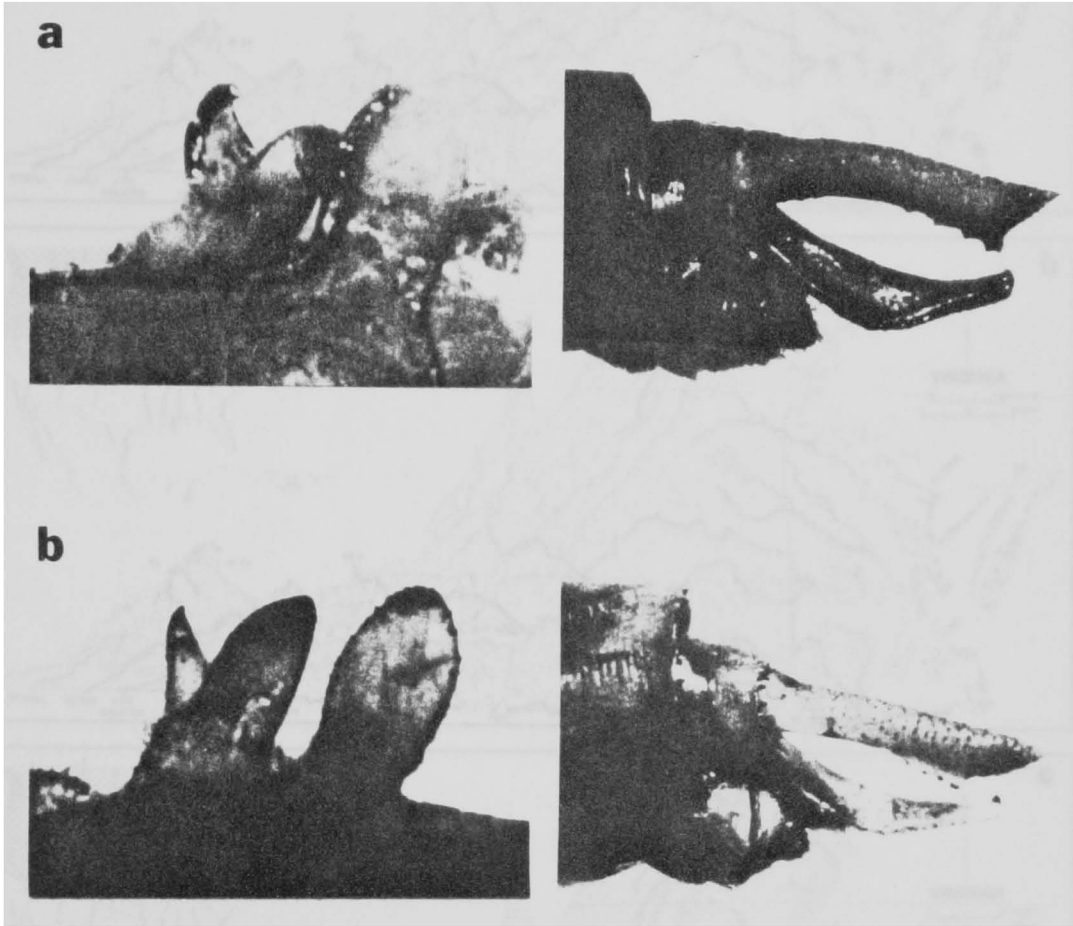


Figure 214. Posterior hamuli x50 and male terminalia x30 in lateral view of *Sympetrum*: (a) *S. semioctatum*; (b) *S. vicinum*.

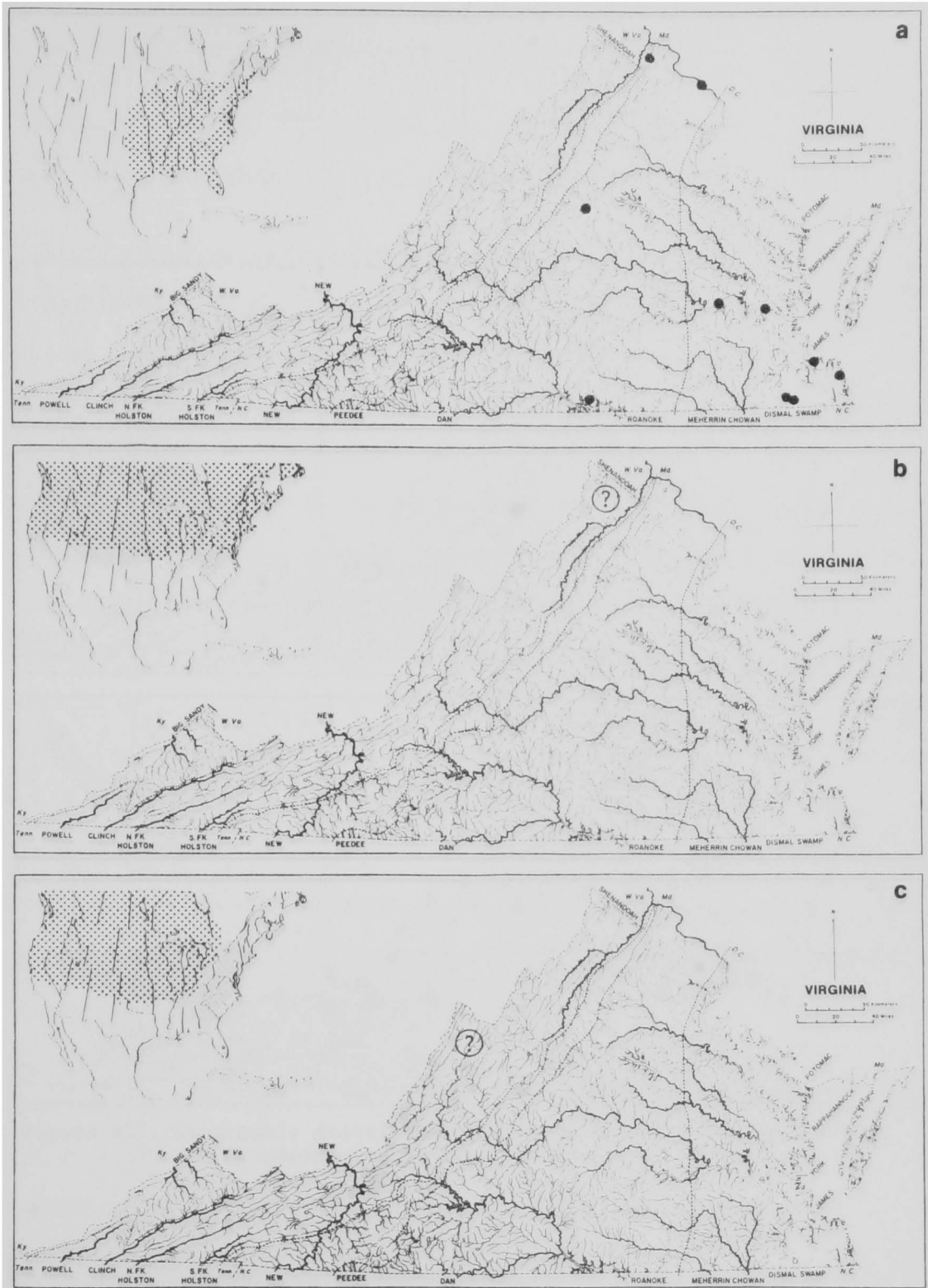


Figure 215. Geographic distribution of *Sympetrum*: (a) *S. ambiguum*; (b) *S. costiferum*; (c) *S. internum*.

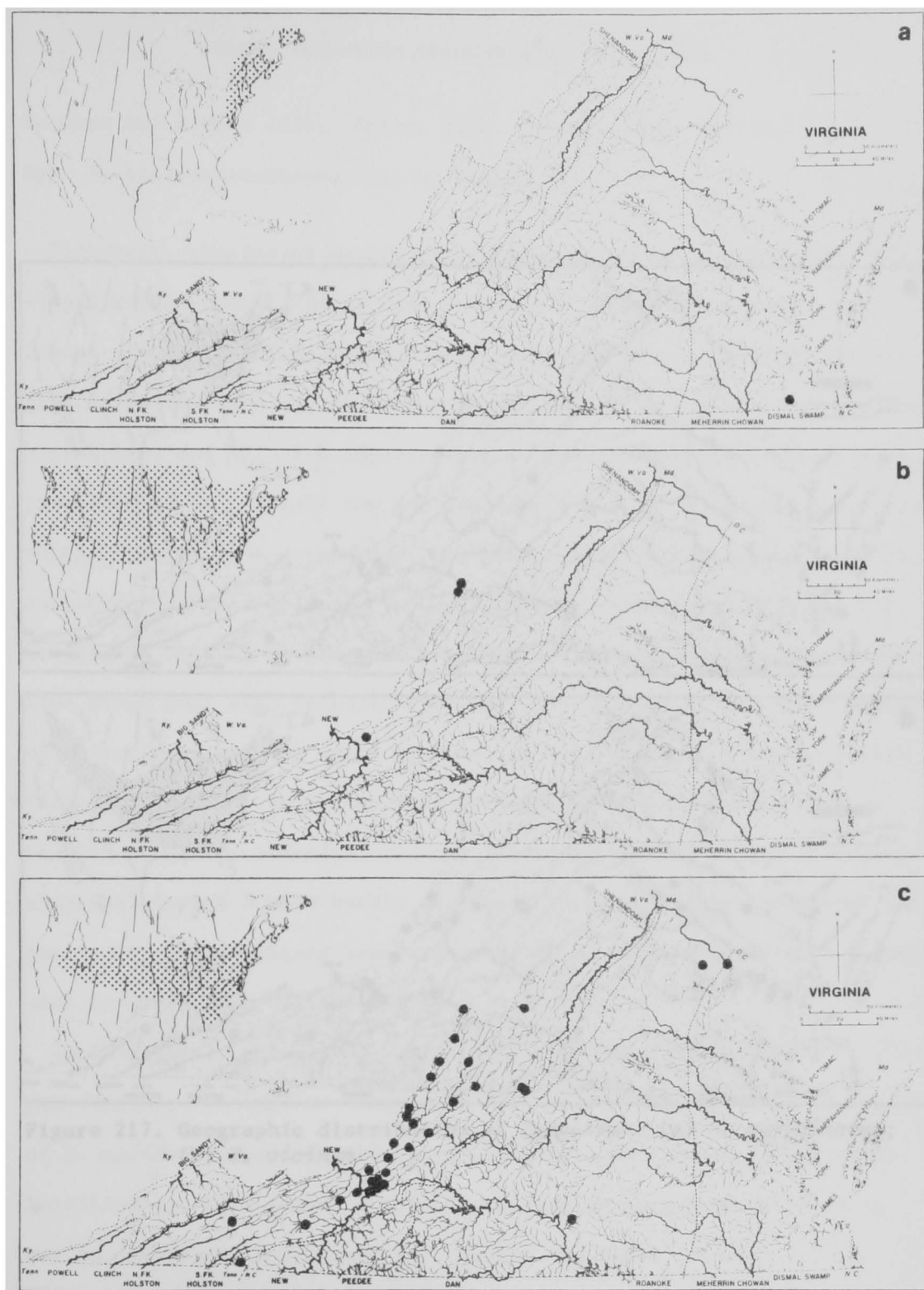


Figure 216. Geographic distribution of *Sympetrum*: (a) *S. janeae*; (b) *S. obtusum*; (c) *S. rubicundulum*.

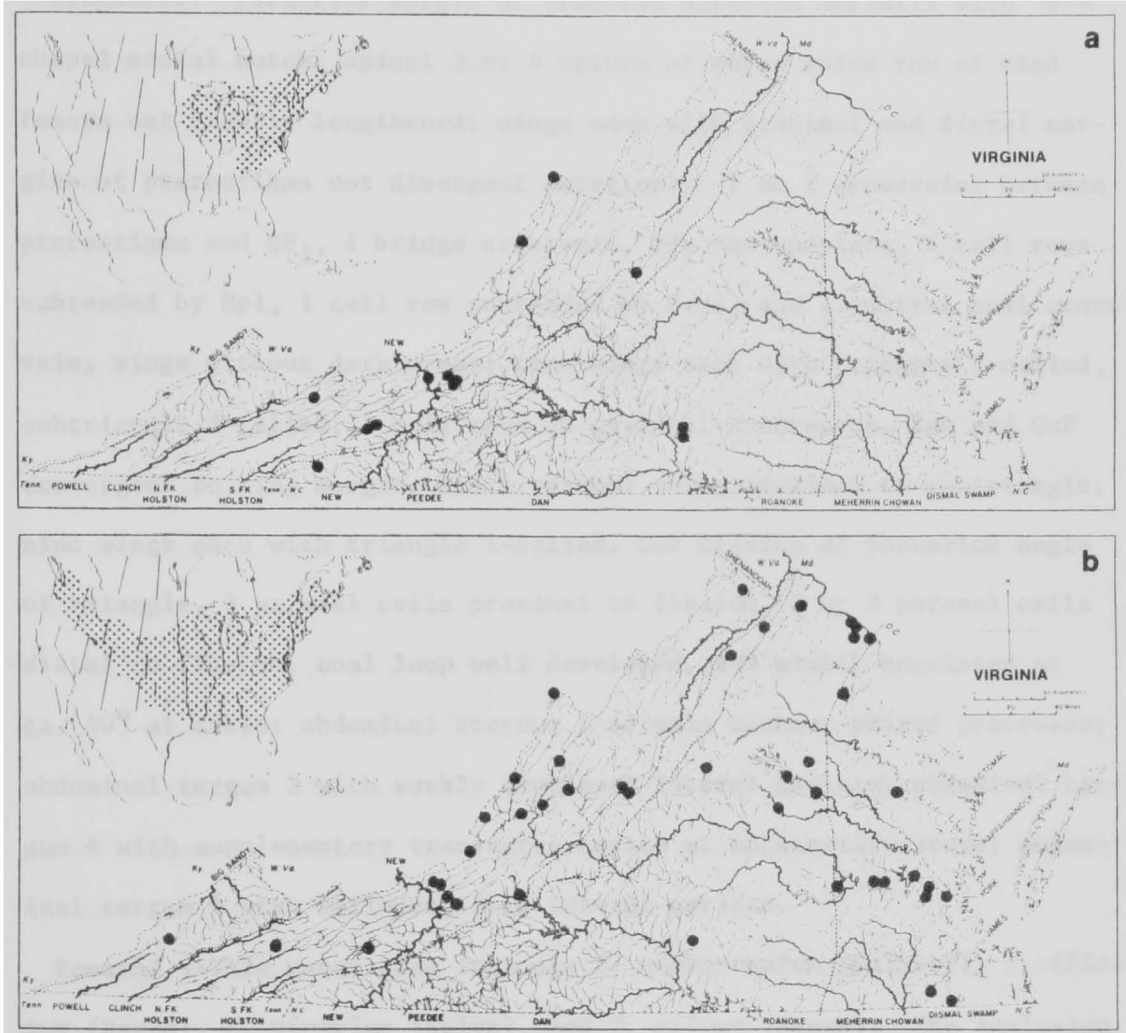


Figure 217. Geographic distribution of *Sympetrum*: (a) *S. semicinctum*; (b) *S. vicinum*.

Genus *Tarnetrum* Needham and Fisher 1936

Needham and Fisher 1936. Trans. Amer. Entomol. Soc. 62:114.

Type Species.--*Mesothemis illo-tum* Hagen.

Diagnosis.--Posterior margin of pronotum directed dorsally with "v"-shaped medial notch; apical 3 or 4 spines of outer spine row of hind femora not greatly lengthened; wings each with proximal and distal margins of pterostigma not divergent anteriorly, 1 or 2 crossveins between pterostigma and RP_1 , 1 bridge crossvein, RP_2 not undulate, 2 cell rows subtended by Mpl , 1 cell row subtended by $Cupl$, and 1 cubital anal crossvein; wings without dark areas; fore wings each with triangle 2-celled, subtriangle 3-celled, 3 cell rows in trigonal interspace, CuA and CuP convergent to wing margin, and 5 paranal cells proximal to subtriangle; hind wings each with triangle 1-celled, CuP arising at posterior angle of triangle, 3 paranal cells proximal to fibulum, 2 or 3 paranal cells distal to fibulum, anal loop well developed, and midrib angulated at ca. 40° at ankle; abdominal sternum 1 of male without paired processes; abdominal tergum 3 with weakly developed lateral carinae; abdominal tergum 4 with supplementary transverse carina at antecostal suture; abdominal tergum 9 with well-developed lateral carinae.

Remarks.--This genus also includes *T. nigrocreatum* (Calvert), *T. illo-tum* (Hagen), *T. virgulum* (Selys), and *T. gilvum* (Hagen). The inclusion of *S. madidum* (Hagen) in this group by Walker and Corbet (1975) seems justifiable. This genus is closely related to *Sympetrum* of which it may be considered a subgenus (cf. Walker and Corbet 1975).

Tarnetrum corruptum (Hagen)

(Figures 218, 219)

Hagen 1861. Syn. Neur. N. Amer., p. 171 (in *Mesothemis*).

Length 37-44 mm; abdomen 24-30 mm; hind wings 27-33 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the states of AL, AZ, AR, CA, CO, DE, FL, GA, ID, IL, IN, IA, KS, LA, MI, MN, MS, MO, MT, NE, NV, NJ, NM, NY, NC, ND, OH, OK, OR, PA, SC, SD, TN, TX, UT, VA, WA, WI, and WY, and the provinces of Alta., B.C., Man., Ont., and Sask, and also from Baja CA, Coahuila, Sonora, and Tamaulipas in Mexico, and south to Honduras, and known also from Asia and the Sea of Okhotsk. Known from the Virginia county of Montgomery. Known distribution among the counties of neighboring states include: Pennsylvania- Delaware and Erie; Tennessee- Davidson.

Virginia Records.--Montgomery Co.; Heath Pd. off Rt. 685 in Blacksburg, 1 Aug. 1977, 1 male, (3 males observed), FLC.

Flight Season.--Jan. 16 (TX) to Dec. 31 (FL); in Virginia Aug. 1. Known season in neighboring states are: Pennsylvania- July 1 to Oct. 7; Tennessee- Mar. 17 to Apr. 29.

Biology.--*Tarnetrum corruptum* inhabits shallow ponds and lake embayments.

Remarks.--Distinguished by the supplementary carinae of abdominal segment 4 and reddish pink wing venation, this species is rare in Virginia but probably occurs throughout the state.

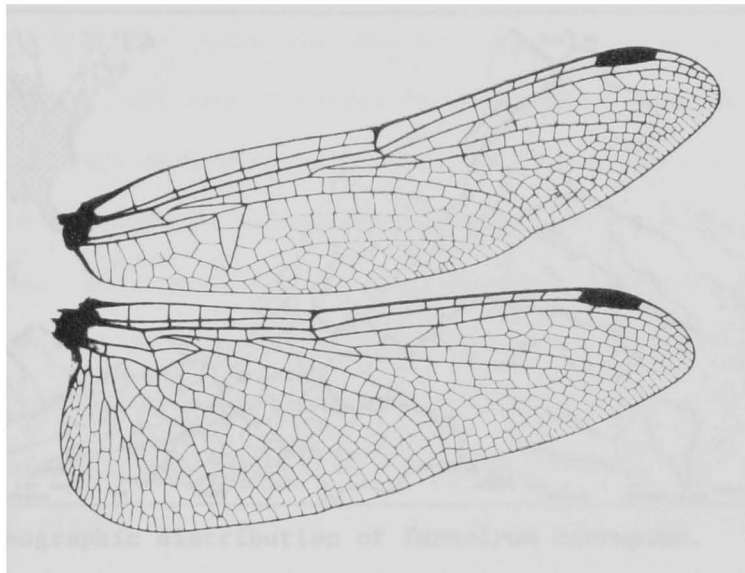


Figure 218. Wings of *Tarnetium corruptum* x3.

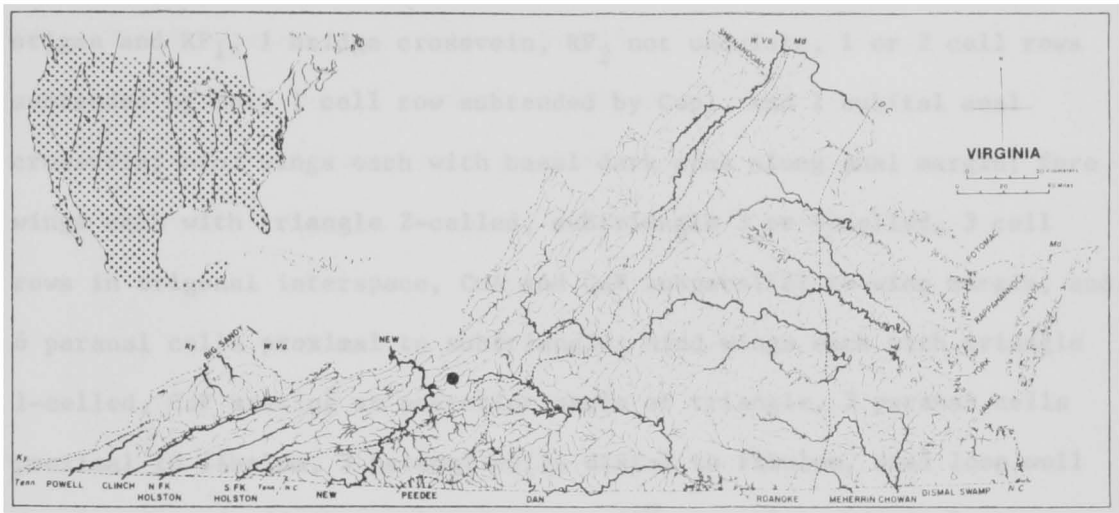


Figure 219. Geographic distribution of *Tarnetrum corruptum*.

Genus *Tauriphila* Kirby 1889

Kirby 1889. Syn. Cat. Neur., p. 258.

Type Species.-- *Tramea australis* Hagen.

Diagnosis.--Posterior margin of pronotum directed posterodorsally without medial notch; apical 3 or 4 spines of outer spine row of hind femora not greatly lengthened; wings each with proximal and distal margins of pterostigma divergent anteriorly, 2 crossveins between pterostigma and RP_1 , 1 bridge crossvein, RP_2 not undulate, 1 or 2 cell rows subtended by Mpl , 1 cell row subtended by Cup_1 , and 1 cubital anal crossvein; hind wings each with basal dark area along anal margin; fore wings each with triangle 2-celled, subtriangle 3 or 4-celled, 3 cell rows in trigonal interspace, CuA and CuP subparallel to wing margin, and 6 paranal cells proximal to subtriangle; hind wings each with triangle 1-celled, CuP arising at posterior angle of triangle, 3 paranal cells proximal to fibulum, 3 paranal cells distal to fibulum, anal loop well developed, and midrib angulated at ca. 45° at ankle; abdominal sternum 1 of male without paired processes; abdominal tergum 3 with well-developed lateral carinae; abdominal tergum 4 without supplementary transverse carina at antecostal suture; abdominal tergum 9 with well-developed lateral carinae.

Remarks.--Both the genera *Tauriphila* and *Miathyria* may represent subgenera of *Macrodiplax*. These genera are based primarily on wing vein characteristics which apparently show a correlation with body size.

Tauriphila australis (Hagen)Syn.: *iphigenia* Hagen

(Figure 220)

Hagen 1867. Stettin. Entomol. Ztg. 28:229 (in *Tramea*).

Length 42-47 mm; abdomen 28-32 mm; hind wings 36-38 mm.

Diagnosis.--Same as for genus.

Distribution.--Known from the state of FL, and also from Cuba, Dom. Rep., Haiti, Mexico, and south to Brazil.

Flight Season.--May 15 to Sept. 7 (Cuba).

Biology.--*Tauriphila australis* inhabits ponds and lakes.

Remarks.--This species is unlikely to be collected in Virginia.

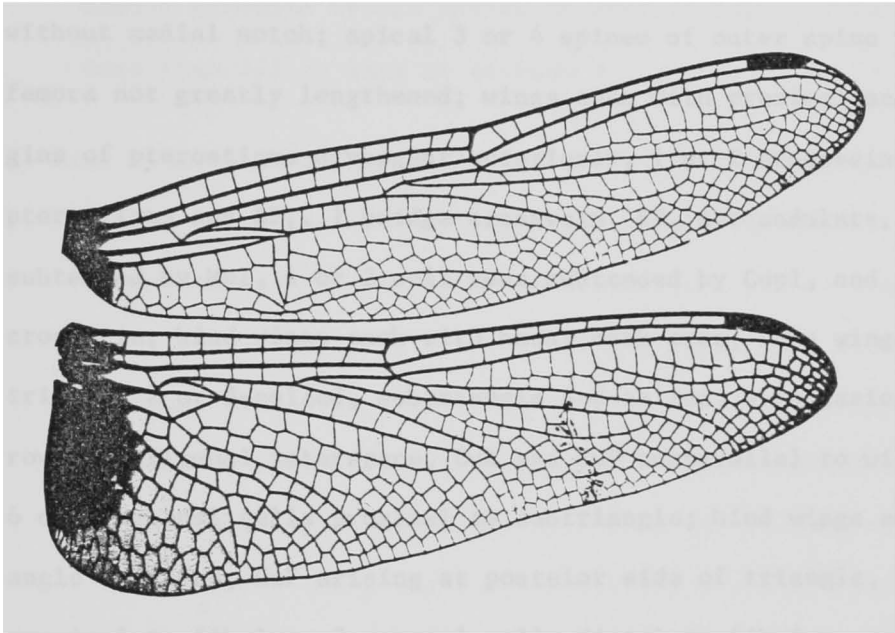


Figure 220. Wings of *Tauriphila australis* x3.

Genus *Tramea* Hagen 1861

Syn.: *Trapezostigma* Hagen

Hagen 1861. Syn. Neur. N. Amer., p. 141.

Type Species.--*Libellula flavescens* Fabricius.

Diagnosis.--Posterior margin of pronotum directed posterodorsally without medial notch; apical 3 or 4 spines of outer spine row of hind femora not greatly lengthened; wings each with proximal and distal margins of pterostigma divergent anteriorly, 1 or 2 crossveins between pterostigma and RP_1 , 1 bridge crossvein, RP_2 not undulate, 2 cell rows subtended by Mpl , 1 or 2 cell rows subtended by $Cupl$, and 1 cubital anal crossvein; hind wings each with basal dark area; fore wings each with triangle 2 or 3-celled, subtriangle 4-8-celled, 4 (occasionally 3) cell rows in trigonal interspace, CuA and CuP subparallel to wing margin, and 6 or 7 paranal cells proximal to subtriangle; hind wings each with triangle 1-celled, CuP arising at posterior side of triangle, 3 paranal cells proximal to fibulum, 3 paranal cells distal to fibulum, anal loop well developed, and midrib angulated at ca. 65° at ankle; abdominal sternum 1 of male without paired processes; abdominal tergum 3 with lateral carinae weakly developed in male and absent in female; abdominal tergum 4 with supplementary transverse carina at antecostal suture; abdominal tergum 9 without well-developed lateral carinae.

Species Key to Adult *Tramea* of Virginia

1. Hind wings each with basal opaque area black; posterior hamuli not extended beyond apices of genital lobes; vulvar lamina ca. 1/2 length of sternum 9 *T. lacerata* p. 932
- Hind wings each with basal opaque area reddish brown; posterior hamuli extended beyond apices of genital lobes; vulvar lamina more than 3/5 as long as sternum 9 2
2. Hind wings each with 2 cell rows between CuP and gaff, cells between midrib and solum opaque; posterior hamuli extended slightly beyond apices of genital lobes; vulvar lamina ca. 2/3 as long as sternum 9 *T. carolina* p. 930
- Hind wings each with 1 cell row between CuP and gaff, cells between midrib and solum hyaline; posterior hamuli extended well beyond apices of genital lobes; vulvar lamina ca. as long as sternum 9 3
3. Hind wings each with triangle and basal 1/3 of antenodal area hyaline, and distal margin of basal opaque area even; mesanepimera and metanepimera with wide yellow stripes . . *T. calverti* p. 929
- Hind wings each with triangle and basal 1/3 of antenodal area opaque, and distal margin of basal opaque area not even; mesanepimera and metanepimera without wide yellow stripes *T. onusta* p. 935

Tramea calverti MuttlowskiSyn.: var. *longicauda* Calvert

(Figures 221a, 223a)

Muttlowski 1910. Cat. Odon. N.A., p. 179.

Length 46-49 mm; abdomen 29-31 mm; hind wings 39-41 mm.

Diagnosis.--Thorax with yellow mesanepimeral and metanepimeral stripes; hind wings each with distal margin of basal opaque areas even, basal 1/3-1/2 of antenodal areas hyaline, triangles hyaline, 1 cell row between CuP and gaff, and anal margin without hyaline area; posterior hamuli extended well beyond apices of genital lobes; abdomen yellowish red with dorsum of segments 8-10 black; vulvar lamina ca. as long as sternum 9, mesal margins not sinuate; base of cerci yellow.

Distribution.--Known from the states of AZ, IA, MD, NC, SC, TN, and TX, and also from Baja CA, Mexico, and from Cuba, Haiti, and Jamaica. Known distribution among the counties of neighboring states include: Maryland- Worcester; North Carolina- Currituck and New Hanover; Tennessee- Davidson.

Flight Season.--Year-round southward. Known season in neighboring states are: Maryland- Aug. 22; Tennessee- Sept. 27 to Oct. 5.

Biology.--*Tramea calverti* inhabits ponds and marsh-bordered lakes.

Remarks.--*Tramea calverti* is distinguished by narrow basal opaque areas of the hind wings. This species has been previously incorrectly considered a synonym of *T. cophysa* (Westfall, personal communication). Although this species has not yet been reported in Virginia it is likely that southern migrants enter the state regularly.

Tramea carolina (Linnaeus)

(Figures 221b, 223b)

Linnaeus 1763. *Amoenit. Acad.* 6:411 (in *Libellula*).

Length 43-53 mm; abdomen 28-36 mm; hind wings 40-46 mm.

Diagnosis.--Thorax without yellow mesanepimeral and metanepimeral stripes; hind wings each with distal margin of basal opaque areas not even, basal 1/3-1/2 of antenodal areas opaque, triangles opaque, 2 cell rows between CuP and gaff, and anal margin with hyaline area; posterior hamuli extended slightly beyond apices of genital lobes; abdomen red with dorsum of segments 8 and 9 black; vulvar lamina ca. 2/3 as long as sternum 9, mesal margins not sinuate; base of cerci yellow.

Distribution.--Known from the states of AL, AR, CT, DC, GA, IL, IN, IA, KS, KY, LA, MD, MA, MI, MS, MO, NJ, NY, NC, OH, OK, PA, RI, SC, TN, TX, VA, and WI, and the province of Ont. Known from the Virginia counties of Accomack, Augusta, Charles City, Fairfax, Hanover, Henrico, James City, Montgomery, Sussex, Washington, and York, and the cities of Chesapeake, Norfolk, Suffolk, and Virginia Beach. Known distribution among the counties of neighboring states include: Kentucky- Allen, Barren, Bell, Breckinridge, Bullit, Butler, Carter, Christian, Edmonson, Fayette, Fulton, Green, Hardin, Harrison, Hart, Jefferson, Letcher, Marion, McCreary, Metcalfe, Monroe, Ohio, Rockcastle, Russell, Taylor, Trigg, Union, Warren, and Whitley; Maryland- Montgomery, Prince Georges, and Worcester; Pennsylvania- Bucks, Centre, Chester, Delaware, Erie, Franklin, Greene, Huntingdon, Lebanon, Northampton, Philadelphia, and Washington; North Carolina- Cherokee, Dare, Guilford, Robeson, and Wake;

Tennessee-- Cocke, Cumberland, Davidson, Hawkins, Knox, Monroe, Obion, Sullivan, and Williamson.

Virginia Records.--Accomack Co.; Chincoteague Island, 27 Aug. 1891, 1 male, F. M. Jones, (Det. F. M. Jones), ANSP. Augusta Co.; Shenandoah Pd., 13 June 1980, 1 male, FLC; Shenandoah Pd., 17 July 1980, 1 male, BCK. Charles City Co.; marl pit on Rt. 5, 19 Apr. 1938, 1 male, (1 mating pair observed), MED and D. T. R., VPI&SU; marl pit on Rt. 5, 23 May 1938, 1 male, MED, VPI&SU; Harrison Lk. at Roxbury, 12 June 1938, 4 males, R. Hess, (Det. A. D. Hess), A. D. Hess Collection; marl pit on Rt. 5, 18 June 1938, 2 males, MED, VPI&SU; Sawmill swamp on Rt. 5, 5 Sept. 1937, (observation), MED, (MDR notes); Berkeley Mills, 5 Sept. 1937, 1 male, MED, VPI&SU. Fairfax Co.; Great Falls, 6 May, RPC, USNM. Hanover Co.; pd. at Rt. 646, 8 May 1969, 2 males, G. M. Simmons, VPI&SU. Henrico Co.; Rasmussen's Pd., 8 June 1967, 1 female, MDR, VPI&SU. James City Co.; Lk. Matoaka at Williamsburg, 4 May 1938, 1 male, MED, and T. D. M., (Det. MED, MDR notes); Williamsburg, 21 May 1937, 1 female, MED, (Det. MED, Davis 1938); Williamsburg, 15 June 1936, 1 male, collector unknown, (Det. MED, MDR notes); Lees Mill Pd. at Fort Eustis, 30 July 1938, 2 females, MED, (Det. MED, MDR notes); Williamsburg, 13 Oct. 1938, 1 male, M. Ripperton, (Det. M. Ripperton, MDR notes). Montgomery Co.; Pandapas Pd., 15 Aug. 1978, 1 male, FLC. Sussex Co.; locality unknown, 21 June 1975, 1 male, JFM and J. Hancock, ODU. Washington Co.; small pd. along rt. 663, 15 June 1980, 1 male, FLC. York Co.; locality unknown, 21 May 1937, 1 female, collector unknown, (Det. MED, MDR notes); Yorktown, 15 July 1937, 1 male, 1 female, CC, (Det. CC). City of Chesapeake, locality unknown, 9 May 1970, 1 male, Donaldson, ODU. City of

Norfolk; pond off Rt. 168, 13 June 1975, 4 males, FLC; locality unknown, 7 July 1974, 1 male, J. Hancock, ODU; locality unknown, 9 July 1974, 4 males, JFM, ODU; locality unknown, 11 July 1973, 1 male, JFM, ODU. City of Suffolk; Dismal Swamp Wildlife Refuge, 19 Aug. 1974, 3 males, J. Hancock, ODU; Cypress Chapel, 14 Sept. 1934, 5 females, LKG and H. K. Gloyd, (Det. LKG, Gloyd 1951), MZUM. City of Virginia Beach; locality unknown, 29 May 1900, 1 male, C. L. Pollard and W. R. Maxon, USNM; Back Bay Refuge, 31 May 1975, 1 male, J. O'Hop, ODU; Back Bay Refuge, 2 June 1973, 1 male, Hucks, ODU; Back Bay Refuge, 8 June 1975, 1 female, J. O'Hop, ODU.

Flight Season.--Year-round (FL); in Virginia Apr. 19 to Oct. 13. Known season in neighboring states are: District of Columbia- Sept. 30; Kentucky- May 7 to Sept.; Maryland- Apr. 30 to Aug. 22; Pennsylvania- Apr. 1 to Sept. 23; North Carolina- Apr. 7 to Oct.; Tennessee- May 17 to Aug. 18.

Biology.--*Tramea carolina* inhabits ponds and marsh-bordered lakes.

Remarks.--*Tramea carolina* is distinguished by the wide basal opaque areas of the hind wings which completely cover each anal loop. This species is the most common *Tramea* inhabiting the coastal plain of Virginia.

Tramea lacerata Hagen

(Figures 222a, 223c)

Hagen 1861. Syn. Neur. N. Amer., p. 145.

Length 45-55 mm; abdomen 32-38 mm; hind wings 40-47 mm.

Diagnosis.--Thorax without yellow mesanepimeral and metanepimeral stripes; hind wings each with distal margin of basal opaque areas not even, basal 1/3-1/2 of antenodal areas opaque, triangles opaque, 1 cell row between CuP and gaff, and anal margin with hyaline area; posterior hamuli shorter beyond apices of genital lobes; abdomen black with dorsal yellow spots on segments 3-7 (spots often diffuse in male); vulvar lamina ca. 1/2 as long as sternum 9, mesal margins sinuate; base of cerci black.

Distribution.--Known from the states of AL, AZ, AR, CA, CT, FL, GA, HI, ID, IL, IN, IA, KS, KY, LA, ME, MD, MA, MI, MS, MO, NE, NV, NH, NJ, NM, NY, NC, OH, OK, OR, PA, SC, TN, TX, UT, VA, WA, WV, and WI, and the province of Ont., and also from Mexico and Cuba. Known from the Virginia counties of Bath, Charlotte, Fairfax, James City, Lee, Montgomery, Page, Russell, Washington, Wythe, and York, and the cities of Norfolk, Portsmouth, Suffolk, and Virginia Beach. Known distribution among the counties of neighboring states include: Kentucky- Allen, Barren, Bell, Breckinridge, Bullitt, Carter, Cumberland, Edmonson, Fayette, Floyd, Green, Harrison, Hart, Hopkins, Marion, Meade, Mercer, Metcalfe, Russell, Taylor, Todd, Trigg, Union, Washington, Warren, and Wayne; Maryland- Montgomery and Worcester; North Carolina- Edgecombe, Macon, McDowell, New Hanover, and Wake; Pennsylvania- Allegheny, Beaver, Berks, Blair, Bucks, Cambria, Centre, Chester, Clinton, Crawford, Dauphin, Delaware, Erie, Franklin, Greene, Huntingdon, Lebanon, Perry, Philadelphia, Venango, Washington, Westmoreland, and York; Tennessee- Anderson, Blount, Coffee, Davidson, Giles, Greene, Hardin, Hawkins, Knox, Madison, Monroe, Obion, Rutherford, Sullivan, Unicoi, and Williamson; West

Virginia- Mason, Raleigh, Ritchie, and Summers.

Virginia Records.--Bath Co.; Coursey Springs, 30 May 1977, 1 male, (observation), FLC; beaver pd. along Rt. 600, 18 June 1978, 1 male, FLC. Charlotte Co.; Keysville, 24 Aug. 1938, 2 males, J. T. Baldwin, VPI&SU. Fairfax Co.; Great Falls, "June 24 to Aug. 23", (Donnelly, 1961); Great Falls, 10 July 1914, 1 male, BPC, USNM. James City Co.; Jamestown Island Pd., 20 May 1938, 1 male, MED, (Det. MED, MDR notes); Barretts Ferry, 18 June 1938, 1 male, MED, VPI&SU. Lee Co.; Keokee Lk., 3 July 1977, 1 male, FLC. Montgomery Co.; Blacksburg, 12 Apr. 1947, 1 male, F. P. Nelson, VPI&SU; Blacksburg, 10 May 1948, 1 male, Weedis, VPI&SU; Blacksburg, 13 May 1948, 1 male, E. C. Kockrell, VPI&SU; Blacksburg, 20 May 1948, 1 male, G. M. Boush, VPI&SU; Craig Cr. beaver pd. at Rt. 621, 27 May 1962, 1 male, D. Innes, VPI&SU; Blacksburg, 14 June 1975, 1 male, T. E. Bailey, VPI&SU; Blacksburg, 25 June 1948, 1 male, G. M. Boush, VPI&SU; Blacksburg, 10 July 1948, 1 male, G. M. Boush, VPI&SU; Blacksburg, 19 July 1973, 1 male, E. C. Turner, VPI&SU; Pandapas Pd., 20 July 1973, 1 male, FLC, VPI&SU; Heath Pd. off Rt. 685 at Blacksburg, 23 July 1977, 1 male, FLC; Pandapas Pd., 28 July 1973, 2 males, 2 females, FLC; Heath Pd. off Rt. 685 at Blacksburg, 1 Aug. 1977, 1 male, FLC. Page Co.; S. Fork Shenandoah R. S.W. of Bentonville, 1 July 1973, 1 male, SWD. Russell Co.; Laurel Bed Lk., 29 Sept. 1977, 1 male, FLC. Washington Co.; small pd. along Rt. 663, 15 June 1980, 1 male, FLC; Abingdon, 2 Aug. 1907, 1 male, collector unknown, USNM. Wythe Co.; Wytheville, 30 June 1935, 5 males, CA, (Det. CA); Wytheville, 30 June 1935, 1 male, CA, (Det. CA), UZUM. York Co.; Yorktown, 10 July 1948, 1 male, R. L. Hoffman, (Det. LKG); Yorktown, 7 Aug. 1948, 1 male, R. L.

Hoffman, (Det. LKG). City of Norfolk; locality unknown, 9 July 1979, 2 males, JFM, ODU; locality unknown, 11 July 1973, 1 male, D. Laist, ODU. City of Portsmouth; locality unknown, 18 June 1966, 1 male, C. Peakersoiz, VPI&SU. City of Suffolk; Dismal Swamp Wildlife Refuge, 5 Aug. 1974, 1 male, J. Hancock, ODU. City of Virginia Beach; Seaside State Park, 12 June 1975, 1 male, FLC; locality unknown, 13 Sept. 1973, 1 female, P. W. Larkins, VPI&SU.

Flight Season.--Mar. 1 (MS) to Jan. 1 (FL); in Virginia Apr. 12 to Sept. 29. Known season in neighboring states are: Kentucky- May 4 to Sept.; Maryland- July 19 to Aug. 23; North Carolina- May 28 to Sept. 14; Pennsylvania- May 1 to Oct. 7; Tennessee- Apr. 23 to Sept. 12; West Virginia- June 6 to Aug. 11.

Biology.--*Tramea lacerata* inhabits ponds and marsh-bordered lakes.

Remarks.--*Tramea lacerata* is distinguished by the black basal areas of the hind wings and the yellow dorsal spots of the abdomen. This species is the *Tramea* most often encountered west of the fall line in Virginia.

Tramea onusta Hagen

(Figures 222b, 224)

Hagen 1861. Syn. Neur. N. Amer., p. 144.

Length 41-49 mm; abdomen 29-34 mm; hind wings 38-43 mm.

Diagnosis.--Thorax without yellow mesanepimeral and metanepimeral stripes; hind wings each with distal margin of basal opaque areas not even, basal 1/3-1/2 of antenodal areas opaque, triangles opaque, 1 cell

row between CuP and gaff, and anal margin with hyaline area; posterior hamuli extended well beyond apices of genital lobes; abdomen reddish brown with black dorsal spots on segments 8-10; vulvar lamina ca. as long as sternum 9, mesal margins not sinuate; base of cerci yellow.

Distribution.--Known from the states of AL, AR, CA, FL, GA, IL, IN, IA, KS, LA, MS, MO, NE, NV, NM, NC, OH, OK, SC, TN, TX, UT, and VA, and the province of Ont., and also from Baja CA and Tamaulipas, Mexico, and Cuba and Puerto Rico, and south to Panama. Known from the Virginia counties of Charles City and Montgomery. Known distribution among the counties of neighboring states include: Kentucky- Carter, Edmonson, Fayette, Hart, Ohio, Pulaski, Trigg, and Wayne; North Carolina- Transylvania; Tennessee- Davidson and Obion.

Virginia Records.--Charles City Co.; Harrison Lk. at Roxbury, 12 June 1938, 2 males, R. Hess, (Det. A. D. Hess), A. D. Hess Collection. Montgomery Co.; Blacksburg, 20 May 1947, 1 male, A. B. Culbertson, VPI&SU.

Flight Season.--Mar. 13 (P.R.) to Nov. 25 (TX); in Virginia May 20 to June 12. Known season in neighboring states are: Kentucky- May 12 to Aug.; North Carolina- July 12 to 16; Tennessee- May to Oct. 12.

Biology.--*Tramea onusta* inhabits ponds and marsh-bordered lakes.

Remarks.--*Tramea onusta* is distinguished by the reddish brown basal areas of the hind wings which do not completely cover each anal loop. This species is occasionally encountered in Virginia, apparently migrating to the state from further west or south. No established populations are known in Virginia.

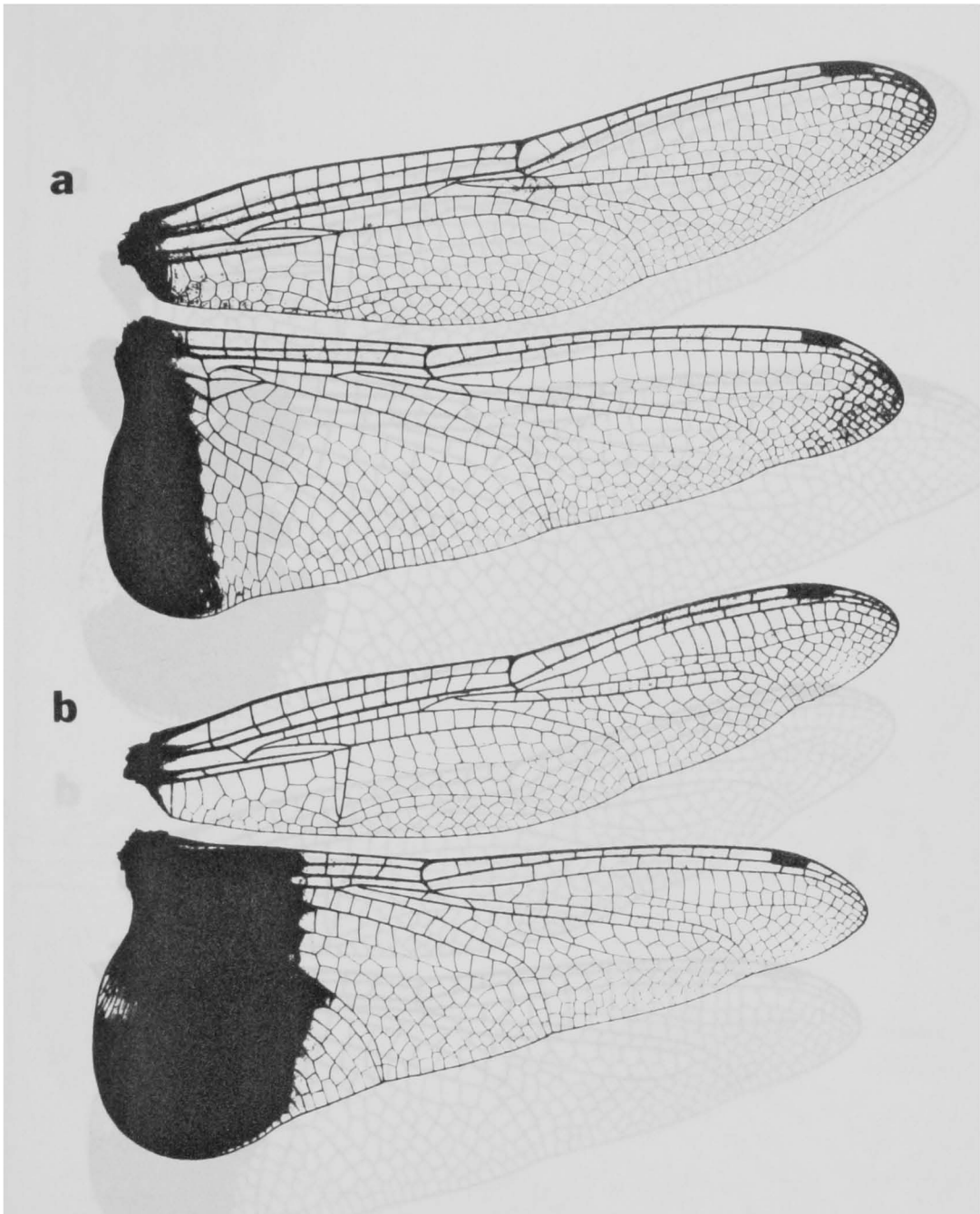


Figure 221. Wings of *Tramea* x3: (a) *T. saliceti*; (b) *T. carolina*.

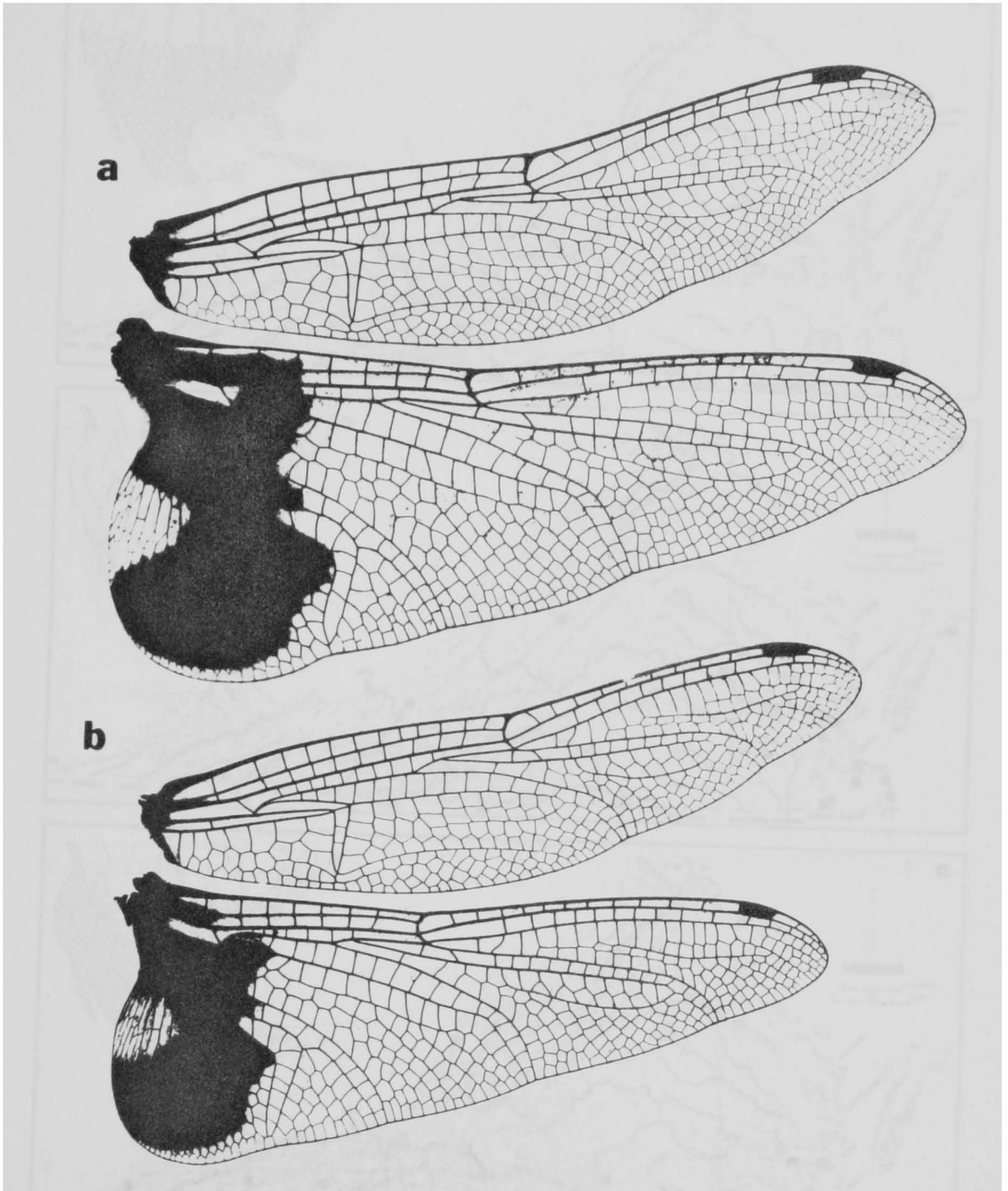


Figure 222. Wings of *Tramea* x3: (a) *T. laevigata*; (b) *T. costata*.

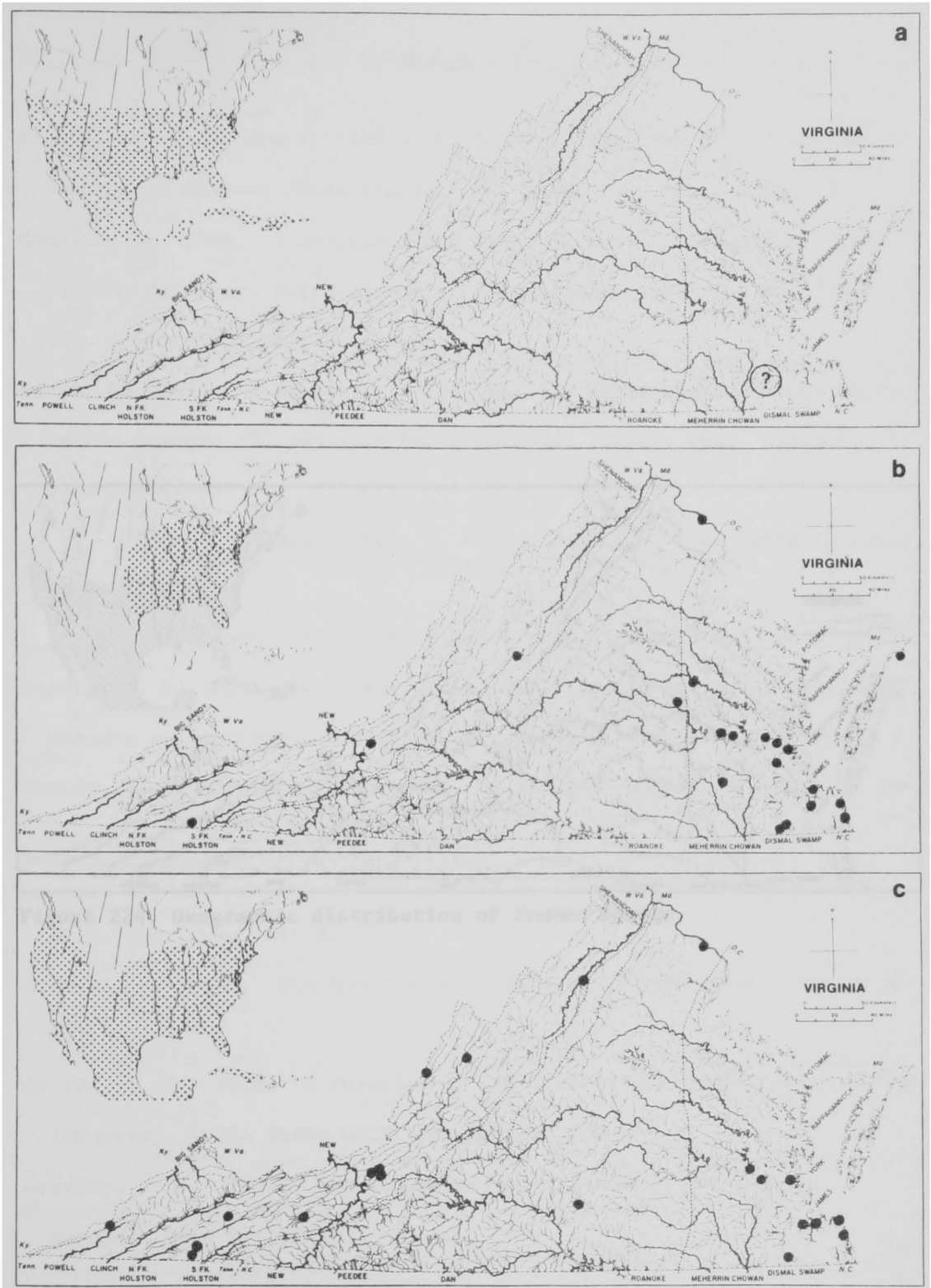


Figure 223. Geographic distribution of *Tramea*: (a) *T. calverti*; (b) *T. carolina*; (c) *T. lacerata*.

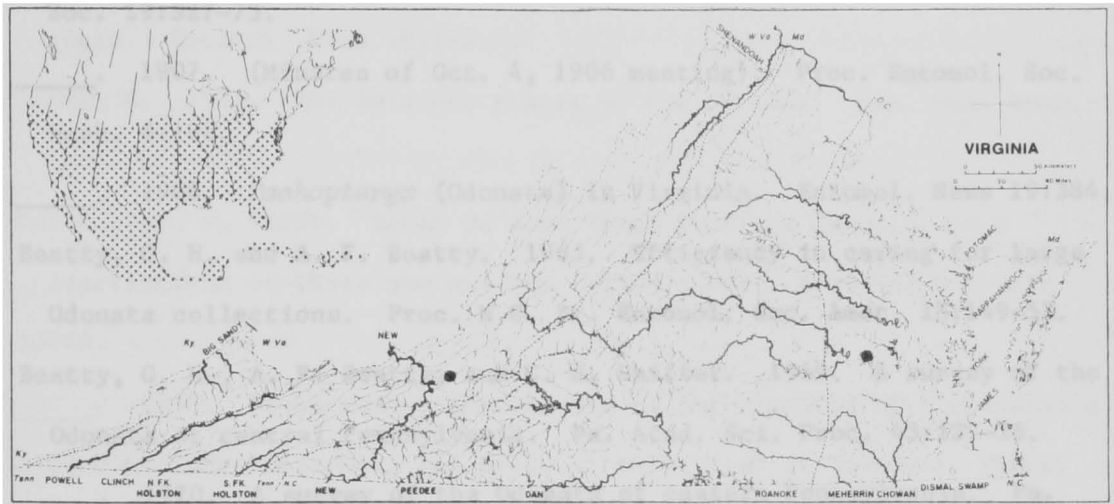


Figure 224. Geographic distribution of *Tramea onusta*.

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APPENDIX I

Two New *Gomphus* (Odonata:Gomphidae) from Eastern North America with
Adult Keys to the Subgenus *Hylogomphus*

ABSTRACT

Adults and nymphs of *Gomphus parvidens* Currie are described and a female allotype is designated. Adults and nymphs of 2 new *Gomphus* (*Hylogomphus*) from Eastern North America are also described. *Gomphus geminatus* n. sp. is described from specimens collected in northwestern Florida and southwestern Georgia. *Gomphus carolinus* n. sp. is described from specimens collected in north-central South Carolina and central North Carolina. Adult keys to species included in *Gomphus* (*Hylogomphus*) are provided, and the known distribution of each species reported.

INTRODUCTION

Needham (1951) established the subgenus *Hylogomphus*¹ to include 4 species formerly placed in *Gomphus* (*Gomphurus*). Adults of *Hylogomphus* may be distinguished from other *Gomphus* by having the gaff of the hind wing 4/5 to slightly longer than the front side of the triangle, AnA₂ beyond gaff straight, abdomen slightly clubed, male cerci (superior appendages) convex ventrally with an inferior spine at apex of convexity, segment 4 of penis short, and female vulvar lamina 1/2 to as long as sternum 9.

Confusion concerning the identity of *Hylogomphus* species has resulted from the supposed loss of the holotype of *Gomphus parvidens* Currie and the existence of undescribed *Hylogomphus*. Currie (1917) described *G. parvidens* from a teneral male and included a key to the species group later designated as *Hylogomphus*. *Gomphus parvidens* apparently was not recollected until June, 1941 when 25 specimens were collected in Transylvania Co., N. C. (Westfall 1942). In a letter to Dr. Westfall dated July 11, 1949, Mrs. L. K. Gloyd listed differences between the specimens determined by Dr. Westfall and other North Carolina specimens determined by Dr. C. S. Brimley as *G. parvidens*; the principal difference was the "rounded" penile vesicle of Brimley's specimens.

¹The generotype of *Gomphus*, *G. vulgatissimus* (L.), seems closer to species of the subgenus *Hylogomphus* than to Neartic species of the subgenus *Gomphus*.

Specimens from Alabama were thereafter determined to be conspecific with Brimley's specimens and used for photographs of *G. parvidens* in the manual of dragonflies by Needham and Westfall (1955). Donnelly (1966) described *G. (H.) apomyius* from specimens collected in Texas, indicating that this species may occur as far east as New Jersey. After a study of the types (the holotype of *G. parvidens*, which had been mislocated, was found by Dr. Westfall at the U.S. National Museum in 1963), I have concluded that Dr. Brimley's specimens were likely *G. apomyius* (Dr. Brimley's specimens cannot be located), as are the photographs labeled *G. parvidens* in Needham and Westfall (1955:229, figs. 138-9). Dr. Westfall's North Carolina specimens are *G. parvidens*.

In the species descriptions I follow the thoracic terminology used by Matsuda (1970). The figures were drawn by projecting reflected light from the specimen on to a drawing board with a microslide projector; corresponding parts of figured species are to the same scale.

Gomphus (Hylogomphus) parvidens Currie

Male

Total length 39.0-44.0 mm, abdomen including cerci 28.5-32.0 mm, cerci 1.3-1.4 mm, hind femora 6.2-7.4 mm, hind wings 24.5-27.5 mm, pterostigmata 2.6-2.8 mm/3.0-3.3 mm.

Head.--Labium pale yellow, distal margin of ligula and 2nd palpal segments brown; bases of maxillae and mandibles yellow; labrum yellow, distal margin brown; postgenae pale yellow; genae yellow; anteclypeus yellow, proximal margin light brown; postclypeus yellow, fronto-clypeal

sulcus with a brown line, lateral clypeal punctae yellow or brown; frons yellow, with ca. $2/5$ of dorsal surface dark brown proximally; pale colors of face greenish in mature individuals; vertex and antennae dark brown and black, ocellar ridge bilobed; anterior surface of occiput yellow, occipital ridge black with long black setae; posterior surface of head black above level of sinuosity of compound eyes, except for large yellow area on posterior occipital surface, yellow below sinuosity with 2 lateral brown spots.

Thorax.--Prothorax mostly brownish black; anterior lobe yellow, black proximally; middle lobe black, with geminate median spot and lateral expansions yellow; posterior lobe black with median yellow spot. Pterothorax brownish black, striped with yellow (Fig. 1a); stripes light green in mature specimens; pterothoracic tergum yellow, anterior margin of meso- and metascutum brown, lateral portion of meso- and metascutellum dark brown; mesothoracic middorsal carina yellow to level of bifurcation; dorsal mesanepisternal yellow stripes divergent anteriorly, $1/3$ to $1/2$ as wide as distance between them, almost extended to antealar carina above, and broadly confluent with yellow collar below; collar narrowly divided by brown lateral to median carina; lateral mesanepisternal yellow stripes ca. $1/2$ as wide below as dorsal mesanepisternal stripes, and abruptly widened at apex to basal width of dorsal stripes; intervening dark brown areas as wide above as apex of dorsal stripes, and ca. twice as wide as dorsal stripes at middle; mesokatepisterna with anterodorsal corners and lower $3/5$ pale yellow; dark bands along mesopleural sulci as wide as mesanepimeral pale stripes above, narrowed to $1/2$ this width below; mesanepimeral yellow stripes broadly confluent with metanepisternal

yellow stripes just above level of spiracles; dark areas along mesopleural sulci obscurely connected ventrally to dark areas along anterior edge of lateral intersegmental sutures, thus forming dark brown "G"-shaped areas surrounding the mesanepimeral yellow stripes; metanepisterna yellow, spiracles at least ringed with brown representing crossbar of the "G", brown anterodorsal areas forming upper end hook of the "G"; metakatepisterna yellow, dorsal margins obscure brown; *metanepimera* yellow with anterior margins brown, brown areas narrow and obscure below middle; dorsolateral carina and antealars dark brown; pale colors of thorax light green in mature individuals; thoracic sternum pale yellow.

Legs.--Coxae yellow; remainder of legs brownish black with inner surfaces of prothoracic trochanters and femora yellow; prothoracic tibial keels pale, $1/5$ as long as tibiae.

Wings.--Venation black, costa with fine yellow submedian stripes, pterostigmata brown; antenodal crossveins 10-13/8-9; postnodal crossveins 9-12/8-12; triangles, subtriangles, and supratrangles without crossveins, gaff $4/5$ to as long as inner side of triangle; bridge crossveins 3-6/3-5.

Abdomen.--Black marked with yellow and white; segments 1 and 2 yellow laterally, black above dorsal margin of auricles, and with a dorsomedian yellow band, this band constricted on acrotergite of segment 2, and narrowed to posterior margin of segment, auricles with 10-35 denticles; intersegmental conjunctiva of segments 1-6 brown, that of 7-9 pale; lateral margins of tergum 3 white, acrotergite with large lateral yellow areas and wedge-shaped middorsal yellow spot with apex narrowly extended to posterior margin of segment; lateral margins of

terga 4-6 white, lateral margin of terga 7 white and yellow, yellow separated from yellow lateral spot of acrotergite; acrotergites of 4-7 with small lateral and wedge-shaped middorsal yellow spots, middorsal spot of terga 6 and 7 may extend to middle of segment; terga 8 and 9 yellow laterally, yellow of tergum 8 reaching posterior margin at lateral margin only, tergum 8 often with a small anteromedian yellow spot; segment 10 black with sublateral yellow spots; abdominal sternum 7 brownish black, 8 and 9 brown and yellow, urosternites brownish yellow. Cerci black, inferior spine located at ca. 7/10 its length, ventral convexity subsymmetrical at apex; epiproct (inferior appendage) brownish black (Fig. 1d), *stout in lateral view, inner margins of rami slightly convex with setae longer and more abundant near apices, distance between apices of rami 2.3-2.4 mm.*

Genitalia.--Hamules light brown; anterior hamule in lateral view parallel-sided, anteromesal lobe rounded at apex, inner margin of posterior lobe with 5-10 teeth; posterior hamule in lateral view widened distally, *distance between shoulder and base of end hook 0.85-1.05 mm, shoulder evenly rounded without denticles, distance between proximal anterior corner and end hook 1.9-2.3 mm.* Penis brown with filament translucent (Fig. 1b); segment 1 in lateral view with posterior margin linear and anterior margin angulated at middle, hood 0.80-1.00 mm high (0.87 mm in holotype) ca. 1/2 length of segment 1; segment 2 straight, swollen distally, 1.3-1.5 mm long; segment 3 straight, 1.25-1.40 mm long excluding prepuce, *apical sclerites rounded apically*; segment 4 with ventral convexity prominent, *lateral distance between collar and crest of ventral convexity ca. 0.41 mm (0.40 mm in holotype)*; filament

0.21-0.38 mm long measured from base of constriction.

Female

Total length 42.0-46.0 mm, abdomen including cerci 31.0-33.5 mm, cerci 0.85-1.15 mm, hind femora 6.8-7.0 mm, hind wings 28.0-31.0 mm, pterostigmata 2.0-3.5 mm/3.3-4.0 mm.

Head.--Colored as in male, distal margin of labrum brown; distal margin of ligula, second palpal segment, anteclypeus, and fronto-clypeal sulcus may be shaded with brown; *vertex with stout cultiform horns lateral to ends of ocellar ridge ca. twice as long as width of lateral ocelli* (Fig. 1c); *ocellar ridge ending behind lateral ocelli*; occiput yellow, occipital ridge and posterior surface black laterally; *occipital ridge in dorsal view strongly convex anteriorly, in frontal view abruptly rising to level of compound eyes laterally with a wide median concavity, maximal "height" of anterior surface 1/4 to 1/3 dorsal separation of compound eyes.*

Thorax.--Colored as in male.

Legs.--Colored as in male, except with inner surface of each mesofemur yellow.

Wings.--Venation black, costa dark brown with fine median yellow stripes, pterostigma light brown; antenodal crossveins 11-14/8-10; postnodal crossveins 9-13/8-11; triangles, subtriangles, and supra-triangles without crossveins; gaff 4/5 to as long as inner side of triangle; bridge crossveins 4-7/3-5.

Abdomen.--Colored as in male with yellow markings more extensive; lateral yellow spots of segment 3, and occasionally 4 extended to near posterior margin of segments; lateral yellow spots of terga 5-7 extended

to posterior margin of acrotergites; middorsal wedge-shaped yellow spots of terga 3-6 narrowly extended to posterior margins of segments, middorsal yellow spot of tergum 7 extended to ca. 7/10 its length; sternum 7 and 8 brown and yellow, sternum 9 yellow, sternum 10 yellow or brown; cerci brownish black, epiproct and paraprocts yellow and brown.

Genitalia.--Vulvar lamina brownish yellow shaded with brown at apices (Fig. 1e); *distance between apex of basal sclerites and apex of vulvar lamina 1.4-1.6 mm, when laid against sternum 9 separated from posterior margin of segment 9 by less than 1.5 times width of an apical vulvar laminal lobe; lateral margins convex in basal half, apical lobes parallel-sided and truncate at apices, apical notch extended proximally to ca. 1/5 length of lateral lobes, apical lobes 0.45-0.57 mm long.*

Nymph

Total length, male 24.5-26.5 mm, female 25.0-27.0 mm; abdomen, male 15.0-16.0 mm, female 15.0-17.0 mm; hind femora 5.0-5.3 mm; prementum 3.3-3.5 mm.

Head.--Prementum constricted in basal 1/3 (Fig. 1f), lateral margins slightly granulate and *slightly if at all convergent anteriorly*; anterior margin slightly convex with ca. 45 setae, margin 0.27-0.28 maximal premental width; 1st segment of labial palp with end hook moderately incurved, inner margin with 6-8 teeth.

Abdomen.--With median line and paired submedian spots pale on dark background; mesothoracic wing pads extended to base of segment 4; abdomen widest at segment 6, *terga 8-10 granulate, ? slightly so*;

lateral spines on segments 6-9 (Fig. 1g) relative lengths 0.6:1.0:1.3:1.9; spines on 6 divergent, on 7-9 subparallel; segments 7 or 8 to 9 with lateral spinules, 0-2 on 7, 4-9 on 8, and 11-20 on 9; posterior margin of tergum 9 with 3-12 spinules and with a short darkened median spine; lateral abdominal hair setae ca. 1/2 median length of terga 9; epiproct and cerci not granulate dorsally, cerci 8/10 length of epiproct, epiproct ca. twice as long as tergum 10.

Types

Allotype, female--Cullasaja River near Cliffside Lake, Macon Co., N.C.; nymph collected Mar. 31, 1978; emerged May 14, 1978; F. Carle; nymphal exuviae in alcohol, adult dry in envelope; deposited Florida State Collection of Arthropods, Gainesville (FSCA). Para-allotypes--North Carolina: Same data as allotype; emerged Apr. 28-May 14, 1978; 4 females. Deposited in pairs (reared female and male with exuviae, both from same locality) at the U. S. National Museum of Natural History (USNM); the E. B. Williamson Collection, Univ. of Michigan, Ann Arbor (EBWC); the Cornell Collection, Cornell Univ. (CCCU); the Virginia Polytechnic Institute and State Univ. Entomology Department Collection (VPIC). Same location as allotype; collected Sept. 1976; emerged May 25, 1977; M. J. Westfall, Jr.; 1 female; deposited FSCA. Little River east of Brevard, Transylvania Co.; collected May 24, 1974; K. Tennessen; 3 females; 2 females deposited FSCA, 1 female deposited in the collection of Dr. K. Knopf.

Additional material was studied from the following states and counties: Maryland--Prince Georges; North Carolina--Macon and Transylvania; and Virginia--Charlotte.

Remarks

The narrow mesanepisternal pale stripes which were used by Currie (1917) to distinguish this species from other *Hylogomphus* are variable in width and also vary with age. Teneral specimens have very narrow stripes which eventually widen as additional pale color develops along the inner margins. The holotype, being teneral, differs from mature specimens from Virginia and North Carolina in having the dark color slightly lighter and more extensive. *Gomphus parvidens* may be distinguished from other *Hylogomphus* by the characters stated in the keys. Westfall (1942) described the unusual behavior of male *G. parvidens*, which for much of the time remain perched on vegetation a few feet above the ground, usually near rapids: "They were not particularly wary and could be closely approached without too much caution." I also noted these behavioral peculiarities while observing a population of *G. parvidens* in Charlotte County, Virginia. I have occasionally observed *G. (H.) abbreviatus* Hagen and *G. (H.) brevis* Hagen to perch low on vegetation, but both species are very wary while at rest.

Gomphus (Hylogomphus) carolinus n. sp.*Male*

Total length 36.5-39.5 mm, abdomen including cerci 26.0-28.5 mm, cerci 1.2-1.3 mm, hind femora 5.9-6.3 mm, hind wings 22.5-24.5 mm, pterostigmata 2.2-2.5 mm/2.5-2.8 mm.

Head.--Labium pale yellow; bases of maxillae and mandibles yellow; labrum yellow; postgenae pale yellow; genae brownish yellow; anteclypeus

yellow occasionally light brown along proximal and distal margin; postclypeus yellow, *fronto-clypeal sulcus covered by a brown band*, lateral clypeal punctae yellow; frons yellow, with ca. $2/5$ of dorsal surface brown proximally; pale colors of face light green in mature specimens; vertex and antennae brown, ocellar ridge bilobed; anterior surface of occiput yellow, occipital ridge brown with long setae; posterior surface of head brown except for yellow on posterior surface of occiput, narrow streaks along compound eyes above sinuosity of eyes, and wide bands along compound eyes below sinuosity.

Thorax.—Prothorax mostly brown; anterior lobe yellow, brown proximally, middle lobe brown, with geminate median spot and lateral expansions yellow, small yellow spot generally present near each anterior tuft of setae, posterior lobe brown with median yellow spot. Pterothorax brown, striped with yellow (Fig. 2a); pterothoracic tergum yellow, brown laterally; mesothoracic middorsal carina yellow to level of bifurcation; dorsal mesanepisternal yellow stripes widely divergent anteriorly, $1/3-1/2$ as wide as the distance between them, almost extended to antealar carina above, and broadly confluent with yellow collar below; collar narrowly divided by brown lateral to median carina; lateral mesanepisternal yellow stripes ca. $1/3$ as wide below as dorsal mesanepisternal stripes, and abruptly widened at apex to basal width of dorsal stripes, apical dilation often separated from lower portion of stripe; intervening brown areas as wide above as apex of dorsal stripes, and ca. $3/2$ as wide as dorsal stripes at middle; mesokatepisternum yellow with upper $2/5$ brown; dark bands along mesopleural sulci as wide as mesanepimeral pale stripes above, narrowed to

1/2 this width below; mesanepimeral yellow stripes broadly confluent with metanepisternal yellow stripes just above level of spiracles, these stripes isolated by dark areas along intersegmental sutures in 1/5 of type-series, dark areas along mesopleural sulci obscurely connected below to brown areas along anterior margin of lateral intersegmental sutures, thus forming "G"-shaped areas surrounding the mesanepimeral yellow stripes; metanepisterna yellow, spiracles at least ringed with brown representing the crossbar of the "G", brown anterodorsal areas forming the upper end hook of the "G"; metakatepisterna yellow, dorsal margins often obscure brown, *metanepimera yellow, metapleural sulci with brown bands well-developed and extended the length of the pleura*; dorsolateral carina and antealars brown; thoracic sternum pale yellow; pale colors of thorax light green in mature individuals.

Legs.--Coxae yellow; remainder of legs brown with inner surfaces of prothoracic trochanters and femora yellow; prothoracic tibial keels pale, 1/5 as long as tibiae.

Wings.--Venation dark brown, costa tan, pterostigmata brown, antenodal crossveins 10-13/7-9; postnodal crossveins 9-10/8-9; triangle, subtriangles, and supratrangles without crossveins; gaff 4/5 to as long as inner side of triangle; bridge crossveins 4-6/3-4.

Abdomen.--Dark brown marked with yellow and white; segments 1 and 2 yellow laterally, brown above auricles, *areas behind and below auricles also brown*, and with a dorsomedian yellow band, this band constricted on acrotergite of segment 2, and narrowed to posterior margin of segment; auricles with 8-15 denticles; intersegmental conjunctiva of segments 1-6 brown, that of 7-9 pale; lateral margins of tergum 3

white, acrotergite with large lateral yellow areas and wedge-shaped middorsal yellow spot with apex narrowly extended to posterior margin of segment; lateral margins of terga 4-6 white, lateral margin of terga 7 white and yellow; yellow narrowly separated from lateral yellow spot of acrotergite, acrotergites 4-7 with small lateral and wedge-shaped middorsal yellow spots; terga 8 and 9 yellow laterally, *yellow of tergum 8 extended to posterior margin of segment only at lateral margin*; segment 10 brown with sublateral yellow spots; abdominal sternum 7 brown, 8-10 brown and yellow, urosternites yellow. Cerci brown, inferior spine located at ca. 7/10 its length; distal margin of ventral convexity subsymmetrical; epiproct brown (Fig. 2d), inner margins of rami slightly convex with setae longer and more abundant near apices; distance between apices of rami 2.1-2.3 mm.

Genitalia.--Anterior hamule light brown, parallel-sided in lateral view, anteromesal lobe rounded at apex, inner margin of posterior lobe with 4-6 teeth; posterior hamule yellow, widened distally in lateral view, *distance between shoulder and base of end hook 0.80-0.88 mm, shoulder without denticles*, distance between proximal anterior corner and end hook 1.85-1.95 mm. Penis light brown with filament translucent (Fig. 2b); *segment 1 in lateral view with posterior margin slightly convex and with a basal swelling*; anterior margin angulated at middle, *hood 0.66-0.73 mm high, ca. 2/5 length of segment 1*; segment 2 straight, swollen distally, 1.2-1.3 mm long; segment 3 straight, 1.05-1.15 mm long excluding prepuce, *apical sclerites somewhat acuminate*; segment 4 with ventral convexity distinct, *lateral distance between collar and crest of ventral convexity ca. 0.32 mm*; filament 0.25-0.30 mm long

measured from base of constriction.

Female

Total length 38.0-42.0 mm, abdomen including cerci 28.0-31.5 mm, cerci 0.9-1.0 mm, hind femora 6.0-6.7 mm, hind wings 24.5-26.0 mm, pterostigmata 2.7-2.9 mm/3.1-3.3 mm.

Head.--Colored as in male; *vertex with cultiform horns lateral to posterior edge of lateral ocelli* (Fig. 2c), *ca. as long as width of lateral ocelli; ocellar ridge ending behind lateral ocelli*; occiput yellow, occipital ridge in dorsal view straight to slightly convex anteriorly generally with small median notch, in frontal view rising near compound eyes and slightly concave between lateral elevations; *maximal "height" 1/5 dorsal separation of compound eyes.*

Thorax.--Colored as in male.

Legs.--Colored as in male, except with inner apical surface of each mesofemur yellow.

Wings.--Venation dark brown, costa tan, pterostigmata light brown; antenodal crossveins 12-14/8-10; postnodal crossveins 9-11/8-10; triangles, subtriangles, and supratrangles without crossveins; gaff 4/5 to as long as inner side of triangle; bridge crossveins 4-6/3-4.

Abdomen.--Colored as in male with yellow markings more extensive; lateral yellow spots of segment 3 extended to near posterior margin of segment, lateral yellow spots of segment 4 occasionally extended to 3/5 the length of segment; lateral yellow spots of terga 5-7 extended to posterior margin of acrotergites, middorsal wedge-shaped yellow spots of terga 3-6 narrowly extended to posterior margin of segments, middorsal yellow spot of tergum 7 extended to ca. 3/4 its length;

sternum 7 brown, sternum 8 yellow and brown, sterna 9-10 yellow; cerci brown, epiproct and paraprocts yellow and brown.

Genitalia.--Vulvar lamina yellow (Fig 2e), *distance between apex of basal sclerites and apex of vulvar lamina 1.2-1.3 mm, apical lobes parallel-sided and truncate at apices, apical notch extended proximally to ca. 7/20 length of lateral lobes, apical lobes ca. 0.4 mm long.*

Nymph

Total length, male 24.0 mm, female 24.5 mm; abdomen, male 14.5 mm, female 15.0 mm; hind femora 4.6-4.7 mm; prementum 2.9-3.1 mm.

Head.--Prementum constricted in basal 1/3 (Fig. 2f) lateral margins slightly granulate and *convergent anteriorly*, anterior margin convex with ca. 40 setae, margin ca. 0.25 maximal premental width; 1st segment of labial palp with end hook moderately incurved, inner margin with 6-7 teeth.

Abdomen.--Mesothoracic wing pads extended to base of segment 4; abdomen widest at segment 6, *terga 7-10 granulate, 6 moderately so; lateral spines on segments 6 or 7-9 (Fig. 2g), those on 6 very minute if present, relative lengths 0.2:1.0:1.5:2.3, spines subparallel; segments 8 and 9 with lateral spinules, 2-4 on 8, 10-12 on 9; posterior margins of terga with only a median spinule on 9; lateral abdominal hair setae ca. as long as median length of tergum 9; cerci 7/10 length of epiproct, epiproct ca. 9/4 as long as tergum 10.*

Types

Holotype, male--U.S. Hgwy. 1, South of Cheraw, Cheraw State Park, Chesterfield Co., S.C.; Apr. 17, 1965; M. J. Westfall, Jr.; dry in envelope; deposited FSCA. Allotype, female--Same data as for holotype;

deposited FSCA. Paratypes--Same data as for holotype; 1 male, 1 female, and 3 nymphal exuviae in alcohol (not associated); deposited as follows: 1 male and 1 female CCCU, 3 nymphal exuviae FSCA. Same data as for holotype; 1 male; in alcohol; deposited FSCA. Same locality as holotype; Apr. 24, 1966; D. Paulson; 3 females; deposited as follows: 1 female EBWC, 1 female FSCA, 1 female USNM. North Carolina: Drowning Cr., Montgomery Co.; May 22, 1965; R. D. Cuyler; dry in envelope; 1 male; deposited EBWC. Mill Cr., Moore Co.; June 25, 1966; R. D. Cuyler; deposited USNM.

Remarks

Gomphus carolinus is similar to *G. parvidens* in many respects, but may be easily distinguished by the relatively shorter hood of the male penile vesicle; the shorter level-sided vulvar lamina, and low-level occiput of the female; and in the nymph, by the convergent premental lateral margins, the minute or absent lateral spines of segment 6, and the long lateral hair setae of the abdomen. The minute or absent lateral spines of abdominal segment 6 will separate the mature nymphs of *G. carolinus* from all other mature *Hylogomphus* nymphs. The adults of *G. carolinus* are readily separated from other *Hylogomphus* by the characteristics stated in the keys. The adult male epiproct, although less robust, is very similar to that of *G. parvidens*, but specimens in which the hair setae are not damaged appear to show slight differences in the distribution and length of hair setae. *Gomphus carolinus* is also smaller than *G. parvidens*; the smallest known specimen of *G. parvidens* is the holotype which does not have a brown band across the frontoclypeal sulcus as in *G. carolinus*. This is likely

related to the teneral condition of the *G. parvidens* holotype, but the discovery of additional populations of the seemingly rare *G. carolinus* may show it to be a subspecies of *G. parvidens*.

Etymology--*G. carolinus* [car·o·li nus] The Gomphus near Carol, "Carol's Gomphus", a name also suggesting the known distribution of the species.

Gomphus (Hylogomphus) geminatus n. sp.

Male

Total length 38.5-45.5 mm, abdomen including cerci 27.5-33.0 mm, cerci 1.3-1.5 mm, hind femora 6.0-7.0 mm, hind wings 23.5-28.5 mm, pterostigmata 2.4-2.8 mm/2.8-3.3 mm.

Head.--Labium, maxillae, mandibles, and labrum pale yellow shaded light brown distally; post genae pale yellow; genae brown; anteclypeus brownish yellow often brown at distal margin, brown narrowly extended onto proximal margin of labrum; postclypeus brownish yellow; *fronto-clypeal sulcus with wide brown band extended above to cover ca. lower 2/3 of frons*, frons greenish yellow, with ca. proximal 2/5 of dorsal surface brown; vertex and antennae brown and black; ocellar ridge strongly bilobed; anterior surface of occiput greenish yellow, posterior surface greenish yellow with lateral margins dark brown; occipital ridge black with long black hair, median portion occasionally greenish yellow; posterior surface of head brown, dark brown along compound eyes above level of sinuosity, yellow below with small brown lateral spots weakly connected to median brown area.

Thorax.--Prothorax brown; anterior lobe with pale anterior margin,

middle lobe with geminate median spot and lateral expansions yellow, *posterior lobe brown*. Pterothorax brown (Fig. 3a), heavily striped with yellow, pterothoracic tergum yellow, lateral margins brown; mesothoracic middorsal carina yellow or brown to level of bifurcation; dorsal mesanepisternal yellow stripes divergent anteriorly; ca. $1/2$ as wide as distance between them, almost extended to antealar carina above, and broadly confluent with yellow collar below; collar divided by brown medially; lateral mesanepisternal yellow stripes ca. $1/3$ as wide as dorsal mesanepisternal stripes, abruptly widened at apex to median width of dorsal stripes, apical dilation often separated from lower portion of stripe; intervening dark brown areas ca. $3/2$ as wide as dorsal stripes at middle; mesokatepisterna yellow with dorsal margin brown; dark areas along mesopleural sulci as wide as mesanepimeral pale stripes above, narrowed to $1/2$ this width below; *mesanepimeral yellow stripes broadly separated from metanepisternal yellow stripes by dark brown along intersegmental sutures*, spiracles ringed with brown; metakatepisterna yellow with dorsal margin occasionally brown; metanepimera yellow, broadly separated from metanepisternal yellow stripe by brown areas along metapleural sulci; dorsolateral carina and antealars brown, thoracic sternum pale yellow.

Legs.--Coxae yellow; trochanters and femora brown with inner surfaces of prothoracic trochanters and femora yellow; tibiae and tarsi black; prothoracic tibial keels pale, $1/5$ as long as tibiae.

Wings.--Venation dark brown, costa brown with fine yellow submedian stripes, pterostigmata brown; antenodal crossveins 11-14/7-10; postnodal crossveins 8-12/7-11; triangles, subtriangles, and

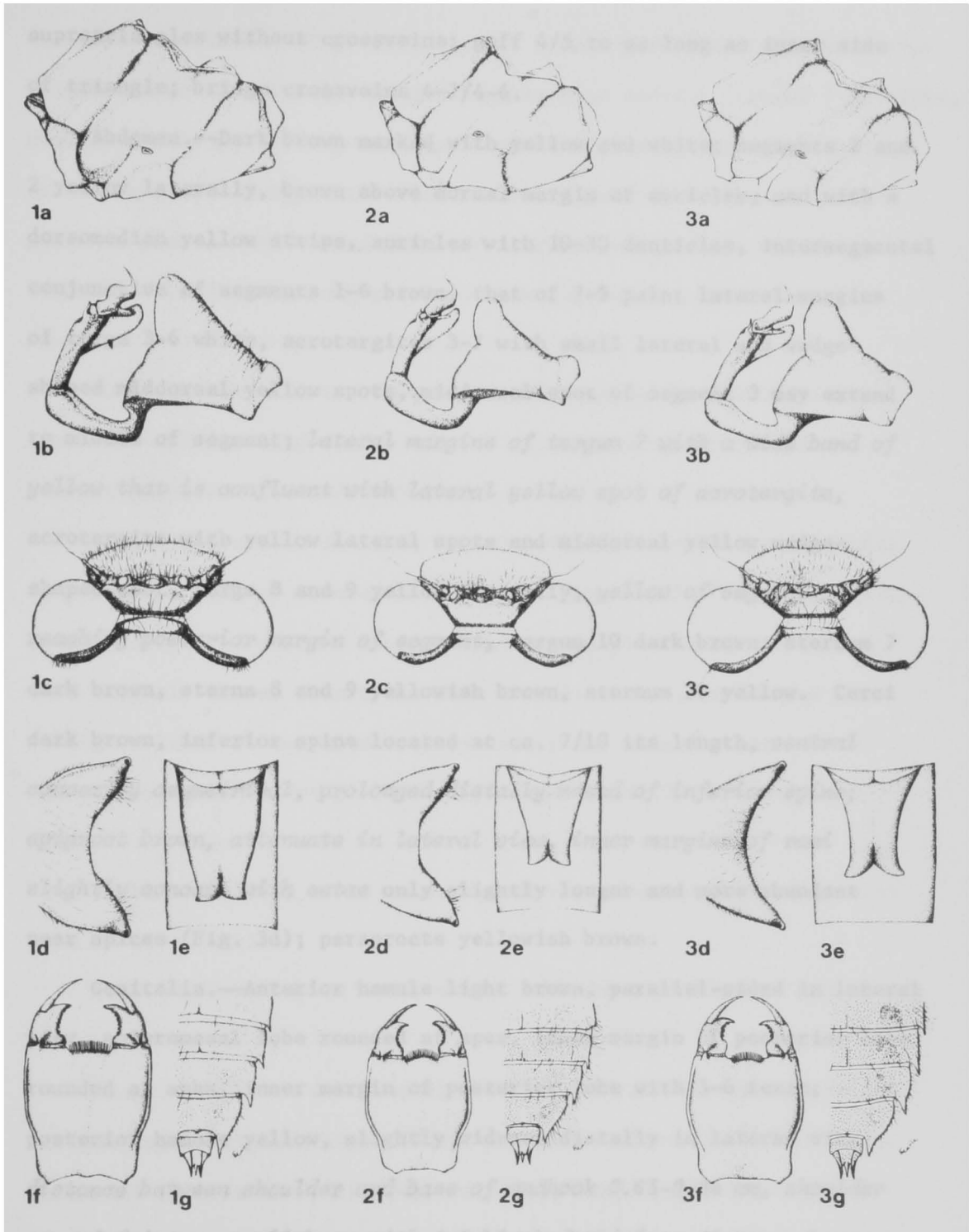


FIG. 1-3.—*Gomphus parvidens*, *Gomphus carolinus*, *Gomphus geminatus*; (a) lateral view of adult thorax, (b) lateral view of male penis, (c) dorsal view of female head, (d) dorsal view of male epiproct, (e) ventral view of female vulvar lamina, (f) ventral view of nymphal prementum, (g) nymphal abdominal terga 6-10.

supratriangles without crossveins; gaff 4/5 to as long as inner side of triangle; bridge crossveins 4-7/4-6.

Abdomen.--Dark brown marked with yellow and white; segments 1 and 2 yellow laterally, brown above dorsal margin of auricles, and with a dorsomedian yellow stripe, auricles with 10-30 denticles, intersegmental conjunctiva of segments 1-6 brown, that of 7-9 pale; lateral margins of terga 3-6 white, acrotergites 3-7 with small lateral and wedge-shaped middorsal yellow spots, middorsal spot of segment 3 may extend to middle of segment; *lateral margins of tergum 7 with a wide band of yellow that is confluent with lateral yellow spot of acrotergite*, acrotergite with yellow lateral spots and middorsal yellow wedge-shaped spot, terga 8 and 9 yellow laterally, *yellow of segment 8 reaching posterior margin of segment*, tergum 10 dark brown; sternum 7 dark brown, sterna 8 and 9 yellowish brown, sternum 10 yellow. Cerci dark brown, inferior spine located at ca. 7/10 its length, *ventral convexity asymmetrical, prolonged distally mesad of inferior spine*; epiproct brown, *attenuate in lateral view, inner margins of rami slightly concave with setae only slightly longer and more abundant near apices* (Fig. 3d); paraprocts yellowish brown.

Genitalia.--Anterior hamule light brown, parallel-sided in lateral view, anteromesal lobe rounded at apex, inner margin of posterior lobe rounded at apex, inner margin of posterior lobe with 3-6 teeth; posterior hamule yellow, slightly widened distally in lateral view, *distance between shoulder and base of endhook 0.65-0.85 mm, shoulder expanded into a small hump with 1-3 black denticles*, distance between proximal anterior corner and end hook 1.8-2.1 mm. Penis brown with

filament translucent (Fig. 3b); segment 1 in lateral view with posterior margin linear and anterior margin angulated at middle; segment 2 straight, swollen distally, 1.2-1.5 mm long; segment 3 straight, 1.1-1.4 mm long excluding prepuce; segment 4 with ventral convexity slight, *lateral distance between collar and crest of ventral convexity ca. 0.48 mm*; filament 0.25-0.38 mm long measured from base of constriction.

Female

Total length 41.0-47.0 mm, abdomen including cerci 30.0-34.0 mm, cerci 1.0-1.2 mm, hind femora 6.0-6.8 mm, hind wings 25.5-29.0 mm, pterostigmata 2.8-3.4 mm/3.1-3.8 mm.

Head.--Colored as in male; *vertex with small erect horns lateral to posterior edge of lateral ocelli* (Fig. 3c); *ocellar ridge ending at lateral margin of vertex*; occiput yellow, occipital ridge in dorsal view slightly convex anteriorly with a median notch, in frontal view rising to level of compound eyes laterally and slightly pitched to median dip; maximal "height" $1/4-1/3$ dorsal separation of compound eyes.

Thorax.--Colored as in male, anterior pronotal lobe occasionally pale in distal half.

Legs.--Colored as in male, except with inner surface of mesofemora yellow.

Wings.--Venation dark brown, costa brown with fine median yellow stripes, pterostigmata light brown; antenodal crossveins 10-13/8-10; postnodal crossveins 8-11/7-10; triangles, subtriangles, and supra-triangles without crossveins; gaff $4/5$ to as long as inner side of triangle; bridge crossveins 4-7/4-5.

Abdomen.--Colored as in male with yellow markings more extensive; lateral yellow spots of segment 3 occasionally extended to near posterior margin of segment, lateral yellow spots of segment 4 occasionally extended to $3/5$ the length of segment; lateral yellow spots of terga 5-7 extended to posterior margin of acrotergites, middorsal wedge-shaped yellow spots of terga 3-6 narrowly extended to posterior margins of segments, middorsal yellow spot of tergum 7 extended to ca. $1/2$ its length; sternum 7 brown, sternum 8-10 yellow and brown; cerci brown, epiproct and paraprocts yellow and brown.

Genitalia.--Vulvar lamina brownish yellow (Fig. 3e), distance between apex of basal sclerites and apex of vulvar lamina 1.20-1.45 mm, *apical lobes concave laterally the apices pointed laterally, apical notch extended proximally to ca. $2/5$ the length of lateral lobes, apical lobes ca. 0.5 mm long.*

Nymph

Total length, male 25.0-27.0 mm, female 27.0-29.0 mm; abdomen, male 15.5-17.0 mm, female 16.5-18.0 mm; hind femora 4.8-5.2 mm; prementum 3.1-3.5 mm.

Head.--Prementum constricted in basal $1/3$ and lateral margins granulate and *strongly convergent anteriorly* (Fig. 3f); anterior margin convex with 40-45 setae, *margin ca. 0.21 maximal premental width; 1st segment of labial palp strongly incurved, inner margin with 4-5 teeth (occasionally a weak 6th also present).*

Abdomen.--Uniformly dark brown; mesothoracic wing pads extended to the base of segment 4; abdomen widest at segment 6; *terga 6-10 heavily granulate, 5 moderately so; lateral spines on segments 6-9*

(Fig. 3g); relative lengths ca. 0.6:1.0:1.3:2.0, 6-8 divergent, 9 subparallel; segments 8 and 9 with lateral spinules, 2-6 on 8, 10-15 on 9; posterior margins of terga without spinules, tergum 9 with a small median spine (occasionally reduced to a large spinule); lateral abdominal hair setae ca. 1/2 median length of tergum 9; *epiproct and cerci granulate dorsally*, cerci 7/10 length of epiproct, epiproct ca. twice as long as tergum 10.

Types

Holotype, male--Pond Creek at Rt. 191, Santa Rosa Co., Fla.; May 16, 1973; M. J. Westfall, Jr; dry in envelope; deposited FSCA.

Allotype, female--Same data as for holotype; deposited FSCA.

Paratypes--Florida: Same data as for holotype, 8 males, 10 females, 9 nymphal exuviae (not associated); adults dry in envelopes, exuviae in alcohol; deposited as follows: 1 male, 1 female, and 1 nymphal exuviae each at USNM, EBWC, CCCU, and VPIC, remainder at FSCA. Same locality as for holotype; Mar. 16, 1974 (reared); M. J. Westfall, Jr.; 2 females; adults and exuviae in alcohol; deposited FSCA. Crooked Cr. at Rt. 270, Gadsden Co.; Apr. 16, 1972 (reared); M. J. Westfall, Jr.; 1 male, adult dry in envelope, nymphal exuviae in alcohol; 1 female, adult and nymphal exuviae in alcohol; deposited FSCA. Same locality; May 8, 1971; M. L. May; 1 male; dry in envelope; deposited FSCA. Same locality; May 27, 1973; S. W. Dunkle; 2 males, 1 female; dry in envelope; deposited FSCA. Sweetwater Cr. at Rt. 270, Liberty Co.; May 26, 1973; S. W. Dunkle; 1 male; dry in envelope; deposited FSCA. Bone Cr., Okaloosa Co.; Mar. 17, 1974 (reared); M. J. Westfall, Jr.; 1 female; adult and nymphal exuviae in alcohol; deposited FSCA.

Georgia: Mosquito Cr., Decatur Co.; Apr. 3, 1955 (reared); M. J. Westfall, Jr.; 5 nymphal exuviae in alcohol (adults not seen); deposited FSCA.

Remarks

Gomphus geminatus is most closely related to *G. parvidens*, from which it is readily distinguished by the characteristics stated in the keys. The nymph of *G. geminatus* is distinct among *Hylogomphus* nymphs in the strongly convergent lateral margins of the prementum, and in having only 4-5 teeth on the inner margin of the first segment of the labial palp, which also has the end hook strongly incurved. Specimens from Liberty Co., Fla. average much larger than specimens from the type-locality.

Etymology.--*G. geminatus* [jem·i·na tus] (from *geminatus*, L. participle meaning "twinned", referring to the twin lateral brown stripes of the adult thorax.)

Species Key to Adult Male *Gomphus* (*Hylogomphus*)

1. Posterior margin of penile vesicle convex in lateral view; inferior spine of cerci keel-like; metanepisternal pale stripe poorly developed, generally represented by a small yellow area near wing base *Gomphus apomyius* Donnelly
- Posterior margin of penile vesicle linear or concave in lateral view; inferior spine of cerci spine-like; metanepisternal pale stripe well-developed, extending the length of the pleuron . . . 2

2. End hook of posterior hamule ending in a measal ridge; inferior spine of cerci located at 0.5-0.6 its length; hood of penile vesicle wider than high *Gomphus abbreviatus* Hagen
- End hook of posterior hamule ending in a point; inferior spine of cerci located at 0.7-0.8 its length; hood of penile vesicle higher than wide 3
3. Posterior margin of epiproct convex in dorsal view; penile vesicle slender in lateral view, ca. 3 times as high as wide at mid-height, anterior surface dish-like; segment 4 of penis with a sharp angulation at base of filament *Gomphus viridifrons* Hine
- Posterior margin of epiproct concave in dorsal view; penile vesicle stout in lateral view, ca. twice as high as wide at mid-height, anterior surface cleft-like; segment 4 of penis evenly rounded at base of filament 4
4. Anterior lobe of anterior hamule ending in a pointed hook; anterior surface of occiput convex; facial sulci including lateral clypeal punctae, and median and apical portion of labrum heavily lined with black *Gomphus brevis* Hagen
- Anterior lobe of anterior hamule rounded; anterior surface of occiput concave; with at most the frontoclypeal sulcus lined with black 5

5. Epiproctal rami attenuate, setae of inner margin only slightly longer and more abundant near apices; shoulder of posterior hamule generally denticulate; mesanepimeral and metanepisternal pale stripes separate *Gomphus geminatus* n. sp.
- Epiproctal rami robust, setae of inner margin much longer and more abundant near apices; shoulder of posterior hamule without denticles; mesanepimeral and metanepisternal pale stripes generally confluent 6
6. Hood of penile vesicle ca. 2/5 as long as segment, hood ca. 0.7 mm high; in ventral view penile vesicle slightly constricted proximal to, and evenly tapering distal to hood; apical sclerites of penile segment 3 somewhat acuminate at inner margins
- *Gomphus carolinus* n. sp.
- Hood of penile vesicle ca. 1/2 as long as segment, hood ca. 0.9 mm high; in ventral view penile vesicle distinctly constricted proximal and distal to hood; apical sclerites of penile segment 3 rounded apically *Gomphus parvidens* Currie

Species Key to Adult Female *Gomphus* (*Hylogomphus*)

1. Vertex with an elongate horn posterior to each end of ocellar ridge 2
- Vertex without horns posterior to ocellar ridge 4

2. Vulvar lamina as long as sternum 9; face light bluish green
 *Gomphus viridifrons* Hine
 Vulvar lamina ca. 1/2 as long as sternum 9; face either yellow, or
 green heavily cross-striped with black 3
3. Lateral margins of vulvar lamina curving away from sternum 9,
 forming a ventromedian trough; face green, heavily cross-striped
 with black *Gomphus brevis* Hagen
 Lateral margins of vulvar lamina level, not forming a ventromedian
 trough; face yellow *Gomphus abbreviatus* Hagen
4. Ocellar ridge extending to lateral margin of vertex; metanepisternal
 pale stripe well-developed and separated from mesanepimeral pale
 stripe by a dark brown band *Gomphus geminatus* n. sp.
 Ocellar ridge ending posterior to lateral ocelli; metanepisternal
 pale stripe either weakly developed, or well developed and
 generally confluent with mesanepimeral pale stripe above level
 of spiracle 5
5. Apical vulvar laminal lobes divergent, the lateral margins
 concave, the apical cleft large; metanepisternal pale stripe
 weakly developed, represented by a small pale area near
 wing base *Gomphus apomyius* Donnelly
 Apical vulvar laminal lobes truncate, the lateral margins
 parallel, the apical cleft small; metanepisternal pale stripe
 well-developed and generally confluent with mesanepimeral
 pale stripe above spiracle 6

6. Distance between apex of vulvar lamina and posterior margin of sternum 9, 3-4 times the width of an apical vulvar laminal lobe, vulvar lamina 1.2-1.3 mm long and level laterally; occipital ridge only slightly, if at all, convex anteriorly in dorsal view *Gomphus carolinus* n. sp.

Distance between apex of vulvar lamina and posterior margin of sternum 9, ca. 1.5 times the width of an apical vulvar laminal lobe, vulvar lamina 1.4-1.6 mm long and convex laterally; occipital ridge distinctly convex anteriorly in dorsal view *Gomphus parvidens* Currie

Distribution

Species of the subgenus *Hylogomphus* are primarily restricted in range to eastern North America. *Gomphus brevis* has the most boreal distribution, *G. geminatus* the most austral; *G. apomyius* is found as far west as Texas. The known distributions for species of *Hylogomphus* are as follows: *G. abbreviatus*, Conn., Me., Md., Mass., N.H., N.J., N.Y., N.C., Ohio, Pa., S.C., Va., W.Va.; *G. apomyius*, Ala., Miss., N.C.³, N.J., Tex.; *G. brevis*, Conn., Me., Mass., Mich., N.H., N.J., N.Y., N.C., Pa., Va., Vt., W.Va., Wis., Canada- N.B., N.S., Ont., Que.; *G. carolinus*, N.C., S.C.; *G. geminatus*, Fla., Ga.; *G. parvidens*, Md., N.C., Va.; *G. viridifrons*, Ala., Ind., Ky., N.Y., N.C., Ohio, Pa., Tenn., Va., W.Va., Canada- Ont. State records for *G. apomyius*

³Based on the tentative identification of Dr. Brimley's specimens.

are from the following locations: Ala., Black Warrior R., Tuscaloosa Co. (Coll: Smith and Hodges); Miss., Chaney Cr., Forrest Co. (Dunkle 1975); N.J., trib. of Friendship Br., Burlington Co. (Coll: Donnelly); Tex., Big. Cr., San Jancinto Co. (Donnelly 1966). Mr. Carl Cook has reared a male *G. geminatus* from Dady's Cr. in Kentucky, but the specimen is unfortunately misassociated with a nymphal exuviae of *G. viridifrons*. A nymphal exuviae in the FSCA which is apparently that of a *Hylogomphus* differs from others of the subgenus, suggesting the possibility of still other undescribed *Hylogomphus*.

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APPENDIX II

A New *Lanthus* (Odonata: Gomphidae) from Eastern North America
with Adult and Nymphal Keys to American Octogomphines

ABSTRACT

A brief taxonomic and nomenclatural history of *Lanthus parvulus* (Selys) and *Stylogomphus albistylus* (Hagen) are given, and the adults and nymphs of *L. parvulus* and *L. vernalis* n. sp. described. The new species may be readily distinguished from *L. parvulus* by the confluence of the mesanepimeral and metanepisternal pale stripes above the metathoracic spiracle. The type locality of *L. vernalis* n. sp. is in western Virginia, and the type series includes specimens from Maine to Georgia. Both species of *Lanthus* prefer pristine upland streams and are valuable biological indicators. Species keys for the determination of adults and nymphs are given, and the taxonomic position of the genus *Lanthus* and related genera discussed.

INTRODUCTION

In 1854 Baron Edmond de Selys Longschamps described *Gomphus parvulus* Selys from a male specimen collected in Nova Scotia (Selys 1854, Hagen 1860). Hagen 1878 later described *Gomphus albistylus* Hagen from a female specimen collected in Maine, and proposed the name *Gomphus naevius* for a few similar but smaller specimens from Pennsylvania. After carefully studying several specimens from Maine, F. L. Harvey and Philip P. Calvert concluded that *G. albistylus* and *G. naevius* were "specifically identical" (Harvey 1898). Hagen (1885) described an "extraordinary nymph" from Kentucky which he doubtfully referred to *Tachopteryx thoreyi* Hagen, but after rearing similar nymphs Needham (1897) established the genus *Lanthus* with *Gomphus parvulus* as its generotype. Needham's keys which were used to characterize his new genus are unreliable, but it is clear from Needham and Heywood (1929) that *G. albistylus* was also included in *Lanthus*. However, the specimens from which Needham obtained his generic characters were likely *Lanthus vernalis* n. sp. since his later description and key (Needham and Heywood 1929) were definitely of this species; *Lanthus parvulus* (Selys) is retained as the generotype of *Lanthus* as it is fortunately a true *Lanthus*. Fraser (1922) established the genus *Stylogomphus* for his new Indian species *S. inglisi* Fraser. Chao (1954) referred *L. albistylus* and the Japanese *L. suzukii* (Matsumura) to *Stylogomphus*, and described two new Chinese species, *S. chunliuae* Chao and *S. tantulus* Chao. The Japanese *G. fujiacus* Fraser was in turn referred to *Lanthus* by Asahina (1957). In a letter to Dr. M. J. Westfall, Jr. dated August 21, 1950, Hsiu-fu Chao mentioned the existence of an undescribed Ameri-

can *Lanthus*, here described as *L. vernalis* n. sp. Walker's (1958) description and figures are of the true *L. parvulus*, but the description and state records in Needham and Westfall (1955) are composite.

Lanthus parvulus (Selys)

Male

Total length 34.0-39.5 mm, abdomen including cerci 24.0-29.5 mm, cerci 1.10-1.20 mm, hind femora 5.5-6.0 mm, hind wings 21.0-24.0 mm, pterostigmata 2.4-2.7/2.8-3.3 mm.

Head.--Labium and maxillae dark brown, laterally pale; bases of mandibles yellow; labrum yellow, distal and proximal margins black; postgenae and genae dark brown; anteclypeus brown; postclypeus yellow, *distal margin dark brown*; frons yellow, fronto-clypeal sulcus and basal $2/5-1/2$ of anterior surface dark brown, and basal $1/3-2/5$ of dorsal surface dark brown; vertex and antennae dark brown and black, ocellar ridge bilobed, *posterolaterally interfacing vertex at an obtuse angle, yellow spot posterior to ocellar ridge subcircular*; distance between compound eyes 0.80-0.91 mm; occiput dark brown or black, *anterior margin longer than distance along midline, with circular yellow spot at middle of posterior surface*; posterior surface of head dark brown and black.

Thorax.--Prothorax mostly brownish black; *anterior lobe black, yellow along anterior margin*; middle lobe black with geminate median, large lateral, and occasionally small anterolateral yellow spots; posterior lobe brownish black with obscure median yellow spot. Pterothorax brownish black, striped with yellow; pterothoracic tergum yellow margined

with black; *mesoscutellum* brown, axillary sclerites black; mesothoracic middorsal carina narrowly yellow to level of bifurcation, confluent with yellow collar below; *yellow collar stripe* $1/2-3/4$ width of dorsal *mesanepisternal yellow stripes*, and nearly divided by lines of brown lateral to middorsal carina; dorsal mesanepisternal yellow stripes divergent anteriorly, widely separated from antealar carina above and yellow collar below; lateral mesanepisternal yellow stripes each represented by large spot near antealar carina and diffuse band centered below middle both of which can be entirely absent, mesokatepisterna dark brown with lower $2/5$ yellow; *mesanepimeral yellow stripes* broadly separated from *metanepisternal yellow stripes* by dark brown along intersegmental interface (Fig. 1a), spiracles ringed with brown; *metanepisternal yellow stripes* often divided at middle into two subtriangular spots, metakatepisterna brown, diffuse yellow anteriorly; metanepimera yellow, anterior margin brown; dorsolateral carina and antealars brown; thoracic sternum pale yellow to brown.

Legs.--Coxae brown, yellow externally; trochanters, femora, tibiae, and tarsi brownish black; prothoracic tibial keels pale, $1/3$ as long as tibiae.

Wings.--Venation brownish black, costa and pterostigmata brown; antenodal crossveins 10-13, 11-15/7-9, 7-9; postnodal crossveins 7-12/7-10; triangles, subtriangles, and supratrangles without crossveins; gaff $1/4-1/2$ as long as inner side of triangle; outer side of fore wing triangle not distinctly angulated near middle; bridge crossveins 4-7/3-5; crossveins under pterostigmata 2-4/2-4, *fore wing pterostigmata* 3.1-3.6 times as long as wide (Fig. 1b).

Abdomen.--Brownish black marked with yellow and white; segments 1 and 2 brown, posterolateral tergal margins yellow, auricles yellow *with yellow extended anteriorly in narrow bands*, and with dorsomedian yellow stripe constricted at antecostal suture; auricles with 15-35 denticles, intersegmental conjunctiva of segments 1-6 brown, that of 7-9 yellow; lateral margins of terga 3-7 narrowly white; acrotergites 3-8 or 9 with small lateral yellow spots, diffuse on 8 and 9; *very narrow mid-dorsal yellow line extended to base of segment 7*, segment 10 and appendages brownish black; *each cercus (superior appendage) with large inferior tubercle at base (Fig. 1c), tubercle 1/4-1/3 basal width of cerci in lateral view, in dorsal view visible as lateral swelling at base of cerci; epiproct (inferior appendage) truncate apically in lateral view (Fig. 1c), ca. 1.4 mm wide, shallowly notched apically, and with lateral margins strongly divergent (Fig. 1d).*

Genitalia.--Anterior hamule brownish black, posterior apical lobe glabrous, anterior lobe setose with *apex directed posteriorly*; posterior hamule dark brown, *end hook evenly tapered to apex, width of end hook less than circumscribed notch*, shoulder expanded mesally. Penis brown, filament and membranes translucent; segment 1 in lateral view with posterior margin strongly angulated at base of hood, *posterior margin of hood as long as apical margin, ca. 0.3 mm (Fig. 1e)*, hood covered with numerous pale hair setae, anterior margin of segment deeply incised at base of hood; segment 2 swollen distally and gently curved basally, *ca. 1.1 mm long, and with distal spine subapical*; segment 3 *ca. 1.00 mm long excluding prepuce, 0.6-0.7 mm wide near apex, apical sclerites truncate apically*; segment 4 *0.5-0.6 mm long*.

Female

Total length 32.5-39.0 mm, abdomen including cerci 24.5-28.5 mm, cerci 0.66-0.80 mm, hind femora 5.0-6.3 mm, hind wings 22.0-26.0 mm, pterostigmata 2.4-2.7/2.8-3.3 mm.

Head.--Colored as in male with yellow slightly more extensive; *ocular ridge interfacing vertex at obtuse angle; distance between compound eyes 0.83-1.00 mm.*

Thorax.--Prothorax and pterothorax colored as in male with yellow more extensive, particularly on the metakatepisterna.

Legs.--Colored as in male; inner spines of hind tibiae longer than in male.

Wings.--Venation brownish black, costa and pterostigmata brown; antenodal crossveins 10-14, 10-15/6-11, 7-11; postnodal crossveins 8-11/7-11; triangles, subtriangles, and supratrangles without crossveins; gaff 1/4-1/2 as long as inner side of triangle; outer side of fore wing triangle not distinctly angulated near middle; bridge crossveins 4-6/3-4; crossveins under pterostigmata 2-5/3-5, fore wing *pterostigmata 3.5-4.0 times as long as wide.*

Abdomen.--Colored as in male with yellow areas more extensive, yellow of auricles broadly confluent with yellow anterior segmental margin and narrowly confluent with yellow posterior segmental margin isolating rectangular brown spot behind each auricle, *narrow brown line extended below each auricle; auricles without denticles; acrotergites 3-9 with lateral yellow spots, tergum 3 with elongate lateral spots in addition to anterior yellow spots; narrow middorsal yellow line extended to apex of segment 7.*

Genitalia.--Vulvar lamina black, ca. $\frac{4}{5}$ the length of sternum 9, 1.00-1.17 mm long (one specimen with vulvar lamina 0.90 mm long); apical cleft "V"-shaped, extended 0.38-0.46 distance to base (Fig. 1f).

Nymph

Total length, male 18.5-21.5 mm, female 20.0-22.5 mm; abdomen, male 11.5-13.0 mm, female 12.0-13.5 mm; hind femora 3.3-3.9 mm; prementum 2.6-3.0 mm.

Head.--Prementum narrowed in basal third to ca. 70 percent its apical width; ligula convex with fringe of short setae and 3-5 (generally 4) dark brown tooth-like denticles; first segment of labial palp rounded distally, and with 7-9 *triangular teeth in a more or less straight row*, basal internal lobe generally weakly developed; frontal shelf well-developed, bifurcate; third antennal segments subelliptical, slightly more than twice as long as wide, widest slightly beyond middle, *width ca. equal to that of frontal shelf, dorsal surface with several short conspicuous papilliform setae which are well separated from each other* (Fig. 1g).

Abdomen.--Long-ovoid in shape, widest at segment 6, abruptly narrowed on segment 9, covered with granules, and almost devoid of hairs; wing pads extended to distal half of segment 4 in mature nymphs; *impressed median line ending at base of segment 8*, tergum 9 with median ridge and shallow lateral concavities; lateral spine of segment 7 minute, 8 and 9 with lateral spines, relative lengths ca. 0.1:0.4:1.0; cerci slightly longer than middorsal length of tergum 10, and ca. $\frac{2}{3}$ length of epi-proct, in male extended to apex of lateral epi-proctal tubercles, *epi-*

proctal tubercles compressed; paraprocts slightly longer than cerci.

Types

Allotype, female-Fillmore Gap, Centre Co., PA; nymph collected May 9, 1979; emerged May 22, 1979; F. Carle; nymphal exuviae and adult dry in envelope; deposited Florida State Collection of Arthropods, Gainesville (FSCA).

Additional Material Studied

New Hampshire: Colebrook, Coos Co.; June 19, 1950; W. J. Morse; 2 males dry in envelope. Pennsylvania: same data as allotype; emerged May 20-22, 1979; F. Carle; 2 males, 1 female; nymphal exuviae and adults dry in envelopes. Same data as allotype; collected June 13, 1975; C. Shiffer; 1 male dry in envelope. Whipple Dam, Huntingdon Co.; June 11, 1972; C. Shiffer; 1 male; dry in envelope. Vermont: Jacksonville, Windham Co.; June 20, 1937; J. F. Hanson; 1 male; dry on pin. Westmore, Orleans Co.; June 17-29, 1945; C. P. Alexander; 3 males, 2 females; dry on pins. Virginia: Poverty Creek, Montgomery Co.; April 16?, 1977; S. Johnsen; 1 male, dry in envelope. West Virginia: Hiett Run, Hampshire Co.; May 14, 1979; C. Shiffer; 3 males, 7 females, 19 nymphal exuviae; dry in envelopes. Representative specimens deposited at the FSCA; U.S. National Museum of Natural History (USNM); the E. B. Williamson Collection, Univ. of Michigan, Ann Arbor (EBWC); the Cornell Collection, Cornell Univ. (CCCU); the University of Massachusetts Department of Entomology Collection (UMEC); and at the Virginia Polytechnic Institute and State University Department of Entomology Collection (VPIC).

Lanthus vernalis n. sp.*Male*

Total length 29.0-39.5 mm, abdomen including cerci 21.5-29.0 mm, cerci 0.90-1.05 mm, hind femora 4.5-6.0 mm, hind wings 20.0-24.0 mm, pterostigmata 2.0-2.7/2.5-3.3 mm.

Head.--Labium and maxillae dark brown, laterally pale; bases of mandibles yellow; labrum yellow, distal and proximal margins black; postgenae and genae dark brown; anteclypeus brown; postclypeus yellow, distal margin with dark brown band which is often absent medially; frons yellow, frontoclypeal sulcus and basal 2/5 of anterior surface dark brown, and basal 2/5-1/2 of dorsal surface dark brown; vertex and antennae dark brown and black, ocellar ridge bilobed, *posterolaterally interfacing vertex at acute angle, yellow spot behind ocellar ridge subtriangular; distance between compound eyes 0.56-0.74 mm; occiput dark brown or black, anterior margin ca. as long as distance along midline, with elongate yellow area on posterior surface; posterior surface of head dark brown and black.*

Thorax.--Prothorax mostly brownish black; *anterior lobe yellow, black basally; middle lobe black with geminate median and large lateral yellow spots; posterior lobe brownish black with small median yellow spot. Pterothorax brownish black, striped with yellow; pterothoracic tergum yellow margined with black, mesoscutellum yellow, axillary sclerites black; mesothoracic middorsal carina yellow to level of bifurcation, confluent with yellow collar below; yellow collar stripe ca. as wide as dorsal mesanepisternal yellow stripes, and widely confluent across midline; dorsal mesanepisternal yellow stripes divergent anteriorly, widely separated from an-*

tealar carina above but often confluent with yellow collar below; lateral mesanepisternal yellow stripes each represented by triangular spot near antealar carina and diffuse band centered below middle, mesokatepisterna dark brown with lower $2/5$ yellow; *mesanepimeral yellow stripes broadly confluent with metanepisternal yellow stripes above metathoracic spiracles* (Fig. 2a), spiracles ringed with brown; *metanepisternal yellow stripes entire*, metakatepisterna brown, diffuse yellow below; metanepimera yellow, anterior margin brown; dorsolateral carina and antealars brown; thoracic sternum pale yellow and brown.

Legs.--Coxae brown, yellow externally; trochanters, femora, tibiae, and tarsi brownish black; prothoracic tibial keels pale, $1/3$ as long as tibiae.

Wings.--Venation brownish black, costa and pterostigmata brown; antenodal crossveins 7-13, 9-14/6-9, 6-10; postnodal crossveins 7-13/7-11; triangles, subtriangles, and supratrangles without crossveins; basal subcostal crossvein occasionally present; gaff ca. $1/3-3/5$ as long as inner side of triangle; outer side of fore wing triangle not distinctly angulated near middle; bridge crossveins 4-6/3-5; crossveins under pterostigmata 2-5/2-5, *fore wing pterostigmata 2.4-3.0 times as long as wide* (Fig. 2b).

Abdomen.--Brownish black marked with yellow and white; segments 1 and 2 brown, posteroventral tergal margins yellow, auricles yellow *with yellow extended anteriorly in wide bands*, and with dorsomedian yellow stripe constricted at antecostal suture; auricles with 20-40 denticles, intersegmental conjunctiva of segments 1-6 brown, that of 7-9 yellow; lateral margins of terga 3-7 narrowly white; acrotergites 3-8 with small lateral yellow spots, diffuse on 8; *narrow middorsal line extended to apex of tergum 3*, segment 10 and appendages brownish black; *each cercus with inferior spine*

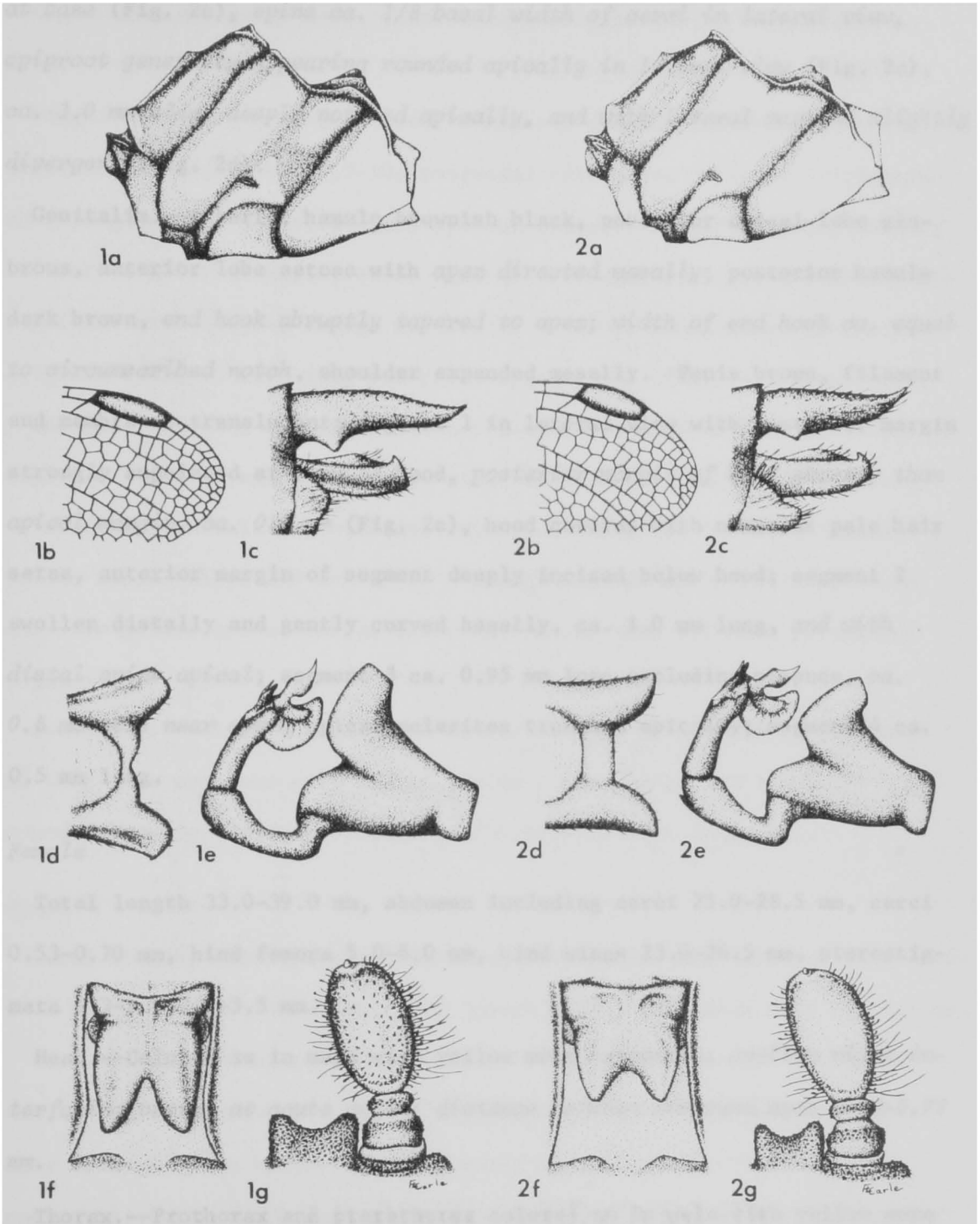


FIG. 1-2. 1.—*Lanthus parvulus* (Selys). 2.—*Lanthus vernalis* n. sp., (a) lateral view of pterothorax, (b) apex of fore wing, (c) lateral view of male terminalia, (d) ventral view of male epiproct, (e) lateral view of penis, (f) ventral view of vulvar lamina, and (g) dorsal view of nymphal frontal shelf and right antenna.

at base (Fig. 2c), spine ca. $1/8$ basal width of cerci in lateral view, epiproct generally appearing rounded apically in lateral view (Fig. 2c), ca. 1.0 mm wide, deeply notched apically, and with lateral margins slightly divergent (Fig. 2d).

Genitalia.--Anterior hamule brownish black, posterior apical lobe glabrous, anterior lobe setose with apex directed mesally; posterior hamule dark brown, end hook abruptly tapered to apex; width of end hook ca. equal to circumscribed notch, shoulder expanded mesally. Penis brown, filament and membranes translucent; segment 1 in lateral view with posterior margin strongly angulated at base of hood, posterior margin of hood shorter than apical margin, ca. 0.1 mm (Fig. 2e), hood covered with numerous pale hair setae, anterior margin of segment deeply incised below hood; segment 2 swollen distally and gently curved basally, ca. 1.0 mm long, and with distal spine apical; segment 3 ca. 0.95 mm long excluding prepuce, ca. 0.5 mm wide near apex, apical sclerites truncate apically; segment 4 ca. 0.5 mm long.

Female

Total length 33.0-39.0 mm, abdomen including cerci 25.0-28.5 mm, cerci 0.53-0.70 mm, hind femora 5.0-6.0 mm, hind wings 23.0-26.5 mm, pterostigmata 2.3-2.8/2.8-3.5 mm.

Head.--Colored as in male with yellow more extensive; ocellar ridge interfacing vertex at acute angle; distance between compound eyes 0.58-0.77 mm.

Thorax.--Prothorax and pterothorax colored as in male with yellow more extensive, particularly in development of lateral mesanepisternal stripes.

Legs.--Colored as in male, inner spines of hind tibiae longer than in male.

Wings.--Venation brownish black, costa and pterostigmata brown; antenodal crossveins 9-13, 10-14/7-9, 7-10; postnodal crossveins 8-13/7-12; triangles, subtriangles, and supratriangles without crossveins; gaff $1/3-3/5$ as long as inner side of triangle, outer side of fore wing triangle not distinctly angulated near middle; bridge crossveins 4-7/3-5; crossveins under pterostigmata 2-4/2-5, fore wing *pterostigmata* 2.6-3.0 times as long as wide.

Abdomen.--Colored as in male with yellow areas more extensive, abdominal segments 1 and 2 yellow laterally with rectangular brown areas posterior to auricles; auricles without denticles; acrotergites 3-9 with lateral yellow spots, *terga 3-6 or 7 with elongate lateral spots in addition to anterior yellow spots*; narrow middorsal yellow line extended to apex of segment 7.

Genitalia.--Vulvar lamina black ca. $3/5$ length of sternum 9, 0.63-0.85 mm long (one specimen with vulvar lamina 1.0 mm long); *apical cleft rounded basally, extended 0.26-0.37 distance to base* (Fig. 2f).

Nymph

Total length, male 17.5-21.0 mm, female 18.5-21.0 mm; abdomen, male 10.0-13.0 mm, female 11.0-13.0 mm; hind femora 3.0-3.6 mm, prementum 2.6-2.9 mm.

Head.--Prementum narrowed in basal third to ca. 70 percent its apical width; ligula convex with fringe of moderately long setae and 3-5 (generally 4) dark brown tooth-like denticles; first segment of labial palp rounded distally, *with 7-9 triangular teeth in curved row*, basal internal lobe well-developed; frontal shelf well-developed, bifurcate; third anten-

nal segments subelliptical, ca. twice as long as wide, widest slightly beyond middle, *width greater than that of frontal shelf, dorsal surface with papilliform setae dense, forming continuous smooth surface* (Fig. 2g).

Abdomen.--Long-ovoid in shape, widest at segment 6, abruptly narrowed on segment 9, covered with granules, and almost devoid of hairs, wing pads extended to distal half of segment 4 in mature nymphs; *impressed median line ending at base of tergum 9 where median ridge is slightly impressed, tergum 9 with median ridge and shallow lateral concavities; lateral spine of segment 7 minute, 8 and 9 with lateral spines; relative lengths ca. 0.1:0.4:1.0; cerci 1.3 times length of tergum 10, and ca. 3/5 length of epiproct, in male not extended to apex of epiproctal tubercles, epiproctal tubercles erect; paraprocts slightly longer than cerci.*

Types

Holotype, male--Cove Branch, Craig Co., VA.; July 14, 1974; F. Carle; dry in envelope; deposited FSCA. Allotype, female--Cherry Run Bog, Union Co., PA; July 20, 1974; C. Shiffer; dry in envelope; deposited FSCA. Paratypes--(Adults dry in envelopes and nymphs preserved in alcohol unless otherwise specified) Georgia: Chattahoochee River at Helen, White Co.; nymphs collected March 30, 1979; M. J. Westfall, Jr.; 2 males; nymphal exuviae and reared adults in alcohol. Maine: Mt. Desert Island, Hancock Co.; June 16, 1935; W. Procter; 1 male; dry on pin. Hallowell, Kennebec Co.; no date; M. Wadsworth; 1 male. Massachusetts: Mt. Toby, Franklin Co.; June 14, 1937; J. F. Hanson; 2 males; dry on pins. Sunderland, Franklin Co.; May 28-30, 1964; F. C. Thompson; 3 males, 3 females. Amherst, Hampshire Co.; June 16, 1937; H. D. Pratt; 2 males; dry on pins. North Caro-

lina: Near Sylva Pond along county road 1724, Jackson Co.; May 31, 1966; G. J. Gantt; 1 male. Highlands, Macon Co.; June 13, 1934; Bellamy; 1 female. Cullasaja River at Gneiss, Macon Co.; nymph collected March 31, 1978; emerged May 10, 1978; F. Carle; 1 female. Smokemont campground, Swain Co.; May 12, 1970; O. S. Flint; 1 male, 1 female. Deep Creek campground, Swain Co.; May 21, 1970; O. S. Flint; 1 male. Brevard, Transylvania Co.; June 12, 1941; M. J. Westfall, Jr.; 1 male. Pennsylvania: Johnstown, Cambria Co.; July 1, 1931; C. F. Byers; 1 male. Bear Meadows, Centre Co.; June 10, 1967; C. Shiffer; 1 male, 2 females; July 9, 1966; C. Shiffer; 1 male. Colyer Lake, Centre Co.; May 25, 1977; F. Fee; 1 male; June 1, 1975; F. Fee; 2 females. Fillmore Gap, Centre Co.; nymph collected April 22, 1956; emerged May 2, 1956; G. H. and A. F. Beatty; 1 female. Fillmore Gap, Centre Co.; nymphs collected May 9, 1979; emerged May 17-22, 1979; F. Carle; 16 males, 28 females; nymphal exuviae and adults dry in envelopes. Fillmore Gap, Centre Co.; nymphs collected May 10, 1979; emerged May 19-22, 1979; C. Shiffer and F. Carle; 6 males, 11 females; nymphal exuviae and adults dry in envelopes. Fillmore Gap, Centre Co.; June 13, 1975; C. Shiffer; 1 male; June 21, 1968; C. Shiffer; 1 male; June 29, 1968; C. Shiffer; pair in tandem; June 30, 1969; C. Shiffer; 1 male. Wyola, Delaware Co.; May 30, 1946; G. H. Beatty, III; 1 male, 1 female. Wind Gap, Northampton Co.; June 19, 1947; J. W. Green; 1 female; June 21, 1946; J. W. Green; 1 male. Millerstown, small stream feeding Cocolamus Creek, Perry Co.; June 11, 1966; C. Shiffer; 5 males, 1 female. South Carolina: Spring Water Creek, Rocky Bottom?; June 14, 1935; H. T. T.; 1 male. Vermont: Westmore, Orleans Co.; June 17, 1945; C. P. Alexander; 1 female; dry on pin. Virginia: Mill Branch, State Rt. 607, Alleghany Co.; Oct. 12,

1972; F. Carle; 1 nymph. Lick Run, State Rt. 634, Bath Co.; Oct. 29,
 1972; F. Carle; 1 nymph. Big Spring, State Rt. 629, Bath Co.; June 20,
 1978; F. Carle; 1 male. Cove Branch, Craig Co.; Oct. 12, 1972; F. Carle;
 3 nymphs. Seep near Potts Bog, Craig Co.; July 14, 1974; F. Carle; 1 fe-
 male. Conway River, Green Co., June 29, 1976; J. Harriston; 1 nymph;
 July 2, 1976; J. Harriston; 1 nymph. Davis Run, Highland Co.; Aug. 17,
 1976; J. Harriston; 1 nymph. Hog Camp Branch, Madison Co.; June 16, 1976;
 J. Harriston; 3 nymphs. Rapidan River, Madison Co.; July 8, 1976; 1 nymph.
 Jeremys Run, Page Co.; July 28-29, 1976; 5 nymphs. Critz, small tributary
 of Little Mill Creek, Patrick Co.; June 3, 1976; F. Carle; 1 male. Small
 tributary of Rock Castle Creek, Patrick Co.; May 21, 1978; F. Carle, C.
 Shiffer, and B. Kondratieff; 5 males, 7 females. Guys Run, Rockbridge
 Co.; May 13, 1977; F. Carle; 1 male. Laurel Run, Shenandoah Co.; Aug. 10,
 1976; J. Harriston; 1 nymph. Small tributary of Cove Creek, State Rt.
 662, Tazwell Co.; June 29, 1979; F. Carle; 1 male; B. Kondratieff; 1 fe-
 male. Representative paratypes deposited at the FSCA, USNM, EBWC, CCCU,
 UMEC, and VPIC.

Remarks

Lanthus vernalis has remained unrecognized resulting from the infrequent capture of adults, and the misidentification in Needham and Heywood (1929). In addition, the predominantly boreal distribution of *L. parvulus* and relatively austral distribution of *L. vernalis* have precluded the collection of both species by most collectors. The two species can be distinguished quite readily by the lateral color pattern of the pterothorax. In *L. parvulus* the pterothorax is yellow laterally with black bands along the inter-

segmental interface (the intersegmental suture is no longer apparent above the metathoracic spiracle in the Anisoptera) and along the pleural sulci which delineate 3 lateral yellow areas, although the middle yellow stripe is often divided into two triangular spots by a confluence of the black bands near the middle. Selys (1857) accurately redescribed the lateral color pattern of the holotype as follows: "... les cotes du thorax sont noirs, avec trois bandes jaunes, une entre chaque suture, l'intermediaire tres-etroite et divisee en deux taches a son milieu." In contrast, *L. vernalis* lacks a black band along the intersegmental interface so that the yellow mesanepimeral and metanepisternal stripes are confluent above the metathoracic spiracle. In both species the yellow of the thorax is often light green in mature individuals. Additional color differences include the shape of the postocellar spot, development of the clypeal and pterothoracic collar stripes, and the extent of yellow markings on the abdomen. The interocular distance of the two species is also very different, in *L. vernalis* the anterior margin of the occiput averages only slightly longer than the anterior-posterior width of the occiput, in *L. parvulus* the anterior margin is much longer than the width. *Lanthus vernalis* averages smaller than *L. parvulus*, and although *L. vernalis* is larger than *Stylogomphus albistylus* on the average, occasional specimens are smaller than any as yet reported for *S. albistylus* indicating that *L. vernalis* may be considered our smallest North American Gomphine. The total length of 25 mm reported by Walker (1958) for *L. parvulus* is a misprint, and the reported male hind wing length of 27 mm is apparently a misprint also. The pterostigmata are of different lengths in the two species and this at least accounts for some of the discrepancy noted by

Walker (1958) concerning his measurements of *L. parvulus* (pterostigmata 3.0-3.5 times as long as wide) and the comment in Needham and Heywood (1929) "The stigma short, hardly more than twice as long as wide." Male *L. vernalis* are also distinguished by several slight differences in the secondary genitalia, these include anterior lobe of anterior hamule directed mesally, end hook of posterior hamule wider than the circumscribed gap, posterior margin of penile hood shorter than the apical margin, distal spine of segment 2 apical, and ventral width of segment 3 ca. 0.5 mm. The male cerci are short and tend to be upturned apically in *L. vernalis*, and lack the large ventrobasal tubercle as found in *L. parvulus*. In male *L. vernalis* the epiproct is nearly parallel-sided so that the epiproctal rami are hidden in dorsal view, in *L. parvulus* the epiproctal rami are strongly divergent with their apices often visible in dorsal view. Laterally, the epiproctal rami generally appear rounded apically in *L. vernalis* and truncate apically in *L. parvulus*. The narrow male epiproct apparently complements the smaller interocular distance and sharp posterolateral delineation of the occipital ridge found in female *L. vernalis*. The vulvar lamina of *L. vernalis* is ca. 0.8 mm long, is cleft to only 1/3 its length, and is rounded at the base of the apical notch; in contrast the vulvar lamina of *L. parvulus* is ca. 1.0 mm long, and is "V"-notched for 2/5 its length. Small and full-grown nymphs may be readily identified by the density of papilliform setae on the dorsum of the third antennal segment; these are sparse in *L. parvulus*, and form a more or less continuous smooth surface in *L. vernalis*. Additional characteristics which will help to distinguish nymphs of *L. vernalis* from those of *L. parvulus* include: frontal shelf narrower than antennal segment 3, teeth of

the labial palp in a curved line, and middorsal abdominal groove extended to the base of tergum 9.

Octogomphus Selys, *Davidius* Selys, *Lanthus* Needham, *Stylogomphus* Fraser, and *Sinogomphus* May, apparently form a monophyletic group which shows many unexpected similarities with *Heliogomphus* Laidlaw, *Dubitogomphus* Fraser, and *Leptogomphus* Selys. Recent classifications of the Gomphidae (Fraser 1957, Belle 1979) have placed the *Octogomphus* series in the Gomphinae, and *Heliogomphus* and *Leptogomphus* in the Epigomphinae. *Dubitogomphus* was proposed by Fraser (1940) for *Leptogomphus bidentatus* Fraser which was placed in the Gomphinae, although the penis is essentially like that of *Heliogomphus* and the cerci like that of *Leptogomphus* (Fraser 1940). Therefore, recent classifications of the Gomphidae may be artificial, the "Gomphinae" in particular seemingly polyphyletic. Williamson (1907) introduced the wing vein characteristics used by recent authors to separate the Gomphinae and Epigomphinae, but doubted the utility of venational characters for properly grouping the Gomphinae. Satisfactory classification of the Gomphidae will likely require exhaustive studies of nymphal and adult morphology. Characteristics of the *Octogomphus* series include, penis of the *Gomphus* type, but generally with the prepuce expanded and the apical segment small; sternum 9 of the female abdomen largely membranous with two laterobasal subcircular sclerites; and in the nymph, anterior margin of prementum with 4 (occasionally 3-5) teeth, first palpal segment rounded distally, abdomen long-ovoid without dorsal knobs, frontal shelf well-developed, and third antennal segment flattened. The hind wings of this group are characterized by CuP and the anal vein strongly diverging toward the wing margin, and the distal costal brace about midway between

the proximal costal brace and the nodus; the fore wings are characterized by relatively wide pterostigmata. In *Heliogomphus* the male terminalia and penis are similar to those of *Stylogomphus*, and there is a tendency for the triangles and occasionally the supratrangles to be crossed as in *Davidius*. The prepuce is expanded in *Leptogomphus*, although it is apparently fused to the fourth segment. Sternum 9 of female *Leptogomphus* possesses two laterobasal subcircular sclerites. Nymphal *Heliogomphus* and *Leptogomphus* have the third antennal segments flattened, the frontal shelf well-developed, and the abdomen long-ovoid in shape.

Etymology.--*L. vernalis* [ver.na'lis] (L. adj. "of the springtime", referring to the early season of the species.)

Species Key to Adult American Octogomphines

- 1. Middorsal mesanepisternal brown stripe absent, front of pterothorax with large inverted urn-shaped yellow spot; abdominal segment 10 with large dorsal yellow spot; wings with trigonal planates; male epiproct with 4 rami; female ocellar ridge 4-lobed
 *Octogomphus specularis* (Hagen)
- Middorsal mesanepisternal brown stripe present, front of pterothorax with yellow or green lateral stripes; abdominal segment 10 dark brown dorsally; wings without trigonal planates; male epiproct with 2 rami; female ocellar ridge 2-lobed 2

2. Anteclypeus and cerci white; outer side of fore wing triangle angulate; lateral margins of male cerci sigmoid; hood of penile vesicle flat, wider than high; anterior hamules cycle-like, without apical cleft; vulvar lamina less than 1/2 length of sternum 9 *Stylogomphus albistylus* (Hagen)

Anteclypeus and cerci brown; outer side of fore wing triangle straight; lateral margins of male cerci straight; hood of penile vesicle erect, higher than wide; anterior hamules stub-like, with narrow apical cleft; vulvar lamina more than 1/2 length of sternum 9 *Lanthus* . . 3

3. Mesanepimeral and metanepisternal yellow stripes confluent above metathoracic spiracle, metanepisternal yellow stripe entire; interocular distance 0.56-0.77 mm; fore wing pterostigmata 2.4-3.0 times as long as wide; male epiproctal rami slightly divergent, male cerci with ventrobasal spine; vulvar lamina ca. 0.8 mm long with "U"-shaped apical cleft *Lanthus vernalis* n. sp.

Mesanepimeral and metanepisternal yellow stripes not confluent above metathoracic spiracle, metanepisternal yellow stripe often divided; interocular distance 0.80-1.00 mm; fore wing pterostigmata 3.1-4.0 times as long as wide; male epiproctal rami strongly divergent, male cerci with ventrobasal tubercle, vulvar lamina ca. 1.0 mm long with "V"-shaped apical cleft *Lanthus parvulus* (Selys)

Species Key to Nymphal American Octogomphines

1. Third antennal segments widest proximally, mesal borders contiguous with papilliform setae decreasing in length distally; frontal shelf truncate apically; anterior margin of prementum nearly straight and generally with 3 teeth *Stylogomphus albistylus* (Hagen)

Third antennal segment not widest proximally, mesal borders not contiguous and without papilliform setae decreasing in length distally; frontal shelf bifurcate; anterior margin of prementum convex and generally with 4 teeth 2

2. Third antennal segments widest in distal half, ca. 3 times as long as wide, and truncate apically; abdominal segments 7-9 with lateral spines; hind femur extended to abdominal segment 5
 *Octogomphus specularis* (Hagen)

Third antennal segments widest near middle, ca. 2 times as long as wide and rounded apically; abdominal segments 8-9 with lateral spines; hind femur extended to abdominal segment 4 . *Lanthus* . . . 3

3. Third antennal segments with dorsal papilliform setae dense, forming smooth surface; teeth of labial palp in curved row; median abdominal groove extended to base of tergum 9 . *Lanthus vernalis* n. sp.

Third antennal segments with dorsal papilliform setae sparse, not forming smooth surface; teeth of labial palp in straight row; median abdominal groove not extended to base of tergum 9
 *Lanthus parvulus* (Selys)

Ecology

The secretive habits of these small dragonflies have long enabled them to elude collectors, and undoubtedly led Needham (1897) to choose the name *Lanthus* "hidden" for them. *Lanthus* nymphs are fairly common in small spring fed rills, but the adults are rarely observed. Walker (1958) reported observing males of *L. parvulus* resting on large boulders in a small forest brook just below the confluence of a small spring. Needham (1901) wrote of the nymphs "They seem to prefer little, trickling streams fed by springs and burrow into beds of sand in the deeper parts." Judging by the size classes of nymphs collected, the duration of the nymphal stage of both species is generally two years. The preferred habitat of both species is small spring brooks, although *L. vernalis* is occasionally collected in small rivers of high water quality. *Lanthus* nymphs are often collected in streams which support naturally reproducing trout populations, and because of high adult vagility are able to quickly reinvade former trout waters which have recovered from disturbance. For these reasons *Lanthus* spp. may be useful in locating suitable habitats for the reestablishment of native trout strains. Emergence generally occurs on the stream bank or on fallen stream-side vegetation 1 to 2 feet above the water. Emergence begins throughout the morning hours and is generally completed within 1/2 hour. Exuviae have been found clinging from 0-180° to the horizontal, a remarkable range of variability which seems dependent on the nature of the stream bank. The maiden flight occurs within a few hours of emergence and is from 1 to 20 m in length, and generally terminates on the leaves of low shrubs or trees. Within a week male *Lanthus* begin to establish territories near suitable oviposition sites and apparently recognize conspecific

females by the lateral color pattern of the thorax. On one occasion where a small spring seep was completely shaded, I collected male *L. vernalis* while they perched on the upper surfaces of leaves 3 to 4 m above the seep, where they were visible only as dark silhouettes through brightly lit leaves. The field notes of Clark Shiffer also indicate that *L. vernalis* prefers to alight on vegetation, differing from the habits of *L. parvulus* as reported by Walker (1958). Mr. Boris Kondratieff (personal communication) has observed a female *L. vernalis* ovipositing; the female tapped her abdomen in a small rill every meter or so, while flying at about 10 cm in an upstream direction. This oviposition behavior differs from that reported for *O. specularis* by Kennedy (1917), and from my observations of *S. albistylus* which fly in figure "8" and "S" patterns while occasionally touching the water surface to release eggs. The known flight season of *L. parvulus* is from April 16 (Virginia) to August 17 (Quebec); and that of *L. vernalis* May 13 - July 20 (Pennsylvania), May 13 - July 14 (Virginia), and May 12 - May 31 (North Carolina). The mayfly *Stenonema merrivulvanum* Carle and Lewis is very sensitive to unusual environmental disturbance, and is often collected in association with *Lanthus* spp. Species of Odonata most often found in association with *L. vernalis* are: *Lanthus parvulus* (Selys), *Zoraena diastatops* (Selys), *Calopteryx maculata* Beauvois, *Tachopteryx thoreyi* (Hagen), *Taeniogaster obliqua* (Say), *Cordulegaster erronea* Hagen, and *Cordulegaster maculata* Selys.

Distribution

North American *Lanthus* and *Stylogomphus* are primarily eastern in distribution with *Lanthus* spp. restricted to the more mountainous regions. *Lanthus parvulus* apparently has a more boreal distribution than *L. vernalis*, and is entirely restricted to mountainous regions in the south. *Stylogomphus albistylus* has the most extensive distribution of American Octogomphines. *Octogomphus specularis* is primarily a Pacific coast species, found from Canada to Mexico. The known distributions for American Octogomphines are as follows: *L. parvulus*, NH, PA, VT, WV, Canada - N.B., N.S., Que.; *L. vernalis*, CT, GA, KY, ME, MA, NJ, NY, NC, PA, SC, TN, VT, VA, WV; *O. specularis*, CA, NV, OR, Canada - B.C., Mexico - Baja Calif.; *S. albistylus*, AL, CT, ME, MD, MA, MI, MO, NH, NJ, NY, NC, OH, PA, TN, VA, WV, Canada - N.B., N.S., Ont., Que.

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APPENDIX III

A New *Ophiogomphus* from Eastern North America
with a Key to the Regional Species (Odonata:Gomphidae)

ABSTRACT

Ophiogomphus acuminatus sp. n. (male holotype, female allotype: Jacks Branch 12 km north of U.S. Route 64 along Natchez Trace Parkway, Lewis Co., Tennessee, USA) is described from adult and larval material and its affinities discussed. Photographs of the male terminalia and secondary genitalia of *O. acuminatus* sp. n. and *O. edmodo* Needham are presented. A key to the adult *Ophiogomphus* of Eastern North America is presented along with a summary of their known distribution.

INTRODUCTION

Through the kindness of Professor Minter J. Westfall, Jr. I was entrusted with completing his studies on the genus *Ophiogomphus*. Among the adult specimens loaned to me was a single large male of an undescribed species collected by W. H. Cross in Tennessee. Attempts to collect additional material in Tennessee have been unsuccessful until only recently when Mr. Carl Cook, Dr. Ken Tennesen, and Professor Westfall collected additional adults and larvae. These specimens are here described as *O. acuminatus* sp. n.. Also included in the borrowed material was a male of *O. edmundo* Needham discovered by Professor Westfall at the Academy of Natural Sciences of Philadelphia. This specimen was apparently from the same lot as the holotype and includes the note "from this specimen I made my drawings, P. P. Calvert", presumably these drawings accompanied the specimens sent to and later described by Needham (1951). Figures of the male terminalia and hamuli of *O. edmundo* are included for comparison with those of the new species.

OPHIOGOMPHUS ACUMINATUS SPEC. NOV.

DESCRIPTION

Material examined.--Holotype male: United States: Tennessee, Lewis Co., Jacks Branch 12 km N of U.S. Rt. 64 along Natchez Trace, K. J. Tennessen, 17 June 1981, deposited in the Ken Tennessen Collection to be eventually donated to the Florida State Collection of Arthropods (FSCA), Gainesville, Florida, USA.--Allotype female: same as for holotype. Paratypes: same locality as holotype: 1 male, 18-VI-1981 (C. Cook), 1 male, 17-VI-1971 (W. H. Cross), 3 larvae, 18-VI-1981 (C. Cook), 6 larvae, 9-V-1981 (K. J. Tennessen).

Male.--Total length 48.5-52.0 mm, abdomen including cerci 35.5-37.5 mm, cerci 1.6-1.8 mm, hind femora 5.7-6.0 mm, hind wings 28.5-30.0 mm, pterostigmata 2.8-3.0/3.1-3.4 mm.

Head: labium, maxillae, and mandibles yellowish white, second palpal segment and mandibles brown; labrum and genae white tinted with brown; anteclypeus greenish white; postclypeus greenish yellow; antefrons greenish yellow, basal 1/5 of dorsal surface brown laterally; antennae and vertex (postfrons) brown, postfrons with small yellow area posterior to postocellar ridge, postocellar ridge bilobed; occiput (dorsal portion) greenish yellow, occipital crest brown laterally with sparse hair fringe; posterior surface of head yellow ventrally and brown dorsally with small yellow spots lateral to dorsal portion of occiput.

Thorax: prothorax brown, anterodorsal edge yellowish white, dorso-medial lobe with paired medial and lateral yellow areas. Pterothorax yellowish green with brown bands; dorsal mesanepisternal pale stripes

broadly confluent with pale collar below and narrowly confluent with lateral mesanepisternal pale stripes above, dorsal stripes separated by narrow brown bands lateral to median carina; lateral mesanepisternal pale stripes separated from mesanepimeral pale stripes by brown bands along mesopleural sulci, these bands narrowed ventrally to ca. $1/2$ width of lateral mesanepisternal pale stripes; katepisterna and ventral portion of epimera predominantly light brown; dorsolateral carinae and antearlars brown.

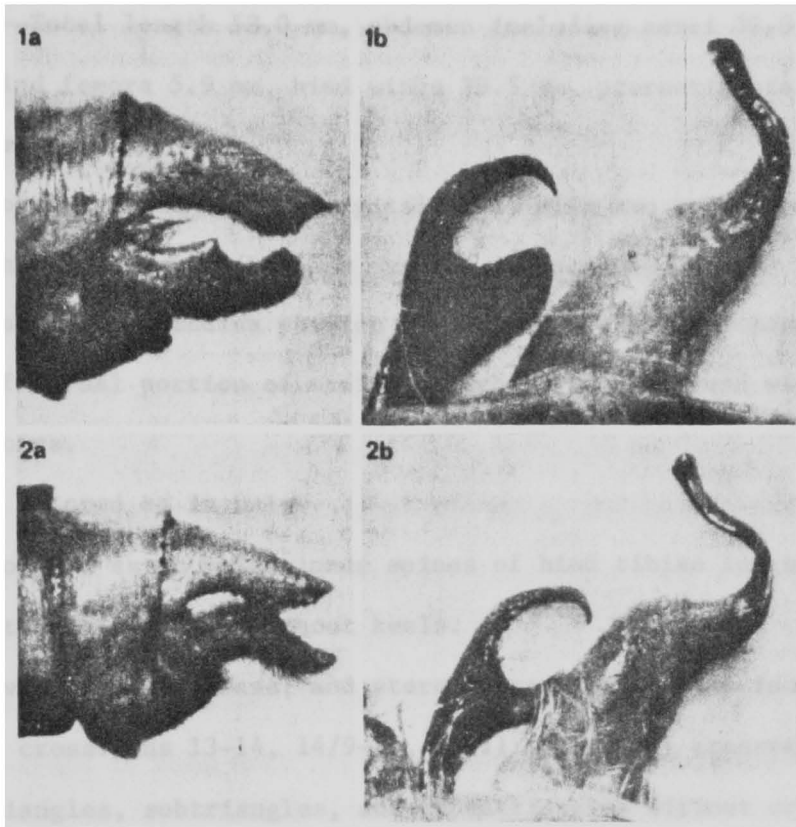
Legs: coxae and trochanters light brown; femora brownish yellow with brown external streak and apical black area, tibiae black with basal portion of external surface and patalae yellow; tarsi black; leg spines black; prothoracic tibial keels pale ca. $1/6$ length of tibiae.

Wings: venation dark brown, costa yellow with black spines; pterostigmata dark brown ventrally and dorsally; membrane hyaline, tinted with brown distally. Antenodal crossveins 12-13, 12-13/9-10, 9-11; postnodal crossveins 10-11/10-12; triangles and subtriangles without crossveins, supratrangles 1 or 2-celled; basal subcostal crossvein absent; gaff $2/5-1/2$ length of inner side of triangle; bridge crossveins 4-6/5-6; crossveins under pterostigma 4-5/4-5; anal loop 3-celled.

Abdomen: brown marked with yellow and white; terga 1 and 2 yellowish white laterally and brown with median yellow band dorsally, auricles yellow with black denticles restricted to posterior edge, area posterior to auricle shaded with brown; terga 3-6 brown, white lateroventrally with posteroventral brown areas, white area divided by brown along antecostal suture, yellow middorsal areas acuminate $4/5$ to as long as terga, constricted at antecostal suture and near apex; sterna 3-7 brown; tergum

7 brown, yellowish white laterally with posterolateral corners brown, pale area divided by brown along antecostal suture, dorsal yellow area lanceolate, narrower than on tergum 6; expanded lateral rim of terga 7-9 dark brown; tergum 8 brown, light yellow laterally with small posterolateral round brown spot, dorsal yellow spot elongate, $1/2-7/10$ length of tergum; tergum 9 yellow with middorsal yellow spot oval and surrounded with brown; tergum 10 yellow with diffuse submedian basal brown areas and apical margin dark brown, sterna 8-10 yellow. Terminalia yellow with ventral denticles dark brown; cerci robust and distinctly longer than epiproct, acuminate apically, dorsal and lateral margins moderately convex (Fig. 1a); epiproct with narrow median cleft extended proximally to apices of paraprocts, each ramus with lateral obtuse spine at ca. $1/2$ length of epiproct.

Genitalia: anterior hamuli brown each with proximal lobelike portion and distal hooklike portion (Fig. 1b), apex of distal portion abruptly decurved and directed toward proximal portion, enclosed gap ca. two times width of distal portion; posterior hamuli greenish yellow each with narrow distal portion dark brown (Fig. 1b), distal portion bent anteriorly with portion distal to bend slightly undulate, flattened apically, and ca. $1/2$ length of proximal portion; shoulder poorly developed. Penis brown, penile hood with diffuse yellow lateral area, filament and membranes translucent; segment 1 with penile hood erect, in lateral view width at middle ca. $1/3$ length, apex cleft with two lateral lobes ca. 2 times as long as wide, penile vesicle wide-trough-like, thinly expanded laterally with distal edge rounded and proximal edge acute in lateral view; segment 2 "J"-shaped, length 2.1-2.3 mm,



Figs 1-2. *Ophiogomphus acuminatus* sp. n. (Fig. 1) and *O. edmodo* Needham (Fig. 2): (a) Lateral view of male terminalia (X 20); -- (b) Lateral view of male hamuli (X 25).

distal portion globose with well-developed retractor spine; segment 3 1.5-1.7 mm long excluding prepuce and strongly constricted basally, prepuce elongate and extended to middle of segment 4; segment 4 ca. 1.1 mm long, filament divided ca. 0.4 mm of length, outer surface of segment with medial decurved lobe.

Female.--Total length 53.0 mm, abdomen including cerci 39.0 mm, cerci 1.5 mm, hind femora 5.9 mm, hind wings 33.5 mm, pterostigmata 3.6-3.7/4.1-4.2 mm.

Head: colored as in male; occipital crest with two anteromedially directed horns separated basally by, and ca. as long as, 1/3 length of postfrontal suture; median portion of occiput troughlike; posterior surface of dorsal portion of occiput slightly bilobate and without lateral horns.

Thorax: colored as in male.

Legs: colored as in male, inner spines of hind tibiae longer than in male, prothoracic tibiae without keels.

Wings: venation, membrane, and pterostigmata colored as in male. Antenodal crossveins 13-14, 14/9-11, 10-11; postnodal crossveins 11-12/11-12; triangles, subtriangles, and supratrangles without crossveins; basal subcostal crossveins absent; gaff ca. 2/5 length of inner side of triangle; bridge crossveins 5/4, crossveins under pterostigma 5-6/5; anal loop 3 or 4-celled.

Abdomen: colored as in male with dorsal pale areas more extensive; middorsal pale stripe of terga 1-6 extended to posterior carinae; pale middorsal stripe of terga 7 and 8 ca. 9/10 and 4/5 length of terga, respectively; tergum 9 yellowish orange dorsally.

Genitalia: vulvar lamina light tan, ca. 1.1 times length of sternum 9, ca. 2.6 mm long and cleft for ca. $2/3$ length, width at base ca. $4/9$ length, lateral lobes narrow, apically raised and recurved, lateral subapical margins not expanded.

Larva (immature, with wing pads extended to base of fifth abdominal segment).--total length 23.0-25.5 mm, abdomen 14.0-16.0 mm, hind femora 3.0-3.5 mm, prementum 3.7 mm.

Head: prementum gradually narrowed in basal $1/3$ to $7/8$ apical width, apical $1/2$ distinctly convergent anteriorly; ligula strongly convex, ca. $3/10$ apical width of prementum with fringe of moderately long setae and 20-24 dark brown toothlike denticles; first segment of labial palps rounded distally each with 9-11 teeth in gently curved row, apical tooth of each palp subacute, third antennal segments elongate-elliptical each ca. 2.7 times as long as wide with inner distal portion directed anteroventrally, fringed with long hairlike setae, and each dorsally with papilliform setae sparse; fourth antennal segments each ca. $2/3$ as wide as base of segment 3, base ringed with short papilliform setae; dorsal surface of head with papilliform setae, scattered setae dark brown.

Thorax: tibiae with long, black external spines.

Abdomen: acuminate-ovoid in shape, widest at segments 5 and 6, lateral taper gradually increasing on segments 7-9, covered with lightly pigmented granules, and scattered black, scalelike setae; wing pads divergent extended to base of fifth segment; middorsal tubercles robust, slightly extended beyond posterior margin of segments, those of segment 2 slightly appressed, those of 3-7 each slightly more appressed, those

of 8 and 9 only slightly elevated in lateral view; segments 7-9 with lateral spines, relative lengths 0.5-0.7:0.8-1.2:1.0 respectively; cerci ca. 1.8 times middorsal length of segment 10 and ca. $3/4$ length of epiproct, apex of epiproct slightly decurved, paraprocts slightly longer than epiproct, male epiproctal tubercles at ca. $3/5$ length of epiproct.

Remarks.--*Ophiogomphus acuminatus* is a rather distinctive member of the *mainensis* species group. The adults are readily distinguished from other species of the group by the narrow middorsal thoracic band. In addition the male exhibits the most acuminate epiproct in the group, and the female is distinguished by the vulvar lamina longer than sternum 9 and the occiput with a median trough. The larva is distinctive in the narrow strongly convex ligula of the prementum.

The male terminalia and hamuli of a recently discovered second male of *O. edmundo* are presented in Figure 2. The terminalia are similar to the photograph of the holotype in Needham and Westfall (1955: fig. 61), and the hamuli which were not adequately described by Needham (1951) show it to be distinct from its nearest relatives *O. carolus* Needham and *O. aspersus* Morse. Unfortunately the locality label of the new specimen reads only "N.C." as in the holotype. The only other clue which could help in the rediscovery of *O. edmundo* is the apparent close affinity between *O. edmundo* and *O. carolus*, this would indicate that *O. edmundo* may occur in the small streams of western North Carolina.

Etymology.--*O. acuminatus* [a·cu·mi·na'tus] (L. part. "furnished with a sharp point", referring to the pointed adult male cerci.)

BIOLOGY

The rarity of *O. acuminatus* is apparently related to habitat requirements during the larval stage, although low vagility and short flight season of the adult may explain the apparent extreme rarity of the species. Carl Cook (personal communication) writes that the larval habitat is "sparse gravel pockets in the fissures of the rock stream bed". Jacks Branch is a small (2-3 m wide) stream located in the Interior Low Plateaus physiographic province of Tennessee indicating that the new species may also occur in northern Alabama and western Kentucky; the elevation of the type locality is 230 m. Larvae of *O. acuminatus* have also been collected from the nearby Brush and Little Swan Creeks. The density of the larval population is low; for example despite considerable effort I have collected only the larvae of *Stylogomphus albistylus* (Hagen) from the type locality. The only other Odonata collected from near Jacks Branch are *Tachopteryx thoreyi* (Hagen) which supports the observation that the stream is largely spring fed.

The only information known concerning adult behavior is contained in the following quote (C. Cook, personal communication): "Ken got his [specimens] from the grass along side the gravel road at the underpass just south of the picnic area. Mine was taken on the rock ledge at the ford across Jacks Branch at the same underpass. They were taken early in the morning (about 8:30 A.M.) and I saw one other which may have been a female flying over the stream but was unable to get near enough to it to be sure, this was also in the morning hours--we saw no activity from adults at any time after midmorning. In the late afternoon I

walked the stream until nightfall to see if there was a "dusk flight" as there is with many of the other species of the genus. There was none at least on the part of the stream I walked."

DISTRIBUTION OF AND KEY TO THE *OPHIOGOMPHUS* SPECIES
OF EASTERN NORTH AMERICA

DISTRIBUTION

All Eastern North American *Ophiogomphus* with the exception of *O. colubrinus* are limited to this region. Their known distributions are as follows: *O. acuminatus*: U.S.A.: TN; -- *O. anomalus*: U.S.A.: ME, NY, WI; Canada: Ont., Que.; -- *O. aspersus*: U.S.A.: CT, KY, ME, MI, NH, NY, NC, VT, VA, WI; Canada: N.B., N.S., Que.; -- *O. carolinus*: U.S.A.: AL, GA, KY, MD, NC, TN, VA, WV; -- *O. carolus*: U.S.A.: ME, MI, NH, NY, PA, VT, VA, WV, WI; Canada: N.B., N.S., Ont., Que.; -- *O. colubrinus*: U.S.A.: ME, MI, NH, WY; Canada: Alta., B.C., Man., Nfld., N.W.T., Ont., Que., Sask.; -- *O. edmundo*: U.S.A.: NC; -- *O. howei*: U.S.A.: KY, MA, NY, NC, PA, VA; -- *O. mainensis*: U.S.A.: CT, ME, MA, NH, NJ, NY, NC, PA, SC, TN, VT, VA, WV; Canada: N.B., Que.; -- *O. rupinsulensis*: U.S.A.: CT, IL, IN, KS, KY, ME, MD, MI, MN, MO, NH, NJ, NY, ND, OH, PA, TN, VT, VA, WV, WI; Canada: Man., N.B., Ont., Que., Sask.

SPECIES KEY TO THE ADULTS

- 1 Antefrons and postclypeus transversely striped with black 2
Antefrons and postclypeus not transversely striped with black 3

2. Metanepisterna each with transverse brown band; male epiproctal rami widely separated apically, apex of anterior hamuli directed posteriorly; vulvar lamina with lateral flange well developed, apices directed posterolaterally *O. anomalus* Harvey
- Metanepisterna each without transverse brown band; male epiproctal rami contiguous apically, apex of anterior hamuli directed ventrally; vulvar lamina with lateral flange vestigial, apices directed posteriorly *O. colubrinus* Selys
3. Middorsal brown band of mesanepisterna vestigial or absent 4
 Middorsal brown band of mesanepisterna well developed 5
4. Tibiae with external surface predominantly black; male cerci acuminate (Fig. 1a); lateral spine of epiproct at ca. 1/2 its length; female without postoccipital horns, vulvar lamina longer than sternum 9 *O. acuminatus* Carle
- Tibiae with external surface predominantly yellow; male cerci not acuminate; lateral spine of epiproct at ca. 4/5 its length; female with postoccipital horns, vulvar lamina shorter than sternum 9 *O. rupinsulensis* Walsh

5. Basal 2/3 of hind wings tinted with yellow; male epiproct abruptly angled dorsally near base, ca. 1/2 length of cerci; female occipital crest with small erect horns separated by ca. 4/5 length of postfrontal suture, vulvar lamina ca. as long as wide *O. howei* Bromley
- Basal 2/3 of hind wings not tinted with yellow; male epiproct not abruptly angled dorsally near base, at least 4/5 as long as cerci; female occipital crest without small erect horns separated by ca. 4/5 length of postfrontal suture, vulvar lamina longer than wide 6
6. Male cerci inflated, each wider at midlength than at base, longer than epiproct; female with postoccipital horns
 *O. aspersus* Morse¹
- Male cerci not inflated, each not wider at midlength than at base, slightly shorter than epiproct; female without postoccipital horns 7
7. Tibiae each with yellow streak along external carinae; basal 2/3 of femora yellow; thorax without brown bands along metapleural sulci *O. incurvatus* Carle
- Tibiae each without yellow streak along external carinae; basal 2/3 of femora not yellow; thorax with brown bands along metapleural sulci 8

¹The female of *O. edmundo* is not positively known and may key here.

8. Dorsal mesanepisternal pale stripes parallel-sided, separated by
 ca. 4/5 their maximum width; gap of anterior hamuli subcircular
 (Fig. 2b); lateral flange of penile hood ca. 1/4 as wide as
 long *O. edmundo* Needham

Dorsal mesanepisternal pale stripes widened ventrally, separated by
 ca. 2/5 their maximum width; gap of anterior hamuli not subcir-
 cular; lateral flange of penile hood more than 1/3 as wide as
 long 9

9. Distal margin of labrum black; male epiproct with apical cleft more
 than 3 times as long as wide, anterior hamuli each with apical
 branch less than 2 times as long as basal branch; female occiput
 bilobate posteriorly, with large contiguous horns anteriorly;
 vulvar lamina constricted near base, apices directed posteriorly .
 *O. mainensis* Packard

Distal margin of labrum not black; male epiproct with apical cleft
 ca. 2 times as long as wide, anterior hamuli each with apical
 branch more than 3 times as long as basal branch; female occiput
 level posteriorly, without or with small widely separated horns
 anteriorly; vulvar lamina parallel-sided, apices directed
 posterolaterally *O. carolus* Needham

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I am grateful to Dr. Minter J. Westfall, Jr. for the loan of an extensive collection of *Ophiogomphus* and to his family for their warm hospitality during my stay in Gainesville. Special thanks is accorded to Dr. A. Newton of the Museum of Comparative Zoology, Harvard University for the loan of the holotypes of *O. carolinus* and *O. mainensis*. I am also grateful to the Academy of Natural Sciences of Philadelphia for the loan of several *Ophiogomphus*. I am indebted to Mr. Carl Cook, Dr. T. W. Donnelly, Dr. O. S. Flint, Mr. B. C. Kondratieff, Dr. M. T. Peters, Mr. Clark Shiffer, Dr. K. J. Tennessen, and Dr. H. B. White for the loan of additional material.

REFERENCES

- Needham, J. G. 1951. A new species of *Ophiogomphus* (Odonata).
Entomol. News 62:41-3.
- Needham, J. G. and M. J. Westfall, Jr. 1955. A manual of the dragonflies of North America (Anisoptera), including the Greater Antilles and the provinces of the Mexican border. Univ. Calif. Press, Berkeley - Los Angeles.

APPENDIX IV

Ophiogomphus incurvatus, a New Name for
Ophiogomphus carolinus Hagen (Odonata:Gomphidae)

ABSTRACT

Ophiogomphus carolinus Hagen is shown to be a synonym of *O. rupinsulensis* Walsh and the name *O. incurvatus* proposed for the species heretofore identified as *O. carolinus*. The adults and nymphs of *O. i. incurvatus* and a new subspecies of *O. i. alleghaniensis* are described. The type locality of *O. i. incurvatus* is in central Virginia and that of *O. i. alleghaniensis* in eastern West Virginia.

In the course of preparing a manual to the Anisoptera of Virginia, it was discovered that *Ophiogomphus carolinus* Hagen 1885 is a synonym of *O. rupinsulensis* Walsh 1862. Hagen (1885) described *O. carolinus* from a female nymphal exuviae collected near Bee Spring, Kentucky, and since no other species of *Ophiogomphus* were then known to occur as far south as the "Middle States" he supposed that adults collected in North Carolina were also of this species. Referring to Hagen's description Needham (1899) states "This is especially unfortunate, because the nymphs in this genus are well-nigh undeterminable". With some reservation Needham (1899) accepted Hagen's supposition, a practice which was later followed by Needham and Heywood (1929) and Needham and Westfall (1955). A comparison of Hagen's description to reared nymphs from Virginia, Georgia, and Alabama conspecific with Hagen's North Carolina adults revealed considerable discrepancies. Hagen's description states "joint three of antennae...enlarged externally to about one-third of its length" and "10th [abdominal segment] half as long as 9th... appendages twice its length". In contrast the reared nymphs have the third antennal segment about 1/2 as wide as long and the terminalia about as long as the middorsal length of abdominal segments 9 and 10 together. A comparison of the *O. carolinus* holotype to the nymphs of other *Ophiogomphus* revealed it to be conspecific with *O. rupinsulensis*. Therefore the name *O. incurvatus* is proposed for the species heretofore identified as *O. carolinus*. Further study of specimens referable to *O. incurvatus* indicated that its distribution apparently forms a "U"-shaped band about the Appalachian mountains with eastern and western populations sufficiently distinct to warrant the recognition of subspecies.

Ophiogomphus incurvatus incurvatus new name

- Needham 1899. Can. Entomol. 31:234-5, 237-8 (as *O. carolinus*).
 Williamson 1902. Entomol. News 13:70 (as *O. carolinus*).
 Needham and Heywood 1929. Handbook, 69, 72-3 (as *O. carolinus*).
 Fisher 1940. Entomol. News 51:37-72 (as *O. mainensis*).
 Needham and Westfall 1955. Manual, 119-22, 126-7 (as *O. carolinus*).

Male

Total length 40.0-43.0 mm, abdomen including cerci 30.0-32.0 mm, cerci 1.5-1.7 mm, hind femora 4.6-5.2 mm, hind wings 23.5-25.0 mm, pterostigma 2.5-2.9/3.0-3.4 mm.

Head.--Labium, maxillae, and mandibles yellowish white, second palpal segment and apex of maxillae and mandibles brown; labrum, anteclypeus, and genae yellowish white, labrum with basomedial yellow area; postclypeus yellow; antefrons yellow, basal 1/4 of dorsal surface brown; antennae and vertex (postfrons) dark brown with small yellow area posterior to postocellar ridge, postocellar ridge bilobed; occiput (dorsal portion) yellow, occipital crest laterally brown with hair fringe more dense; posterior surface of head predominantly yellow, brown dorsolaterally.

Thorax.--Prothorax brown, anterodorsal edge yellowish white, dorso-medial lobe with paired medial and lateral yellow areas. Pterothorax greenish yellow with brown bands; dorsal mesanepisternal pale stripes broadly confluent with pale collar below and narrowly confluent with lateral mesanepisternal pale stripes above, dorsal stripes separated by 1/2-2/3 their middle width; lateral mesanepisternal pale stripes separated from mesanepimeral pale stripes by brown bands along meso-

pleural sulci, these bands gradually narrowed ventrally; narrow brown areas often present along ventral portions of intersegmental interface; dorsolateral carinae and antealar brown.

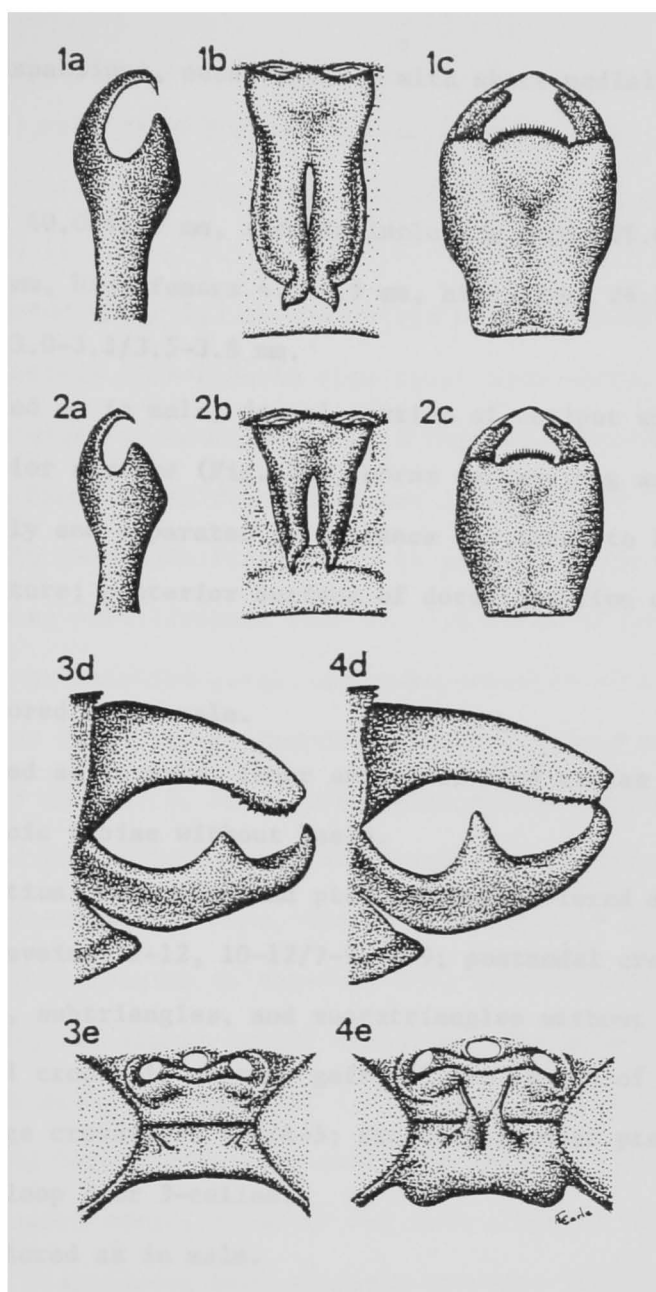
Legs.--Coxae and trochanters yellowish white; femora yellow with ca. apical $2/3$, $2/5$, and $1/3$ of fore, middle, and hind femora black respectively; tibiae black with external ridge and patellae yellow; tarsi black; leg spines black; prothoracic tibial keels pale, ca. $1/7$ length of tibiae.

Wings.--Venation dark brown, costa yellow with black spines; pterostigmata light brown ventrally, brown dorsally; membrane hyaline, faintly flavescent basally. Antenodal crossveins 11-14, 10-13/ 8-11, 8-10; postnodal crossveins 7-10/7-10; triangles, subtriangles, and supratrangles without crossveins; basal subcostal crossvein absent; gaff $2/5$ - $3/5$ length of inner side of triangle; bridge crossveins 3-6/ 3-6; crossveins under pterostigma 3-5/3-6; anal loop 2 or 3-celled.

Abdomen.--Brown marked with yellow and white; terga 1 and 2 yellowish white laterally and brown with median yellow band dorsally, auricles yellow with black denticles restricted to posterior edge, area posterior to auricle shaded with light brown; terga 3-6 brown, white lateroventrally with posteroventral corner brown, white area divided by brown along antecostal suture, yellow middorsal areas $4/5$ length of terga, constricted at antecostal suture and near apex; sterna 3-7 brown; tergum 7 brown, yellow laterally with posterolateral corner brown, yellow divided by brown along antecostal suture, dorsal yellow area narrower than on tergum 6; expanded lateral rim of terga 7-9 dark brown; tergum 8 brown, yellow laterally with small posterolateral brown spot, dorsal

yellow spot elongate, ca. $3/5$ length of tergum; tergum 9 yellow with middorsal yellow spot oval and surrounded with brown or dorsum yellow with two submedian basal brown areas; tergum 10 yellow with diffuse submedian basal brown areas and apical margin dark brown, sterna 8-10 yellow; terminalia yellow, apices of epiproct and denticles of cerci brown. Cerci slightly shorter than epiproct (Fig. 3d), subacuminate apically, dorsal and lateral margins strongly convex; cerci strongly narrowed distally and distinctly incurvate; epiproct with narrow median cleft extended proximally to apices of paraprocts, each ramus with lateral obtuse spine at ca. $2/3$ length of epiproct.

Genitalia.--Anterior hamuli (Fig. 2a) brown each with proximal lobe-like portion and distal hooklike portion, apex of distal portion abruptly decurved and directed toward proximal portion, enclosed gap ca. as wide as basal width of distal portion; posterior hamuli greenish yellow, each with narrow distal portion brown, upcurved and dilated toward apex, and ca. $9/10$ length of anterior margin of proximal portion; shoulder well developed. Penis brown, penile hood with yellow lateral area, filament and membranes translucent; segment 1 with penile hood erect, in lateral view width at middle ca. $2/3$ length, apex cleft with two lateral lobes ca. 1.5 times as long as wide, penile vesicle wide-troughlike, thinly expanded laterally with proximal edges more than $1/2$ length of anterior edge; segment 2 "J"-shaped, length ca. 1.5 mm, distal portion globose with well-developed retractor spine; segment 3 ca. 1.2 mm long excluding prepuce and strongly constricted basally, prepuce elongate and extended between flaplike extensions of segment 4; segment 4 ca. 1.0 mm long, filament divided ca. 0.4 mm of length, inner surface



Figs. 1-4. 1- *Ophiogomphus mainensis*, 2 and 3- *O. i. incurvatus*, and 4- *O. i. alleghaniensis*; (a) anterolateral view of anterior hamulus X25, (b) ventral view of vulvar lamina X15, (c) ventral view of nymphal prementum X7.5, (d) lateral view of male terminalia X20, and (e) dorsal view of female occiput X15.

with lateral expansions, outer surface with short medial decurved lobe.

Female

Total length 40.0-42.0 mm, abdomen including cerci 29.0-30.0 mm, cerci 1.0-1.1 mm, hind femora 4.6-4.9 mm, hind wings 24.5-26.5 mm, pterostigmata 3.0-3.3/3.5-3.8 mm.

Head.--Colored as in male; dorsal portion of occiput with two small horns on anterior surface (Fig. 3e), horns ca. as long as pedicel, directed laterally and separated by distance ca. equal to 1/2 length of postfrontal suture; posterior surface of dorsal portion of occiput level.

Thorax.--Colored as in male.

Legs.--Colored as in male, inner spines of hind tibiae longer than in male, prothoracic tibiae without keels.

Wings.--Venation, membrane, and pterostigmata colored as in male. Antenodal crossveins 11-12, 10-12/7-9, 8-9; postnodal crossveins 7-9/7-9; triangles, subtriangles, and supratriangles without crossveins; basal subcostal crossvein absent; gaff $2/5$ - $3/5$ length of inner side of triangle; bridge crossveins 4-6/4-5; crossveins under pterostigmata 4-5/4-5; anal loop 2 or 3-celled.

Abdomen.--Colored as in male.

Genitalia.--Vulvar lamina (Fig. 2b) yellow ca. $4/5$ length of sternum 9, ca. 1.5 mm long, and cleft for ca. $2/3$ its length, width at base ca. $7/10$ length; lateral lobes narrow, apically raised and recurved, lateral subapical margins not expanded.

Nymph

Total length, male 21.0-22.0 mm, female 22.5-24.0 mm; abdomen, male 13.0-14.0 mm, female 13.5-14.5 mm; hind femora 3.4-3.7 mm; prementum 3.3-3.6 mm.

Head.--Prementum (Fig. 2c) gradually narrowed in basal 1/3 to 7/10 apical width, apical 2/3 slightly convergent anteriorly; ligula convex, ca. 3/8 apical width of prementum with fringe of moderately long setae and 20-25 dark brown toothlike denticles; first segment of labial palps rounded distally each with 10-12 teeth in gently curved row; third antennal segments subelliptical each ca. 1.8 times as long as wide, fringed with long hairlike setae, and each dorsally with papilliform setae more dense toward apex; fourth antennal segments each ca. 3/4 as wide as base of segment 3, base ringed with papilliform setae; dorsal surface of head granulate, cuticular granules not deeply pigmented.

Abdomen.--Long-ovoid in shape, widest at segments 5 and 6, lateral taper gradually increasing on segments 7-9, covered with slightly pigmented granules, and almost devoid of hairs; wing pads divergent, extended to distal half of segment 4 in mature nymphs; dorsal tubercles robust, extended beyond posterior cuticular margin of segments, those of segments 2 and 3 erect, those of 4-7 each slightly more appressed, those of 8 and 9 appearing only slightly elevated in lateral view; segments 7-9 with lateral spines, relative lengths 0.6-0.7:1.0-1.2:1.0 respectively; cerci 1.7-1.8 times middorsal length of segment 10 and ca. 7/10 length of epiproct, apex of male epiproctal tubercles at ca. 5/8 length of epiproct, apex of epiproct with slight upward bend, paraprocts slightly longer than epiproct.

Types

Holotype, male--Spring Cr. at Rt. 654, Charlotte Co., VA; May 18, 1978; F. L. Carle; dry in envelope, deposited Florida State Collection of Arthropods (FSCA). Allotype, female--Alamance Cr. at Rt. 1005, Guilford Co., NC; June 4, 1981, B. C. Kondratieff; dry in envelope; deposited FSCA. Paratypes--Georgia: White Co.: Chattahoochee R. at Helen, 2 nymphs collected 30 March 1979, M. J. Westfall, Jr., 2 females emerged 16 and 20 April 1979, nymphal exuviae and reared adults in alcohol. Maryland: Baltimore Co.: Shawan "along a meadow brook", 28 May 1941, E. G. Fisher, 2 males; Shawan "along a meadow brook", 8 June 1939, E. G. Fisher, 7 males, dry in envelopes. North Carolina: C.U. lot 35; date unknown, collector unknown, 1 male, 2 females; dry on pins. Guilford Co.: same as for allotype, 1 female. Wilkes Co.: small stream at W. Kerr Scott Dam - elev. 275 m, 14 May 1965, D. R. Paulson, 1 male; Lewis Fork Cr. at Maple Springs, 16 May 1965, D. R. Paulson, 1 male; Lewis Fork Cr. at Rt. 421, 19 May 1971, Carl Cook, 2 males; Lewis Fork Cr. at Rt. 421, 22 May 1971, Carl Cook, 1 male; Lewis Fork Cr. at Rt. 421, 27 May 1967, Duncan Cuyler, 2 males, dry in envelopes. Yadkin Co.: S. Deep Cr., 28 May 1967, Duncan Cuyler, 1 male, dry in envelope. South Carolina: Laurens Co.: Durbin Cr. at Rt. 101, 2 nymphs collected 17 April 1980, P. H. Carlson and E. M. Younginer, 1 male and 1 female and nymphal exuviae in alcohol. Virginia: Bedford Co.: Five Forks Cr. at Rt. 819, 16 May 1979, B. C. Kondratieff, 1 male, dry in envelope. Charlotte Co.: Spring Cr. at Rt. 654, 1 nymph collected 1 May 1975, F. L. Carle, 1 male emerged 16 May 1975, nymphal exuviae and adult dry in envelope; Spring Cr. at Rt. 654, 14 Sept. 1975, F. L. Carle, 5 nymphs;

Spring Cr. at Rt. 654, 20 April 1976, F. L. Carle, 3 nymphs, in alcohol; Spring Cr. at Rt. 654, 18 May 1978, F. L. Carle, 1 male, dry in envelope. Representative paratypes deposited at FSCA, U.S. National Museum of Natural History (USNM); E. B. Williamson Collection, Univ. of Michigan, Ann Arbor (EBWC); and at the Virginia Polytechnic Institute and State Univ. Dept. of Entomology Collection (VPIC).

Ophiogomphus incurvatus alleghaniensis n. subsp.

Male

Total length 46.5–48.0 mm, abdomen including cerci 34.0–35.0 mm, cerci 1.8–1.9 mm, hind femora 5.4–5.7 mm, hind wings 26.5–27.5 mm, pterostigmata 2.8–3.3/3.0–3.5 mm.

Head.--Colored as in *O. i. incurvatus*.

Thorax.--Colored as in *O. i. incurvatus* with brown more extensive, lower portion of mesanepimera, metakatepisterna, and upper portion of metapleural sulci mostly brown.

Legs.--Coxae yellowish white shaded with brown; femora yellow with apical $\frac{2}{3}$, $\frac{1}{2}$, and $\frac{2}{5}$ of fore, middle, and hind femora black respectively, each with two brown lines extended to base; tibiae black with external ridge and patalae yellow, inner ridge also yellow on middle and fore tibiae, fore tibiae with proximal yellow area between yellow ridges; tarsi black; leg spines black; prothoracic tibial keels pale, ca. $\frac{1}{5}$ length of tibiae.

Wings.--Venation dark brown, costa yellow with black spines; pterostigma dark brown; membrane hyaline, faintly flavescent basally. Ante-

nodal crossveins 12-13, 12-14/8-9, 9-10; postnodal crossveins 8-10/8-9; triangles and subtriangles without crossveins, supratriangles without or with 1 crossvein; basal subcostal crossveins absent; gaff $2/5-1/2$ length of inner side of triangle; bridge crossveins 4-6/4-5; crossveins under pterostigmata 4-5/4-5; anal loop 3-celled.

Abdomen.--Colored as in *O. i. incurvatus*. Cerci slightly longer than epiproct, truncate apically, dorsal and lateral margins not strongly convex; cerci not strongly narrowed distally or distinctly incurvate (Fig. 4d); epiproct with narrow median cleft extended proximally to apices of paraprocts, each ramus with lateral acute spine at ca. $1/2$ length of epiproct.

Genitalia.--Anterior hamuli similar to those of *O. i. incurvatus* but with distal hooklike portion longer and apex directed dorsolaterally, enclosed gap ca. twice basal width of distal portion; posterior hamuli similar to those of *O. i. incurvatus* but with distal portion more elongate, and less curved and dilated. Penis similar to that of *O. i. incurvatus*; segment 1 with hood erect, in lateral view width at middle ca. $1/2$ length, apical lobes ca. as long as wide; segment 2 ca. 1.9 mm long, proximal end of retractor spine abruptly delineated; segment 3 ca. 1.3 mm long excluding prepuce; segment 4 ca. 1.1 mm long, filament divided ca. 0.5 mm of length.

Female

Total length 47.0-48.5 mm, abdomen including cerci 35.0-36.0 mm, cerci 1.4-1.5 mm, hind femora 5.0-5.4 mm, hind wings 29.0-30.0 mm, pterostigmata 3.1-3.3/3.8-3.9 mm.

Head.--Colored as in male; dorsal portion of occiput with two large horns on anterior surface (Fig. 4e), horns ca. 2.5 times length of pedicel, directed anteriorly and contiguous; posterior surface of dorsal portion of occiput laterally swollen.

Thorax.--Colored as in male.

Legs.--Colored as in male, inner spines of hind tibiae longer than in male, prothoracic tibiae without keels.

Wings.--Venation, membrane, and pterostigmata colored as in male. Antenodal crossveins 12-14, 12-14/9-14, 9-12: postnodal crossveins 9-10/9-12; triangles 1 or 2-celled, subtriangles 1-celled, and supra-triangles 1-3-celled; basal subcostal crossvein present or absent; gaff $2/5-1/2$ length of inner side of triangle; bridge crossveins 5-6/4-6; crossveins under pterostigmata 5-6/4-6; anal loop 2-4-celled.

Abdomen.--Colored as in male.

Genitalia.--Vulvar lamina yellow ca. $9/10$ length of sternum 9, ca. 2.0 mm long, and cleft for ca. $5/8$ its length, width at base ca. $3/5$ length; lateral lobes narrow apically raised and recurved, lateral subapical margins not expanded.

Nymph

Total length, male 27.0-28.0 mm, female 28.0-29.0 mm; abdomen, male 15.5-16.0 mm, female 16.5-17.0 mm; hind femora 3.0-4.0 mm; prementum 3.8-4.0 mm.

Head.--Similar to that of *O. i. incurvatus* but with ligula ca. $1/3$ apical width of prementum.

Abdomen.--Similar to that of *O. i. incurvatus* but with relative

lengths of lateral spines of segments 7-9, 1.0-1.2:1.0-1.2:1.0 respectively, and with male epiproctal tubercles at ca. 2/3 length of epiproct.

Types

Holotype, male--Rich Cr., Monroe Co., WV; June 14, 1980; F. L. Carle, dry in envelope; deposited FSCA. Allotype, female--same as for holotype. Paratypes--Tennessee: Blount Co.: Little R. nr. Walland, 2 May 1980, K. J. Tennessen, 1 nymph, in alcohol. Virginia: Giles Co.: Rich Cr. nr. Peterstown, 12 June 1974, F. L. Carle, 2 nymphs, in alcohol. West Virginia: Monroe Co.: Rich Cr. 4.5 km. upstream from Peterstown, 12 June 1974, F. L. Carle, 3 males, 1 female, 10 nymphs; Rich Cr. 4.5 km. upstream from Peterstown, 14 June 1980, F. L. Carle, 2 males, 1 female, adults dry in envelopes, nymphs in alcohol. Representative paratypes deposited at the FSCA, USNM, EBWC, and VPIC.

Additional material studied--Alabama: Tuscaloosa Co.: Cooley Cr., 21 Feb. 1937, Smith and Hodges, 2 nymphs, in alcohol; Cooley Cr., 26 Feb. to 12 March 1938, Smith and Hodges, 4 male nymphs, 8 female nymphs, emerged 15-29 March 1938, 4 males and 1 nymphal exuviae in alcohol, 4 females and nymphal exuviae in alcohol, 4 females in envelopes; Cooley Cr., 13 March 1937, Smith and Hodges, 1 female nymph, emerged 10 April 1937, nymph and adult in alcohol; Cooley Cr., 10 April 1937, Smith and Hodges, 1 exuviae, in alcohol. Deposited FSCA.

Remarks

Ophiogomphus incurvatus is most closely related to *O. mainensis* Packard, and adults of the two species may be distinguished respectively by the predominantly yellow or brown color of the femora, anterior edge of

labrum, area along metapleural sulci, and dorsal surface of abdominal terga 9 and 10. Also in *O. mainensis* the male cerci are not incurvate, the anterior hamuli are more deeply cleft (Fig. 1a), and the subapical lateral margins of the vulvar lamina are distinctly expanded (Fig. 1b). The nymphs of the two species are characterized by the suboval shape of antennal segment 3, but may be distinguished by the relative width of the ligula, it is ca. 0.35 the width of the prementum in *O. incurvatus*, and ca. 0.45 this width in *O. mainensis* (Fig. 1c). The nymph of *O. mainensis* also differs in having the lateral margins of the prementum slightly divergent apically, and in having the dorsal abdominal knobs relatively flattened and less developed.

Both subspecies of *O. incurvatus* will key to *O. carolinus* in the key provided by Carle (1981). *Ophiogomphus i. alleghaniensis* is readily distinguished from *O. i. incurvatus* by the form of the female occiput and male terminalia. The differences are so great as to suggest that demes east of the Appalachian mountains are reproductively isolated from demes west of the Appalachians. Specimens from Alabama resemble western material but they are in many respects intermediate and suggest a situation similar to that shown by *Enallagma triavatum triavatum* Selys which intergrades with *E. t. westfalli* Donnelly in the southern Appalachians. Alabama specimens resemble *O. i. incurvatus* in size and in the shape of the male cerci. However, Alabama males have the secondary genitalia and epiproct similar to those of *O. i. alleghaniensis*. Females from Alabama have the posterior portion of the occiput slightly inflated laterally, and have the occipital horns separated by ca. 1/4 the length of the postfrontal suture and are ca. 1.5 times the length

of the pedicel.

Etymology.--*O. incurvatus* [in-cur.va'tus] (L. mas. part. adj. "bent inward", referring to the incurvate adult male cerci.)

Biology.--The rarity of *O. incurvatus* is apparently related to habitat requirements during the nymphal stage, although low vagility and short flight season of the adults may explain their infrequent capture. The nymphs have been collected from riffle areas of spring-fed piedmont streams 1-7 m wide. They seem to prefer riffle areas where gravel overlies soft mud in 5-20 cm of water. Carl Cook has collected adults in North Carolina from 1-2 m above Lewis Fork Creek while they perched on overhanging trees. In Virginia adults have been observed perching on streamside vegetation 0.2-1.0 m above Spring Creek. Fisher (1940) who incorrectly reported this species as *O. mainensis* states that the males rested on grasses and reeds that directly overhung a meadow brook near Shawan, Maryland. In contrast *O. i. alleghaniensis* has never been observed at streamside, all known specimens being collected in sunlit openings at least 10 m from Rich Creek, West Virginia. The known flight season extends from May 16 (NC and VA) to June 14 (WV), although the season in Alabama may begin as early as April 10. Nymphs of Odonata collected in association with those of *O. incurvatus* include *Cordulegaster maculata* Selys, *Gomphus lividus* Selys, *G. parvidens* Currie, *G. lineatifrons* Calvert, *Lanthus vernalis* Carle, *Progomphus obscurus* (Rambur), and *Hagenius brevistylus* Selys. Additional Odonata collected from near the type locality include *Stylurus laurae* Williamson, *Erpetogomphus designatus* Hagen, *Dromogomphus spinosus* Selys, *Boyeria vinosa*

(Say), *Didymops transversa* (Say), *Macromia illinoiensis* Walsh, *Helocordulia selysii* (Hagen), and *Calopteryx dimidiata* Burmeister.

Distribution

The distribution of *O. incurvatus* apparently forms a "U"-shaped band about the Appalachian mountains; it is known from the states of AL, GA, MD, NC, SC, TN, VA, and WV. The distribution of *O. mainensis* is more boreal than that of *O. incurvatus* with its distribution overlapping that of *O. incurvatus* along the upper piedmont of the southern Appalachians; it is known from the provinces of N.B. and Que., and the states of CT, ME, MA, NH, NJ, NY, NC, PA, SC, TN, VT, VA, and WV.

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APPENDIX V

A New *Zoraena* (Odonata:Cordulegastridae) from Eastern North America
with a Key to Adult Cordulegastridae of America

ABSTRACT

A brief taxonomic and nomenclatural history of *Zoraena* Kirby and its species is presented. The adults of *Z. bilineata* n. sp. are described, and *Z. bilineata* n. sp., *Z. diastatops* (Selys), and *Z. sayi* (Selys) figured. The new species may be readily distinguished from other species of *Zoraena* by the brown base color and less extensive yellow markings of the body, and by the shape of the male terminalia. The type locality is in western Virginia, and the type series includes specimens collected in an area extending from Delaware and Michigan to Mississippi and Georgia. The new species inhabits spring runs where the males characteristically perch on sunlit plant stems. A key to adult American Cordulegastridae is provided, and the taxonomic position of *Zoraena* and related genera discussed.

In his Synopsis Des Gomphines, Edmond de Selys Longchamps (1854) described *Thecaphora diastatops* from a male specimen reportedly collected in Colombia, South America. The monotypic genus was distinguished from related genera by the slight dorsal separation of the compound eyes and the lateral wedgelike markings of the abdomen. The name *Thecaphora* was borrowed from Burmeister's (1839) name for *Cordulegaster* Leach (1815), and the genus subsequently considered a subgenus of *Cordulegaster* by Selys (1858). Scudder (1866) described *C. lateralis* from specimens collected near the White Mountains of New Hampshire and although Scudder (1867) had pointed out its distinctness from *C. sayi* Selys, both Hagen (1867, 1875) and Selys (1869) considered them synonymous. After studying specimens of *C. lateralis* from New Hampshire Selys (1878) considered it a synonym of *C. diastatops* and corrected the type locality to Eastern North America. The resulting confusion of reported locality records has persisted until Needham and Westfall (1955) noted that all northern records of *C. sayi* are questionable. Selys (1878) also suggested that *C. sayi* should probably be placed in *Thecaphora*, a label on the type actually reads "*Thecaphora sayi*" (Fraser 1929). However, in the same publication Selys decided to follow Hagen's suggestion of not recognizing *Thecaphora* because *C. sayi* exhibited an annulate abdominal color pattern typical of various *Cordulegaster* species. Kirby (1890) noted that the name *Thecaphora* was preoccupied and renamed the group *Zoraena*, including only *Z. diastatops* in the genus. In his revision of the Fissilabioidea Fraser (1929) noted that *C. diastatops* and *C. sayi* were distinct from other *Cordulegaster*, but did not recognize *Zoraena* because he was not able to find correlated differences in the genitalia or

venation. However, an analysis of the distinctive characteristics of *Zoraena* (including the shape of the anterior hamuli) indicate that it represents the most ancient group of the Cordulegastrinae.

The new species is relatively common but has been previously confused with *Z. diastatops* from which it may be readily distinguished by the brown base color of the body. The new species has also been occasionally confused with *C. maculata* Selys. A female of the new species determined as *C. maculata* apparently by Hagen has been found at the Museum of Comparative Zoology; and a male of the new species was originally determined as *C. maculata* by Williamson (1902), although later Williamson (1904) redetermined the specimen as *C. diastatops*. Descriptions of *Z. diastatops* by the following authors are apparently composite: Hagen (1885), Garman (1927), Fraser (1929), and Needham and Westfall (1955). Both species are represented in the Selys collection (Tennessen, personal communication) and both were figured by Fraser (1929; Plate 12, Figs. 8 and 10). However, the original descriptions of *Z. diastatops* by Selys (1854, 1858) and those of Needham and Heywood (1929), and Walker (1958) were apparently based only upon specimens of the true *Z. diastatops*.

Zoraena bilineata n. sp.

Male

Total length 55.0-65.5 mm, abdomen including cerci 42.0-50.0 mm, cerci 1.6-1.8 mm, hind femora 4.8-5.8 mm, hind wings 34.0-39.5 mm, pterostigmata 2.8-3.6/3.3-4.3 mm.

Head.--Labium and maxillae brownish white; mandibles yellowish white, brown apically; labrum and genae yellow; anteclypeus light brown; postclypeus yellow with distal margin light brown; antefrons yellow, faintly brown over basal $2/3$; antennae and vertex (postfrons) dark brown, ocellar ridge bilobed; compound eyes separated by ca. $0.4-0.7$ width of median ocelli; postfrontal suture ca. $1/5$ as long as width of median ocelli; occiput (dorsal portion) yellow, occipital crest brown with fringe of brown hair setae; posterior surface of head predominantly yellow or light brown, dark brown dorsolaterally, denticles limited to postocular carinae.

Thorax.--Prothorax brown, anterodorsal edge yellow, posterodorsal edge dark brown. Pterothorax brown with yellow stripes; mesanepisterna and carinae darker brown; dorsal mesanepisternal yellow stripes narrowed to point and widely divergent ventrally, rounded and separated by ca. $4/5$ width dorsally; lateral mesanepisternal pale stripes absent; mesanepimeral yellow stripes narrow (Fig. 1a), parallel-sided, ca. $1/5$ as wide as long; ventral $1/3$ of mesokatepisterna yellow; metanepimeral yellow stripes vestigial or absent; metanepimeral yellow stripes less than $1/2$ width of metanepimera, parallel-sided, ca. $1/4$ as wide as long; posterodorsal carinae of metanepimera yellow.

Legs.--Coxae, trochanters, femora, and tibiae brown with black spines, spines of hind tibiae reduced, each lobelike with vestigial distal spine, tarsi black; prothoracic tibial keels pale, $1/7-1/6$ length of tibiae.

Wings.--Venation brown, costa tan with medial dull yellow line and black lateral spots; pterostigma tan; membrane hyaline; membranule white.

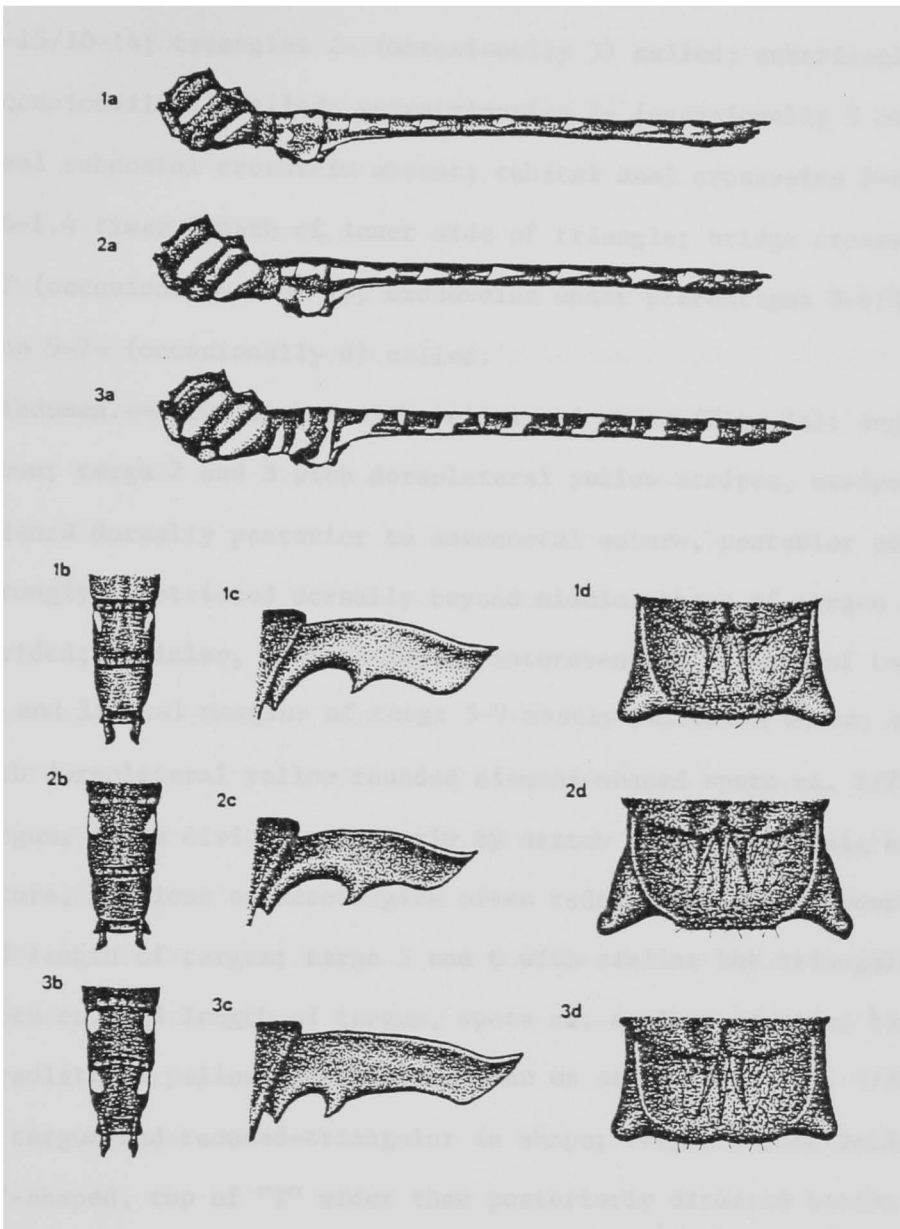


Figure 1-3. 1- *Zoraena bilineata* n. sp., 2- *Z. diastatops* (Selys),
 3- *Z. sayi* (Selys); (a) lateral view of thorax and abdomen X1.5,
 (b) dorsal view of abdominal apex X4, (c) ventrolateral view of
 male cerci X20, and (d) ventral view of male epiproct X18.

Antenodal crossveins 15-20, 12-17/10-15, 9-13; postnodal crossveins 11-15/10-14; triangles 2- (occasionally 3) celled; subtriangles 1- (occasionally 2) celled; supratriangles 1- (occasionally 2 or 3) celled; basal subcostal crossvein absent; cubital anal crossveins 3-4/2-3; gaff 0.6-1.4 times length of inner side of triangle; bridge crossveins 4-7/4-7 (occasionally 8 or 9); crossveins under pterostigma 3-6/3-5; anal loop 5-7- (occasionally 8) celled.

Abdomen.--Brown marked with yellow and white (Fig. 1a); segment 1 brown; terga 2 and 3 with dorsolateral yellow stripes, stripes abruptly widened dorsally posterior to antecostal suture, posterior portions strongly constricted dorsally beyond middle, those of tergum 3 often divided; auricles, genital lobes, anteroventral corners of terga 2 and 3, and lateral margins of terga 3-9 mostly yellowish white; tergum 4 with dorsolateral yellow rounded diamond-shaped spots ca. 1/2 length of tergum, spots divided anteriorly by narrow brown line along antecostal suture, portions on acrotergite often reduced and spots reduced to ca. 1/3 length of tergum; terga 5 and 6 with similar but triangular yellow spots ca. 1/3 length of tergum, spots ca. as long as wide; tergum 7 with dorsolateral yellow spots larger than on other terga, ca. 7/10 length of tergum and rounded-triangular in shape; tergum 8 with yellow spots "T"-shaped, top of "T" wider than posteriorly directed bottom portion; tergum 9 basally with small dorsolateral elongate-oval yellow spots 1/3-1/2 length of tergum; sterna 3-9 brown; segment 10 and terminalia brown, segment 10 occasionally with small basal lateral yellow areas. Cerci shorter than segment 10, each with laterobasal and ventromedian spine, latter spine at ca. 2/5 length of cerci; dorsomedial surface

convex, ventrolateral surface concave, in ventrolateral view (Fig. 3a) distinctly dilated and truncate apically although somewhat variable in shape; epiproct nearly truncate apically (Fig. 4a), corners not elongate, only slightly visible in dorsal view (Fig. 2a), apical width ca. equal to length of cerci.

Genitalia.--Anterior lamina brown with transverse ventral ridge; anterior hamuli brown, anteroventral portions curved medially, posteriorly with inner and outer ridges, and in lateral view with anteroventral corner rounded and angled at 130-140°; posterior hamuli brown, slender and hooklike, with inner apical surface black. Penis brown, membranes white, segment 1 ca. 1.6 times as long as high, length 2.5-2.9 mm; penile hood with ventrolateral margins slightly raised, hood located near base of segment 1; segment 2 "J"-shaped with retractor spine prominent, length 1.5-1.7 mm; segment 3 1.7-1.9 mm in length, apex bilobed and curved dorsally; segment 4 globose ca. 1.7 mm long and attached to inner surface of segment 3, anteroventrally with large triangular lateral sclerites, anteriorly with transverse setose ridge, anterodorsally with setose boot-shaped lateral lobes, posteroventrally with small oval lateral sclerites, and posterior half scleritic ca. 1.6 times as long as wide in lateral view with apical oval orifice and vestigial dorsal flanges.

Female

Total length 61.0-68.5 mm, abdomen including ovipositor 46.0-52.0 mm, cerci 0.9-1.0 mm, hind femora 6.6-7.3 mm, hind wings 39.0-43.0 mm, pterostigmata 3.5-4.1/4.0-4.6 mm.

Head.--Colored as in male, compound eyes separated dorsally by ca.

1.2 times width of median ocelli, postfrontal suture ca. $1/3$ as long as width of median ocelli.

Thorax.--Colored as in male with yellow stripes slightly narrower.

Legs.--Colored as in male; spines of hind tibiae typical, not modified as in male; prothoracic tibiae without keels.

Wings.--Venation, membrane, and pterostigmata colored as in male. Antenodal crossveins 15-21, 13-17/11-16, 10-12; postnodal crossveins 12-17/11-17; triangles 2-celled; subtriangles 2-celled; supratrangles 1 or 2-celled; basal subcostal crossvein absent; cubital anal crossveins 3-4/2-4; gaff 0.7-1.3 times length of inner side of triangle; bridge crossveins 4-9/4-8; crossveins under pterostigmata 3-5/3-6; anal loop 5-9-celled.

Abdomen.--Colored as in male with dorsolateral yellow spots smaller, those of terga 4-8 ca. $2/5$, $3/10$, $3/10$, $1/2$, and $3/8$ length of respective terga, spots of tergum 8 smaller than those of tergum 6; small dorsolateral yellow spots of tergum 9 diffuse or absent.

Genitalia.--Ovipositor brown, extended beyond apex of abdomen for ca. $1/4$ its length (ovipositor length measured from midbasal junction with sternum 8).

Types

Holotype, male--small tributary of Cove Cr. along Rt. 662, Tazewell Co., VA; June 10, 1978; F. L. Carle (FLC); dry in envelope, deposited Florida State Collection of Arthropods (FSCA).

Allotype, female--Cold Spring seepage area at Rt. 611; Craig Co., VA; June 17, 1978; FLC; dry in envelope, deposited FSCA.

Paratypes--(Adults dry in envelopes unless otherwise specified).

Delaware--New Castle Co.: Muddy Run near Glasgow, 12 June 1977, H. B. White, 1 male; Muddy Run near Glasgow, 5 July 1976, H. B. White, 1 male.

Georgia--Habersham Co.: Spring Run at N end of Nancytown Lake, 19 June 1979, S. W. Dunkle, 1 female. Murray Co.: Lake Conasauga, 15 June 1979, S. W. Dunkle, 1 male. Richmond Co.: 1.6 km. S. of Takoma, 20 Apr. 1952, W. H. Cross, 1 male. Union Co.: Lake Winnfield Scott Rec. Area, 29 May 1966, W. F. Mauffray, 2 males; 2.1 km. NW. of Suches on Rt. 60, 17 June 1979, S. W. Dunkle, 2 males.

Indiana--Cass Co.: Peabody farm near Hoover, 13 June 1929, J. G. Needham, N. D. Shufelt, and Eli Captain, 1 female; Mud Cr. in Peabody woods, 23 June 1929, L. A. C., Eli Captain, and E. B. Williamson, 7 males; Peabody farm near Hoover, 13 July 1929, collector unknown, 1 male. Huntington Co.: Bog Cr. just below Monument City, 9 June 1929, N. D. Shufelt, and E. B. Williamson, 1 male; bog along creek at Salamonie R., 11 June 1929, N. D. Shufelt, Eli Captain, and E. B. Williamson, 1 male; Monument City Bog, 12 June 1929, E. B. Williamson, 1 male.

Maryland--locality, date, and collector unknown, 1 female.

Michigan--Antrim Co.: locality unknown, 10 July 1949, R. R. Dreisbach, 1 female. Berrien Co.: small stream ca. 0.5 m. wide flowing through marshy meadow near Buchanan, 29 May 1914, E. B. Williamson, 1 male. Crawford Co.: Bradford Cr. 5 km. N. of Frederick, 10 July 1935, J. W. Leonard, 1 male, Lake Co.: Luther, 19 June 1934, C. F. Byers, 1 female. Washtenaw Co.: bog near Willis, 4 July, Sherman Moore, 1 male.

Mississippi--Franklin Co.: Clear Springs Rec. Area, 25 Apr. 1966, W. F. Mauffray, 1 female. Perry Co.: 10 km. NW. of Benndale, 8 Apr. 1974, S. W. Dunkle, 1 female.

North Carolina--county and locality unknown, 23 May 1899, J. S. Hine, 1 male. Cumberland-Harnett Co.: Little R. near

Bunnlevel, 2 May 1975, R. D. Cuyler, 1 male. Jackson Co.: grassy spring bog in Dillard farm pasture beside Rt. 1330 1.2 km. S. of Cullowhee, 31 May 1966, W. E. Sipe, 1 female; spring above lower pond in Dillard farm pasture near Cullowhee, 2-20 June 1966, G. J. Gantt, 5 males, 2 females; pond on Jackson Cr. S. of Rt. 1163 4.8 km. W. of Rt. 1145, 22 June 1966, G. J. Gantt, 1 male. Transylvania Co.: Brevard, 12-19 June 1941, M. J. Westfall, 1 male, 1 female; Brevard, 14-26 June 1942, M. J. Westfall, 3 males; Brevard, 30 June-2 July 1940, M. J. Westfall, 2 males; Brevard, 30 June 1940, Mike Wright, 1 male; Brevard, 2 July 1941, M. J. Westfall, 2 males. Ohio--Campaign Co.: Cedar Swamp near Urbana, 5 June 1936, D. J. Borrer, 1 male; Cedar Swamp near Urbana, 11 June 1934, D. J. Borrer, 1 male; Cedar Bog, 12 June 1971, R. A. Restifo, 1 male; Cedar Swamp near Urbana, 1 July 1968, R. E. Woodruff, 1 male. Pennsylvania--Fayette Co.: ditch along railroad track at Ohio Pyle, 25 June 1900, E. B. Williamson, J. L. Graf, and D. A. Atkinson, 1 male. Mercer Co.: Sandy Lake, 10 July 1904, D. A. Atkinson, 1 male. South Carolina--Chesterfield Co.: Cheraw State Park at U.S. Rt. 1 S. of Cheraw, 7 Apr. 1965, M. J. Westfall, 1 female. Tennessee--Cocke Co.: Carson's Spring near English Cr., 1 June 1946, W. B. Robinson, 1 female. Hardin Co.; small tributary of Mud Cr. 2.4 km. W. of Walkerton on Rt. 0013, 25-28 Apr. 1981, K. J. Tennessen, 5 males, 1 female. Johnson Co.; Johnny Murphy's ponds near Mt. City, 30 June 1959, R. P. Trogdon, 4 males, 1 female; Johnny Murphy's ponds near Mt. City, 17 June 1959, R. P. Trogdon, 1 female. Virginia--Alleghany Co.: Powell farm at Rt. 602 on Big Ridge Mtn., 10 June 1978, P. K. Powell, 1 male. Botetourt Co.: Spring Run 2 km. N. of Oriskany, 17 June 1978, FLC, 2 males. Craig Co.: Cold

Spring seepage area at Rt. 611, 17 June 1978, FLC, 1 female. Fairfax Co.: Pohick Cr. at Gunston Cove, 1 May 1949, T. W. Donnelly, 1 female. Floyd Co.: spring run entering Camp Cr. S. of Rt. 615, 10 June 1978, FLC, 2 males. Giles Co.: seepage area above Riopel Pond at Mtn. Lake Biological Station, 26 June 1977, FLC, 1 male; above Riopel Pond at Mtn. Lake Biological Station, 29 June 1977, B. C. Kondratieff, 1 male; Mtn. Lake, 1 Aug. 1949, C. F. Byers, 1 female. Highland Co.: small tributary of Back Cr. at Rt. 250, 4 June 1977, FLC, 3 males; spring run near Buck Run beaver ponds, 10 June 1979, B. C. Kondratieff, 1 male; spring run near Buck Run beaver ponds, 18 June 1978, FLC, 1 male; spring run near Buck Run beaver ponds, 8 Aug. 1978, FLC, 1 male. Madison Co.: spring run flowing into Robinson R., 7 July 1980, E. Smith, 1 female. Montgomery Co.: Blacksburg, 15 Apr. 1958, G. Rock, 1 male; locality unknown, 18 May 1960, M. G. Nichols, 1 male; marshy spring run flowing into Poverty Cr. at Rt. 708, 25 May 1978, FLC, 1 male; spring seep along Pedlar Hollow at Rt. 603, 13 June 1978, FLC, 1 male. Patrick Co.: spring run flowing into Rock Castle Cr. at Rt. 605, 21 May 1978, FLC and C. N. Shiffer, 1 male, 3 females (teneral); spring run flowing into Rock Castle Cr. at Rt. 605, 11 June 1978, FLC, 3 males, 1 female. Rockbridge Co.: spring run flowing into Brattons Run 1 km. N. of California near Rts. 60 and 780, 4 June 1977, FLC, 2 males. Russell Co.: spring run flowing into west side of Laurel Bed Lake, 4 July 1977, FLC, 1 female. Tazewell Co.: spring run flowing into Cove Cr. at Rt. 662, 10 June 1978, FLC and B. C. Kondratieff, 9 males. Warren Co.: spring run flowing through marshy area S. of Rt. 634, 6 June 1977, FLC, 1 male. West Virginia--county unknown, Cheat R., 1 June, collector unknown, 1 female.

Randolph Co.: Elkins, 19 June 1935, Carsten Ahrens, 1 male. Representative paratypes deposited at the FSCA; U.S. National Museum of Natural History; E. B. Williamson Collection, Univ. of Michigan, Ann Arbor; Museum of Comparative Zoology, Harvard Univ.; Virginia Polytechnic Institute and State Univ. Department of Entomology Collection; Carl Cook Collection, Sid Dunkle Collection, and Ken Tennesen Collection.

Remarks

Several characteristics of *Z. diastatops* noted by Selys (1854, 1858, 1878) distinguish it from *Z. bilineata* n. sp., these are: anteclypeus, distal margin of postclypeus, legs, terminalia, and base color of thorax and abdomen black; lateral yellow spots of abdomen wedge-shaped with the posterior ends pointed; and male epiproct convex distally with corners elongate. The male terminalia of *Z. diastatops* also differs in that the apical width of the epiproct is greater than the length of the cerci, and the cerci are relatively shorter and less dilated and truncate apically than in *Z. bilineata* n. sp., these diagnostic characteristics are evident in figure 2 as well as in Hagen's plate 16, figure 4 (Selys 1858). The name *bilineata* refers to the narrow lateral yellow thoracic stripes which are less than 1/2 the width of the metanepimera in the new species. Additional characteristics not illustrated which distinguish *Z. bilineata* include: transverse ridge above frontal-clypeal suture absent or vestigial, compound eyes in male separated dorsally by less than width of median ocellus (by more than width of median ocellus in other *Zoraena*), thoracic stripes never greenish yellow, and apical scleritic portion of fourth penile segment ca. 2/3 as wide as long

(ca. 1/2 as wide as long in other *Zoraena*). In many of the characteristics mentioned *Z. sayi* is similar to *Z. diastatops*; *Z. sayi* may be readily distinguished from other *Zoraena* by the yellow annulations of the abdomen, reddish brown metanepisternal stripes, yellow costa, and subbasal position of the male cercal spine (Fig. 3).

Zoraena is a very ancient genus of the Cordulegastrinae, but it has remained unrecognized apparently because it is not conspicuously different from *Cordulegaster*. This is unfortunate because the use of derived characteristics to define *Anotogaster* Selys, *Neallogaster* Cowley (= *Allogaster* Selys), and *Kuldanagaster* Yousuf and Yunus, has left *Cordulegaster* paraphyletic. In order to make *Cordulegaster* monophyletic it is evidently necessary to recognize *Taeniogaster* Selys and possibly *Thecagaster* Selys in addition to *Zoraena*. For example *Taeniogaster* is intermediate between *Zoraena* and *Cordulegaster* in that the compound eyes are very slightly separated, the head moderately tumid behind the compound eyes, the female ovipositor is extended for ca. 2/5 its length beyond the cerci, and the male epiproct ca. as wide as long. Derived characteristics which separate other Cordulegastrinae from *Zoraena* include: postfrontal suture absent, middorsal abdominal carinae slightly more developed, male epiproct elongate, vulvar lamina extended for ca. 1/2 its length beyond the cerci, and male cerci inflated beyond the ventral spine. Additional characteristics of the head which distinguish *Zoraena* include: slight curvature of the antefrontal carina, compound eyes distinctly separated dorsally, anterolateral carinae of occiput weakly developed, and posterior surface of compound eyes tumid. Although Fraser (1929) reported that the genitalia and venation of *Zoraena* did not differ from

those of *Cordulegaster*, they are different from all other Cordulegastrinae in the following characteristics: anterior margins of anterior hamuli angled at ca. 130° , first penile segment ca. 1.6 times as long as high with penile hood originating from posterior margin, fourth penile segment without inner flanges and with lateral lobes bootlike, genital lobes semicircular, cells of anal field reduced in number, and two cell rows between RP_1 and RP_2 to ca. $1/2$ distance between pterostigma and nodus. The male terminalia of *Zoraena* are also unique, the portion of the epiproct beyond segment 10 is wider than long and the cerci are separated basally by more than twice the basal width of the cerci. In addition, the male cerci of both *Zoraena* and *Taeniogaster* differ from other Cordulegastrinae in being laminate as opposed to inflated beyond the ventral spine. *Zoraena* are also the smallest Cordulegastrines.

Nymphal *Zoraena* may be distinguished from other Cordulegastrinae by the following characteristics: frontal shelf appearing subacute in lateral view (acute and ridgelike in other Cordulegastrinae); postero-lateral corners of head tumid, in lateral view eye occupying ca. $1/5$ of head length (ca. $2/7$ in other Cordulegastridae); base of prementum truncate, basal width ca. $2/5$ length (ca. $1/3$ in other Cordulegastrinae); hair setae of epaulets ca. as long as epiproct; lateral spines of abdominal segment 8 ca. $1/5$ length of lateral margin and strongly up-curved; and female ovipositor ca. $7/10$ length of sternum 9 ($9/10$ in *Taeniogaster*, and 1.0-1.2 in *Cordulegaster*). The genus *Taeniogaster* has been distinguished in the nymphal stage by Byers (1930) and Pennak (1953); nymphal *Taeniogaster* are unique in the high number of premental setae (12-14 on each side).

The recognition of *Anotoagaster* based on the absence of male auricles (actually present but vestigial) and the anal brace indicates that the group may be polyphyletic, particularly because the two characteristics are correlated. It is noted that the evolution of auricles in the Anisoptera apparently coincided with the establishment of the mating position in flight and the loss of auricles in *Anax* and the Libellulidae coincides with the strengthening of the abdomen by the increased formation of carinae. Observations of the author indicate that the hind legs are placed over the auricles while grasping the apex of the female abdomen to aid in achieving the copulatory position. It is also noted that the spines of male anisopteran hind tibiae are reduced in size presumably for this function. If this is true the loss of auricles and anal brace (which strengthens the incurvate hind wing margin apparently necessary for leg clearance) can be initiated by a simple change in copulatory behavior.

The *Kuldanagastrinae* was established by Yousuf and Yunus (1974) and characterized by the "median lobe of the labium entire and equal in size to the lateral lobes; characteristic shape of the posterior end of penis-sheath [Fig. 1g]; size of the posterior hamules which are very long; denticles of each hind tibiae with a long fine spine sprouting from base of each denticle". All characteristics except the loss of the labial cleft are typical of other *Cordulegastrinae* and therefore *Kuldanagaster* is here placed within this subfamily. The lack of a labial cleft in *Kuldanagaster* may be due to an aberrant condition of the only known specimen in which case *K. pakistanica* could be reasonably

placed in *Neallogaster*. This type of confusion is less probable if taxonomic classifications are based on careful analyses of character state polarity. In any event, the contiguous compound eyes and raised antefrons in addition to the loss of the labial cleft indicate *Kuldanagaster* is an appreciably more recent group than *Zoraena*. It is also noted that the prothoracic tibiae of male Cordulegastridae have keels which were apparently overlooked by Fraser (1929, 1957) and Yousuf and Yunus (1974).

Etymology.--*Z. bilineata* [bi·li·ne·a'ta] (L. prefix *bi*- "double"; L. participle *lineata* "provided with lines"; M.L. fem. adj. *bilineata* "provided with two lines", referring to the two narrow lateral stripes of the adult thorax.)

Species Key to Adult American Cordulegastridae

1. Occiput conically elevated, posterodorsal portions of head denticulate; abdominal terga 3-7 with middorsal spear-headshaped yellow spots; male cerci separated at base by less than basal width of cercus, each with both ventral spines located basally
 *Taeniojaster obliqua* (Say)
- Occiput evenly convex, posterodorsal portions of head not denticulate; abdominal terga 3-7 without middorsal spear-headshaped yellow spots; male cerci separated at base by more than basal width of cercus, each with both ventral spines not located basally . . . 2

2. Compound eyes separated dorsally, head distinctly tumid behind compound eyes; male epiproct shorter than wide; female ovipositor projecting beyond abdomen for 1/3 or less of its length
 *Zoraena* 3
- Compound eyes contiguous at point dorsally, head not distinctly tumid behind compound eyes; male epiproct longer than wide; female ovipositor projecting beyond abdomen for 1/2 or more of its length
 *Cordulegaster* 5
3. Abdominal terga 2-8 with yellow annulations; metanepisternal stripes reddish brown; costa yellow; male cerci each with inner spine at ca. 1/4 distance between laterobasal spine and apex
 *Z. sayi* (Selys)
- Abdominal terga 2-8 without yellow annulations; metanepisternal stripes vestigial; costa not yellow; male cerci each with inner spine at 2/5-1/2 distance between laterobasal spine and apex . . . 4
4. Anteclypeus and legs light brown; metanepimeral pale stripes less than 1/2 as wide as metanepimera; apical width of male epiproct nearly equal to length of cerci *Z. bilineata* n. sp.
- Anteclypeus and legs black; metanepimeral pale stripes more than 1/2 as wide as metanepimera; apical width of male epiproct ca. 1.3 times length of cerci *Z. diastatops* (Selys)

5. Anterior surface of antefrons predominantly yellow; abdominal terga 2-8 with paired submedian yellow spots which may be contiguous middorsally 6
 Anterior surface of antefrons dark brown; abdominal terga 2-8 with yellow annulations which may be interrupted middorsally 7
6. Dorsal surface of antefrons yellow; abdominal terga 2-8 with paired submedian yellow spots contiguous middorsally; fore wing with 2 cubital anal crossveins *C. dorsalis* Hagen
 Dorsal surface of antefrons light brown; abdominal terga 2-8 with paired submedian yellow spots separated middorsally; fore wing with 3 cubital anal crossveins *C. maculata* Selys
7. Dorsal surface of antefrons brown; abdominal terga 3-7 with yellow annulations interrupted middorsally; yellow annulation of tergum 7 ventrally without anterior extensions and width less than 1/6 length of tergum *C. godmani* MacLachlan
 Dorsal surface of antefrons yellow; abdominal terga 3-7 with yellow annulations not interrupted middorsally; yellow annulation of tergum 7 ventrally with anterior extensions and width more than 1/4 length of tergum 8
8. Abdominal terga 8 and 9 with yellow annulations interrupted middorsally; posterior surface of head predominantly brown; fore wings with 3 or 4 cubital anal crossveins *C. erronea* Hagen
 Abdominal terga 8 and 9 with yellow annulations not interrupted middorsally; posterior surface of head predominantly yellow; fore wings with 2 cubital anal crossveins *C. diadema* Selys

Biology.--Several aspects of preferred habitat distinguish species of *Zoraena* from other Cordulegastridae. Nymphal *Zoraena* prefer the pools of spring seeps, and spring runs, but *Z. diastatops* often inhabits small streams in the vicinity of beaver dams. *Zoraena* are generally not associated with species of *Cordulegaster*, but *Z. diastatops* and *C. maculata* often fly along the same stream, with *C. maculata* preferring the more shaded sections. Although preferring faster flowing streams, *C. erronea* has occasionally been collected in association with *Z. diastatops* and *Z. bilineata*. The complete sequence of anisopteran genera typically occurring along a stream beginning at a spring seep is *Tachopteryx* Selys, *Zoraena*, *Taeniogaster*, and *Cordulegaster*. However, the almost imperceptible flow of water through forest debris preferred by *Tachopteryx*, and the muddy-bottomed spring runs preferred by *Taeniogaster* are often absent and exclude these genera from the sequence. It is noted that the sequence also parallels the apparent evolution of these groups with *Tachopteryx* characterized by the largest proportion of primitive character states. In western North America *Tachopteryx* is replaced by *Tanypteryx*, and *Zoraena* and *Taeniogaster* do not occur. *Lanthus* Needham often occurs with *Cordulegaster* and is replaced by *Octogomphus* Selys in western North America.

Several aspects of behavior also distinguish *Zoraena*. However, emergence is apparently similar to that of other Cordulegastridae; Needham and Heywood (1929) state that exuviae of *Z. diastatops* "are found commonly sticking to roots and logs at the edges of [the settling basins in the brooks]". Dr. Dunkle (personal communication) has collected an exuviae of *Z. sayi* from the underside of a fern frond at

about 30 cm above a spring run. During the period following emergence the adults are commonly found in clearings resting on low bushes and plant stems with the body characteristically held at about 45° from the horizontal. In about two weeks the adults return to the sunlit portions of spring runs. Here the males patrol at from 5-30 cm above the water between periods of resting on sunlit plant stems 10-40 cm above the ground. Patrolling flight is more common on overcast days or toward dusk, during which the males will often hover briefly while apparently searching for females. Upon returning to the streams the females become quite secretive and are seen most often ovipositing, the abdomen held characteristically at about 60° from the horizontal between thrusts of the ovipositor. Other Cordulegastrinae characteristically hold the body in a near vertical position while at rest or while ovipositing. In addition, *Zoraena* seem to prefer oviposition sites along pool areas whereas *Cordulegaster* females prefer areas of running water. The author's observations indicate a high degree of variability in the number of eggs layed at a particular site. For example, a female *C. dorsalis* was observed striking the stream bottom 223 times in the same place while briefly resting only twice upon the adjacent stream bank, in contrast a female *C. erronea* was observed to strike the small accumulations of mud behind the emergent rocks of a stream 2-3 times while flying in an up-stream direction. The aberrant oviposition behavior of *C. maculata* reported by Williamson (1907) "they crawled about in an awkward almost crippled manner thrusting the abdomen with much commotion" suggests the former case and may be related to a weakened condition accompanying old age. The latter case of only a few strikes at a given location has also

been observed in *C. maculata* and may represent a type of searching behavior. However, in general female *Zoraena* seem to strike the substrate fewer times at a given site and at a slower rate than either *Cordulegaster* or *Taeniogaster*.

Apparently *Z. diastatops* and *Z. bilineata* have only been collected at the same locality twice. Williamson collected a single male of each species from a marshy spring run near Buchanan, Michigan on May 29, 1914. The author has collected both species from the same locality in Highland county, Virginia; *Z. diastatops* from Buck Run, and *Z. bilineata* from a nearby spring seep. It is also known that the records of *Z. diastatops* reported for Pennsylvania by Beatty and Beatty (1971) and for Michigan by Kormondy (1958) are composite. *Zoraena sayi* has not been collected in association with other *Zoraena*.

The known flight seasons of *Zoraena* species are: *Z. bilineata* n. sp., Mar. 20 (MS) to Aug. 8 (VA); *Z. diastatops*, May 28 (Ont.) to Aug. 29 (Que.); and *Z. sayi*, Feb. 27 (FL) to Apr. 14 (FL).

Distribution

Cordulegastrines are distributed throughout the northern hemisphere complementing the Gandwanian distribution of the Neopetaliines. Three of the nine American Cordulegastrines are restricted to western North America and six are restricted to eastern North America. *Cordulegaster maculata* has the most extensive distribution, and *Zoraena sayi* has the most restricted range being known from only seven localities in Florida (Westfall, personal communication) and one locality in Georgia. The latitudinal range of the genus *Zoraena* extends from 50° N where the

author has collected *Z. diastatops* at a small tributary of the Godbout river, Quebec, south to about 30° N where a population of *Z. sayi* has been discovered near Gainesville, Florida. The known distributions of American species of the Cordulegastridae are as follows: *Cordulegaster diadema*, U.S.A.- AZ and UT, Mexico- Morelos and Veracruz; *C. dorsalis*, U.S.A.- AK, CA, ID, MT, NV, OR, UT, and WA, Canada- B.C.; *C. erronea*, U.S.A.- CT, D.C., DE, GA, KY, MD, MA, MI, MS, NY, NC, OH, PA, SC, TN, VA, and WV; *C. godmani*, Costa Rica, Guatemala, Mexico; *C. maculata*, U.S.A.- AL, CT, D.C., FL, GA, IN, KY, LA, ME, MD, MA, MI, MN, MS, NH, NJ, NY, NC, OH, PA, SC, TN, TX, VT, VA, WV, and WI, Canada- N.B., N.S., Ont., and Que.; *Taeniogaster obliqua*, U.S.A.- AL, AR, CT, D.C., FL, GA, IL, IN, KS, KY, LA, ME, MD, MA, MI, MS, NJ, NY, NC, OH, OK, PA, SC, TN, TX, VA, WV, and WI, Canada- Ont. and Que.; *Zoraena bilineata*, U.S.A.- AL, DE, GA, IN, KY, MD, MI, MS, NC, OH, PA, SC, TN, VA, and WV; *Z. diastatops*, U.S.A.- CT, ME, MA, MI, NH, NJ, NY, PA, VT, VA, and WV, Canada- N.B., N.S., Ont., and Que.; *Z. sayi*, U.S.A.- FL and GA.

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APPENDIX VI

A New *Sympetrum* from Eastern North America,
with a Key to American *Sympetrum* (Odonata:Libellulidae)

ABSTRACT

Sympetrum janeae sp. n. (male holotype, female allotype: marsh at N. end of Joes Pond, Washington Co., Vermont, USA) is described from adult and larval material and its affinities discussed. A key to American *Sympetrum* is presented along with a summary of their known distributions.

INTRODUCTION

While determining specimens of *Sympetrum* collected in Vermont it became apparent that taxonomic problems continued to exist in the genus. Utilizing the keys provided by Needham and Westfall (1955) the males and females of pairs taken in tandem often keyed to *S. rubicundulum* (Say) and *S. obtrusum* (Hagen) respectively. Following the publication of new keys presented in Walker and Corbet (1975) the specimens were redetermined; the males as *S. internum* Montgomery, and the females again as *S. obtrusum*. Carle (1978) reported the problem and found that Dr. H. B. White and Mr. Clark Shiffer had also noticed the "intermediate" specimens which according to Williamson (1933) did not exist. Several additional *Sympetrum* were collected in tandem and in copulation throughout eastern North America and it was determined that the aberrant specimens represented an undescribed species. The nymphs of the new species were also discovered and are similar to those of *S. obtrusum* and *S. rubicundulum*, perhaps explaining the inability of Needham and Westfall (1955) to distinguish the nymphs of these species. The new species is known to be sympatric with *S. obtrusum* in Maine, Massachusetts, Maryland, New Jersey, New Hampshire, New York, Pennsylvania, Quebec, Vermont, and Virginia; and sympatric with *S. rubicundulum* in Maryland, New York, Pennsylvania, and Virginia.

TAXONOMIC HISTORY

The taxonomic history of *S. rubicundulum* and related species has been confusing. Thomas Say (1839) described *Libellula rubicundula* from "many individuals" collected in Indiana and Massachusetts, but unfortunately Say's types are lost and "neotypes" at the Museum of Comparative Zoology (MCZ) mentioned by Muttkowski (1910) have not been designated as such. Say also described a variety of his species with the "ferruginous tinge" of the wings extended to the nodus. Uhler (1857) described *L. assimilata* from three Nebraska specimens which had the wings tinged with yellow along the base and humeral margin. Hagen (1861) redescribed *Diplax rubicundula* and *D. assimilata* from specimens in part determined by Uhler. A study of the specimens grouped under the heading *S. rubicundulum* at the MCZ revealed seven species, of which the following material was utilized by Hagen (1861) in his description of *D. rubicundula*: *S. rubicundulum* - 1 male and 1 female from Maryland (determined as *L. rubicundula* by Uhler 1858 and likely the "neotypes" mentioned by Muttkowski), 1 male from Washington D.C. (Osten Sacken); *S. obtrusum* - 2 females from Chicago (Osten Sacken, the male type of *S. obtrusum* was originally also included here); and *S. janeae* sp. n. - 1 male from Maryland (determined as *L. rubicundula* by Uhler, 1858), 2 females from Bergin Hill, New Jersey (Guex), 1 female from New York (Osten Sacken), and 1 male from Philadelphia (Osten Sacken). It is evident that neither Say, Uhler, nor Hagen differentiated *S. obtrusum* or *S. janeae* sp. n. from clear winged specimens of *S. rubicundulum*. However, Hagen (1861) had noted differences in a male specimen from

Chicago which was of the then undescribed *S. obtrusum*. Walsh (1862) correctly considered Say's *L. rubicundula* and Uhler's *L. assimilata* synonymous, but incorrectly considered Hagen's composite description of *D. rubicundula* to be of *L. ambigua* Rambur. Walsh's specimens which he identified as the *D. rubicundula* of Hagen were clearly the *D. obtrusa* later described by Hagen (1867). Scudder (1866) also considered *L. rubicundula* and *L. assimilata* synonymous, but his New Hampshire specimens which he identified as the *D. rubicundula* of Hagen were *S. janeae* sp. n. An undescribed species from Yellowstone closely related to *D. rubicundula* was mentioned by Hagen (1873) and considered probably the same as specimens from Fort Hill, Colorado used in his description of *D. decisa* Hagen (1874). The distinctness of *D. decisa* and *D. obtrusa* was questioned by Hagen (1875) and later by Calvert (Currie 1905). Also in 1875 Hagen referred to specimens labeled *D. interna* which were collected in "Saskatchewan, southern Lake Winnipeg, British America". However, two males from this lot were found under the heading *S. rubicundulum* at the MCZ and were apparently the specimens from "British America" included in the description of *D. rubicundula* by Hagen (1890). Ris (1911) considered Hagen's *D. decisa* a subspecies of *S. rubicundulum*, and Williamson (1917, 1933) considered it a distinct species; Williamson also confirmed the synonymy of *S. assimilatum* with *S. rubicundulum*. After studying the types of Hagen's *D. decisa* Montgomery (1943) correctly synonymized it with *S. obtrusum* and proposed the name *S. internum* for the species referred to by Hagen under the nomen nudum *D. interna* and called *S. decisum* by Ris (1911) and later workers. Needham and Westfall (1955) incorrectly listed *S. decisum* a synonym of *S. internum*.

SYMPETRUM JANEAE SPEC. NOV.

DESCRIPTION

Material examined.--Holotype male: United States: Vermont, Washington Co., marsh at N. end of Joes Pond, Frank L. Carle (FLC), 22 Aug. 1980, deposited Florida State Collection of Arthropods.--Allotype female: same as for holotype.--Paratypes: MAINE: Oxford Co.: Norway, 1 male, 2 females, date unknown, S. J. Smith; Penobscot Co.: locality unknown, 1 male, 1 July 1899, F. L. Harvey; Bradley, 1 male, 1 female (in tandem), 11 July 1899, F. L. Harvey; Old Town, 2 males, 1 female, 20 Aug. 1899, F. L. Harvey. MARYLAND: locality unknown, 1 male, 1858, P. R. Uhler; Frederick Co.: locality unknown, 1 male, 1 female, date unknown, collector unknown. MASSACHUSETTS: locality unknown, 3 males, 1 female, date unknown, collector unknown; Dukes Co.: West Chop Point, 2 males, 1893, A. P. Morse; Essex Co.: Nahant, 1 male, 1874, Moring; Rockport, 1 female, 11 Aug. 1871, collector unknown; Hampshire Co.: Ware, 2 males, 19 Aug. 1923, collector unknown; Middlesex Co.: Cambridge, 1 male, 1 female (in tandem), date unknown, collector unknown; Medford, 1 female, 8 June 1919, W. J. Clench; Newton Centre, 1 female, 16 June 1931, A. Loveridge; Sherborn, 1 male, 12 July 1894, A. P. Morse; Sherborn, 1 male, 16 July 1894, A. P. Morse; Cambridge, 1 female, 1 Aug. (1858?), P. R. Uhler; Sherborn, 1 male, 1 Aug. 1894, A. P. Morse; Lincoln, 1 male, 1 female, 4 Aug. 1937, C. H. Blake; Natick, 1 male, 1 female, 11 Aug. 1864, collector unknown; Weston, 2 males, 14 Aug. 1866, collector unknown; Weston, 2 males, 3 females, 8 Sept. 1866, collector unknown;

Malden, 1 male, 9 Sept. 1879, collector unknown; Norfolk Co.: Brookline, 11 July 1863, 1 male, collector unknown; Charles River, 1 male, 1 female, 12 Aug. 1931, A. Loveridge; Cohasset, 1 female, 16 Aug. 1924, A. Loveridge; Blue Hills S. of Boston, 1 male, 31 Aug. 1915, W. J. Clench; Blue Hills, 1 female, 10 Sept. 1928, A. Loveridge; Plymouth Co.: Whitman, 1 female, 1874, collector unknown; Wareham, 1 male, 17 June (1912?), O. Bangs; Wareham, 1 female, 30 July 1912, O. Bangs; Worcester Co.: Lunenburg, 4 males, Aug. 1934, W. T. Davis. NEW HAMPSHIRE: Carroll Co.: Moultonboro, 1 female, 13 Aug., H. Howe; Coos Co.: Pinkins Notch at Mt. Washington, 2 males, 28 July 1981, FLC; Hillsboro Co.: nr. Benson's Farm Zoo in Nashua, 1 female, 31 Aug. 1932, A. Loveridge. NEW JERSEY: Bergen Co.: Bergin Hill, 2 females, (ca. 1861), Guex; Burlington Co.: marsh nr. Pakim Pond in Lebanon State Forest, 2 males, 8 Sept. 1980, FLC; marsh nr. Pakim Pond in Lebanon State Forest, 1 female, 10 Sept. 1979, FLC; Morris Co.: marsh along Lamington River at Rt. 206, 4 males, 1 female, 6 Sept. 1977, FLC; Somerset Co.: marsh nr. Carle's Pond at Mt. Bethel, 1 male, 25 July 1978, FLC; marsh nr. Carle's Pond at Mt. Bethel, 2 females, F. L. & C. J. Carle; West Millington, 1 female, 6 Sept. 1978, C. J. Carle; West Millington, 1 male, 11 Sept. 1979, C. J. Carle. NEW YORK: "New York", 1 female, (ca. 1861), O. Sacken; Broome Co.: Binghamton, 3 males, date unknown, collector unknown; Herkimer Co.: Rt. 28 nr. Fourth Lake, 1 male, 25 Aug. 1977, FLC; Schuyler Co.: Texas Hollow S. of Bennetsburg, 1 male, 28 Aug. 1973, K. J. Tennessen; Tompkins Co.: Ithaca, 1 female, date unknown, collector unknown; Ithaca, 2 males, 1 female, 30 June 1890, A. P. Morse; Ithaca, 2 females, 24 July 1906, collector unknown; Michigan Hollow nr. Danby, 1 male, 21 Aug.

1973, K. J. Tennessen. PENNSYLVANIA: Philadelphia Co.: "Philadelphia", 1 male, (ca. 1861), O. Sacken; Pike Co.: marsh nr. Lake Wallenpaupack, 2 males, 1 female, 19 Aug. 1979, FLC. QUEBEC: "Chateauguay", 1 male, date unknown, collector unknown. VERMONT: Addison Co.: marsh nr. Weybridge, 7 males, 18 nymphal exuviae, 26 July 1981, F. L., L. E., & A. M. Carle, marsh nr. Weybridge, 5 males, 26 July 1981, FLC; Lake Dummore, 1 male, 2 females, 27-31 July 1931, A. Loveridge; marsh nr. Weybridge, 6 males, 3 Sept. 1977, FLC; Caledonia Co.: marsh nr. Barnet, 1 nymph, 15 July 1979, FLC; Peacham, 1 male, 15 July 1979, FLC; Peacham, 1 female, 30 Aug. 1978, C. J. Carle; Peacham, 1 male, 1 Sept. 1977, FLC; Chittenden Co.: marsh nr. Shelburne Bay, 2 males, 16 Sept. 1969, FLC; Colchester Bog, 4 males, 2 females (2 pair in tandem), 18 Sept. 1970, FLC; Essex Co.: marsh at Mud Pond nr. Granby, 2 males, 14 July 1979, FLC; Nulhegan Pond, 2 males, 1 female (1 pair), 23 Aug. 1980, FLC; marsh at Mud Pond nr. Granby, 5 males, 2 Sept. 1977, FLC; Victory Bog, 1 female, 2 Sept. 1977, FLC; Ferdinand Bog, 7 males, 2 Sept. 1977, F. L. & C. J. Carle; Grand Isle Co.: South Hero, 2 males, date unknown, A. P. Morse; Lamoille Co.: Lamoille Valley, 1 male, date unknown, collector unknown; Washington Co.: field nr. Loor Hole at Joes Pond, 24 males, 3 females, 22 Aug. 1980, FLC; marsh at N. end of Joes Pond, 9 males, 7 females (7 pair in tandem), 22 Aug. 1980, FLC. VIRGINIA: City of Suffolk: Dismal Swamp National Wildlife Refuge, 1 male, 20 Sept. 1978, J. F. Matta.

Male.--Total length 30.0-36.5 mm, abdomen including cerci 21.0-25.0 mm, cerci 1.4-1.6 mm, hind femora 4.5-5.8 mm, hind wings 24.0-28.0 mm, pterostigmata 2.1-2.5/2.1-2.5 mm.

Head: labium yellowish white, prementum with medial distally widened brown line; maxillae and mandibles yellowish white, brown apically; labrum yellowish white; genae, anteclypeus, and postclypeus white, antefrons white, tinged with yellow anteriorly, basal 1/5 of dorsal surface brown; antennae brown; vertex (postfrons) light brown with dark brown bands around lateral ocelli; ocellar ridge inflated-conical, somewhat bilobed apically; occiput (dorsal portion) brown; posterior surface of head yellow, dark brown ventrally, with well developed transverse lateral ridges and medial tubercle.

Thorax: prothorax reddish brown, posterior margin directed dorsally with distinct medial cleft. Pterothorax reddish brown (pale yellow in immature males), mesanepisterna and terga primarily red, metanepimera with ventrolateral portion pinkish red at maturity; dorsolateral carinae of mesanepimera brown; sternum yellow-brown.

Legs: coxae and trochanters yellow-brown; femora black, with internal surface of front and generally middle femur brownish yellow; tibiae and tarsi black.

Wings: venation brown, yellow proximal to cubital-anal crossvein; costa brown with black spines; pterostigmata red, white proximally and distally, veins along anterior and posterior margins thickened, black; membrane hyaline, fore wing transparent saffron at extreme base, hind wing transparent saffron proximal to cubital-anal crossvein, membranule white. Antenodal crossveins 6-8, 6-8/5-8, 5-7 (5-62%, 6-38%); postnodal crossveins 6-9/6-11, supratrangles and hind wing triangle 1-celled (occasionally 2-celled), subtriangles 3-celled, fore wing triangle 2-celled; 1 or rarely 2 bridge crossveins; radial and median planates

subtend 1 cell row; crossveins under pterostigmata 1-2/1-2; anal loop 16-24-celled.

Abdomen: red marked with black (pale yellow and black in immature males); terga 1-3 red, generally with black area along lateral carinae of tergum 3; terga 4-8 red dorsally with full length triangular lateral black areas, black areas widened distally, extended dorsally to ca. 1/2 length of posterodorsal carinae (ca. 1/2 of tergum 5 covered by black in lateral view), ventrally black areas extended slightly below lateral carinae; ventral surface of terga 4-10 yellowish brown; tergum 9 dorsally red with lateral black band; terga 8 and 9 occasionally with black dorsal area on posterior half; tergum 10 red often with lateral black area; sternum 4-9 black, sternum 10 yellowish brown. Cerci yellowish red to red with ventral denticles and often apex black, dorsal surface concave in lateral view, ventral tooth at ca. 1/2 length; epiproct yellowish brown to reddish brown extended beyond ventral tooth of cerci with slight apical cleft; paraprocts reddish brown.

Genitalia: posterior hamuli brownish yellow, forked for ca. 1/3 length, ventromedial hook extended posteriorly beyond triangular dorsolateral lobe, hook slightly shorter than genital lobe; in ventral view dorso-lateral lobe with distinct inner lobe, inner surface somewhat shelf-like. Penile segment 1 globose, light brown, ca. 1.1 mm long; segment 2 gently curved, retractor spine located at ca. 2/3 length, ca. 1.1 mm long; segments 3 and 4 ca. 1.0 mm long excluding filaments (cornua), medial lobe with lateral setal tufts, cornua forked, lanceolate, with apices decurved, and ca. 0.7 mm long; lateral lobes black apically extended to ca. middle of cornua; internal lobes white, decurved apically,

extended to ca. 2/3 length of cornua; posterior lobe robust, curved ventrally at apex, extended to ca. 2/3 length of cornua.

Female.--Total length 29.5-35.0 mm, abdomen including cerci 20.0-24.5 mm, cerci 0.9-1.1 mm, hind femora 4.4-5.5 mm, hind wings 22.0-27.5 mm, pterostigmata 2.1-2.5/2.1-2.5 mm.

Head: as in male.

Thorax: as in immature male with lateral portions yellowish white, occasionally as in mature male.

Legs: as in male with inner surface of hind femora often predominantly yellowish brown.

Wings: venation brown, yellow proximal to cubital-anal crossvein; costa brown with medial yellow streak; pterostigmata red, proximally and distally yellowish red dorsally and white ventrally, veins along anterior and posterior margins thickened, black; membrane hyaline, fore wing transparent saffron at extreme base, hind wing transparent saffron proximal to cubital-anal crossvein; membranule white. Antenodal crossveins 6-8, 6-8/4-6, 4-6 (5-77%, 6-23%), postnodal crossveins 5-8/6-10, supratrangles and hind wing triangle 1-celled (occasionally 2-celled), subtriangles 3-celled, fore wing triangle 2-celled; 1 or rarely 2 bridge crossveins; radial and median planates subtend 1 cell row; crossveins under pterostigmata 1-2/1-2; anal loop 16-22-celled.

Abdomen: golden yellow marked with black (mature females occasionally colored as in male, black lateral triangular areas largely separated from black line along lateral carinae on segments 3-5 to 3-7, black triangular areas 2/3 to as long as respective terga. Terminalia yellowish brown.

Genitalia: vulvar lamina bilobate, ca. $\frac{3}{8}$ as long as sternum 8 (ca. 0.5 mm long), in ventral view with apices directed posteriorly, in lateral view ca. $\frac{1}{2}$ as high as long with apices subacute and directed posterodorsally.

Larva (exuviae).--Total length 13.5-15.5 mm, abdomen 8.6-9.8 mm, hind femora 3.5-4.1 mm, prementum 4.5 mm.

Head: palpal setae 10 (end hook not included), premental setae 11-13.

Thorax: hind femora extended to ca. middle of segment 7.

Abdomen: long-ovoid in shape, widest at segments 5 and 6; dorsal spines on abdominal segments 4 or 5-8, that on 4 generally vestigial, that on 6 largest; lateral spines present on segments 8 and 9, that of 8 ca. $\frac{1}{8}$ as long as lateral margin of segment (spine included), that of 9 ca. $\frac{1}{4}$ as long as lateral margin of segment; epiproct ca. $\frac{7}{8}$ length of paraprocts, cerci ca. $\frac{4}{7}$ length of paraprocts.

Remarks.--*Sympetrum janeae* is closely related to *S. rubicundulum* and *S. obtrusum*. The new species is sympatric with *S. obtrusum* throughout its range, while its range overlaps that of *S. rubicundulum* in a band extending from Virginia to New York and Canada. The almost mutually exclusive distributions of the latter case suggest that hybridization may be occurring. However, the distinctiveness of the two along such an extensive front seems to preclude the recognition of subspecies. Mixed pairs are actually quite common in *Sympetrum* and have been comprised of such distantly related species as *S. daneae* and *S. obtrusum* (Whitehouse 1941) and *S. costiferum* and *S. internum*. *Sympetrum obtrusum* and *S. rubicundulum* are often captured in tandem, but no mixed pairs of *S. rubicundulum* or *S. obtrusum* with *S. janeae* are yet known. In

addition to the characteristics mentioned in the key a few aspects of the color pattern will also generally help distinguish it from its nearer relatives. The face of *S. janeae* is white with a tinge of yellow, and in *S. rubicundulum* it is predominantly yellow, and in *S. obtrusum* it is white. The femora of *S. janeae* are black with generally only the inner surfaces of the fore and middle femora pale yellow, in *S. rubicundulum* the femora are often predominantly yellow, and in *S. obtrusum* they are black with generally only the inner surfaces of the front femora pale yellow. The abdominal color pattern in *S. janeae* and *S. obtrusum* is composed of a series of lateral black triangles which are generally confluent with the black lateral carinae of each segment for its entire length. In *S. rubicundulum* the lateral black triangles are smaller (about 1/2 length of segments) and generally separated anteriorly from the black band along the lateral carinae. The size of the three species also differs; the size of *S. rubicundulum* ranges from 31-40 mm, that of *S. obtrusum* 30-38 mm, and that of *S. janeae* 32-36 mm. The nymph of *S. janeae* differs from that of related species by having a vestigial dorsal hook on abdominal segment 4, by having a well-developed dorsal hook on segment 8, and by having the lateral spine of segment 8 ca. 1/4 the length of segment 8 including the spine.

Needham and Fisher (1936) established *Tarnetrum* which was distinguished from *Sympetrum* by the absence of dorsal abdominal spines in the nymph, and the presence of an additional transverse carina of abdominal segment 4 in the adult. Borror (1945) listed the following species in *Tarnetrum*: *T. illotum* (Hagen), *T. corruptum* (Hagen), *T. nigrocreatum* (Calvert), *T. virgulum* (Selys), and *T. gilrum* (Hagen). Although Needham

and Westfall (1955) attributed generic rank to *Tarnetrum* this status has not been supported by Gloyd and Wright (1959) or Walker and Corbet (1975). The latter authors also placed *S. madidum* in the subgenus *Tarnetrum* based on the double row of cells subtended by the radial planate, an apparent similarity of the genitalia, and the assumed incorrect association of its nymph as described by Needham (1904). The shape of the abdomen, male cerci, and genitalia, in addition to the lack of an additional transverse carina on abdominal segment 4 indicates that *S. madidum*, although aberrant, should probably be placed in *Sympetrum*. *Tarnetrum* is here considered a distinct genus because both the nymph and adult differ from *Sympetrum* in several respects ranging from body shape to penile structure.

Etymology.--*S. janeae* [jane'ae] (English given name Jane; M. L. gen. noun *janeae* "Jane's", in honor of my wife.)

BIOLOGY

Little is known about the nymphal habitat, but the location of exuviae and oviposition sites indicate a preferred habitat most similar to that of *S. obtrusum*. The preferred habitat of *S. janeae* is apparently the temporary pools of marsh areas. In contrast the related *S. rubicundulum* seems to prefer the stands of emergent vegetation along ponds, lakes, and slow streams. During the period following emergence the adults are commonly found in open fields generally within a hundred meters of the larval habitat. The female apparently does not oviposit in tandem as do many other *Sympetrum*. Other species of *Sympetrum*

commonly associated with the new species include *S. obtrusum*, *S. vicinum*, and *S. costiferum*.

DISTRIBUTION OF AND KEY TO THE *SYMPETRUM* SPECIES OF AMERICA

DISTRIBUTION

Of the twelve American *Sympetrum* five have a transcontinental distribution, four are limited to western North America, and three are limited to eastern North America. The known distributions of American *Sympetrum* are as follows: *S. ambiguum*: U.S.A.: AL, AR, FL, GA, IL, IN, IA, KS, KY, LA, ME, MD, MA, MI, MN, MS, MO, NE, NJ, NC, OH, OK, PA, SC, TN, TX, VA; Canada: Ont.; -- *S. costiferum*: U.S.A.: CA, CT, ID, IA, ME, MA, MI, MO, MT, NE, NV, NH, NY, OH, OR, PA, RI, SD, UT, VT, WA, WI, WY; Canada: Alta., B.C., Man., N.B., Nfld., N.W.T., N.S., Ont., Que., Sask.; -- *S. danae*: U.S.A.: AK, CA, CO, KY, IL, ME, MI, NV, NH, NY, OH, OR, UT, VT, WY; Canada: Alta., B.C., Man., N.B., Nfld., N.W.T., Ont., Que., Sask.; also Europe and Asia; -- *S. internum*: U.S.A.: AK, CA, CO, ID, IL, IN, IA, KS, KY(?), MI, MN, MO, MT, NE, NV, ND, OK, OR, PA(?), SD, UT, WA, WI, WY; Canada: Alta., B.C., Man., N.W.T., Nfld.(?), Ont., Que(?), Sask.; -- *S. janeae*: U.S.A.: CT, DE, ME, MD, MA, NH, NJ, NY, PA, VT, VA; Canada: Que.; -- *S. madidum*: U.S.A.: CA, CO, MO, MT, NV, OR, WA, WY; Canada: Alta., B.C., Man., N.W.T., Sask.; -- *S. obtrusum*: U.S.A.: CA, CO, ID, IL, IN, IA, KS, KY, ME, MD, MA, MI, MN, MT, NE, NH, NJ, NY, NC, ND, OH, OR, PA, RI, SD, UT, VT, VA, WA, WV, WI, WY; Canada: Alta., B.C., Man., N.B., N.S., N.W.T., Ont., P.E.I., Que., Sask.; -- *S. occidentale*:

U.S.A.: CA, ID, NV, OR, UT, WA, WY; Canada: Alta., B.C.; -- *S. pallipes*:
 U.S.A.: CA, CO, MT, NE, NV, OR, TX, UT, WA, WY; Canada: Alta., B.C.; --
S. rubicundulum: U.S.A.: CO, CT, D.C., GA, ID, IL, IN, IA, KS, KY, MD,
 MA(?), MI, MN, MO, NE, NV, NJ(?), NY, NC, OH, PA, SD, TN, UT, VA, WV,
 WI, WY; Canada: Ont., Que.(?); -- *S. semicinctum*: U.S.A.: CT, D.C., IL,
 IN, IA, KY, ME, MD, MA, MI, MN(?), NH, NJ, NY, NC, OH, PA, RI, TN, VT,
 VA, WV, WI; Canada: N.B., N.S., Ont., Que.; -- *S. vicinum*: AL, AR, CO,
 CT, D.C., DE, FL, GA, ID, IL, IN, IA, KS, KY, LA, ME, MD, MA, MI, MN,
 MS, MO, NE, NH, NJ, NY, NC, OH, OK, PA, RI, SC, TN, TX, VT, VA, WA, WV,
 WI, WY; Canada: B.C., N.B., N.S., Ont., Que.

SPECIES KEY TO THE ADULTS

1. Male cerci convex dorsally in lateral view, each without prominent ventral tooth; genital lobes spatulate, lobes and posterior hamuli directed posteroventrally; vulvar lamina apparently absent, represented by posteroventrally directed emarginate or entire margin of sternum 8 2
- Male cerci concave dorsally in lateral view, each with prominent ventral tooth; genital lobes triangular, lobes and posterior hamuli directed posteriorly; vulvar lamina present, bilobate . . 7
2. Hind wings predominantly transparent saffron over basal half; abdominal segment 9 with lateral carinae 3
- Hind wings predominantly hyaline over basal half; abdominal segment 9 without lateral carinae 4

3. Pterothorax with upper portions of pleural sulci and lower portion of intersegmental interface black; face whitish yellow; genital lobe obovate, strongly constricted basally; female with posterior margin of sternum 8 entire *S. occidentale* Bartenev
- Pterothorax without upper portions of pleural sulci and lower portion of intersegmental interface black; face yellowish brown; genital lobe elongate, slightly constricted basally; female with posterior margin of sternum 8 emarginate *S. semicinctum* (Say)
4. Fore wings with radial planate subtending 2 cell rows; pterothorax with pale lateral stripes; posterior hamuli with dorsolateral lobe broadly rounded apically; female with apex of vulvar lamina directed posteriorly *S. madidum* (Hagen)
- Fore wings with radial planate subtending 1 cell row; pterothorax without pale lateral stripes; posterior hamuli with dorsolateral lobe not broadly rounded apically; female with apex of vulvar lamina posteroventrally 5
5. Lateral abdominal carinae not black; legs predominantly yellow; genital lobe more than 2 times as long as wide; female with posterior margin of sternum 8 in lateral view ca. as long as segment 8 *S. vicinum* (Hagen)
- Lateral abdominal carinae black; legs predominantly black; genital lobe less than 2 times as long as wide; female with posterior margin of sternum 8 in lateral view shorter than segment 8 . . . 6

6. Pterostigma yellow or red dorsally; metanepisterna without transverse black area above spiracles; posterior 1/3 of abdominal terga 8 and 9 not black; posterior hamule with ventromedial hook shorter than dorsolateral lobe; posterior margin of sternum 8 in lateral view ca. as long as segment 10 *S. costiferum* (Hagen)

Pterostigma brown or black dorsally; metanepisterna with transverse black area above spiracles; posterior 1/3 of abdominal terga 8 and 9 black; posterior hamule with ventromedial hook ca. as long as dorsolateral lobe; posterior margin of sternum 8 in lateral view ca. as long as segment 9 *S. danae* Sulzer

7. Abdominal segments 4-9 with black apical annulations; posterior surface of head without ridges; posterior hamuli each with dorsolateral lobe shelflike internally and rounded apically in ventral view; vulvar lamina ca. 4 times as wide as long
 *S. ambiguum* (Rambur)

Abdominal segments 4-9 without black apical annulations; posterior surface of head with ridges; posterior hamuli each without dorsolateral lobe shelflike internally and rounded apically in ventral view; vulvar lamina ca. as wide as long 8

8. Pterothorax with lateral pale stripes; abdominal terga 4-9 without posteriorly widened black lateral spots; external surface of tibiae yellow or brown *S. pallipes* (Hagen)

Pterothorax without lateral pale stripes; abdominal terga 4-9 with posteriorly widened black lateral spots; external surface of tibiae black 9

9. Costa yellow with black spines; hind wings each with 4 cell rows between inner side of anal loop and wing margin; face yellowish red at maturity; vulvar lamina with ventral ridges curved posterolaterally *S. internum* Montgomery
- Costa not yellow with black spines; hind wings each with 3 cell rows between inner side of anal loop and wing margin; face not yellowish red at maturity; vulvar lamina with ventral ridges directed posteriorly 10
10. Face predominantly yellow; hind femora generally predominantly yellow; posterior hamuli each without mesal processes on dorso-lateral lobe; vulvar lamina inflated, ca. as high as long
. *S. rubicundulum* (Say)
- Face predominantly white; hind femora predominantly black; posterior hamuli each with mesal processes on dorsolateral lobe; vulvar lamina not inflated, ca. 1/2 as high as long 11
11. Posterior hamuli each with dorsolateral lobe acuminate apically and obtuse-angulate medially, and with ventromedial hook extended posteriorly beyond dorsolateral lobe; ventral surface of vulvar lamina convexly curved to blunt posterodorsally directed apices
. *S. januae* n. sp.
- Posterior hamuli each with dorsolateral lobe truncate apically and tuberculate medially, and with ventromedial hook not extended posteriorly beyond dorsolateral lobe; ventral surface of vulvar lamina flatly tapered to acute posteriorly directed apices
. *S. obtrusum* (Hagen)

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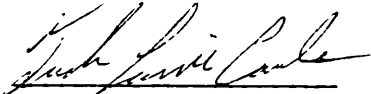
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VITA

Frank Louis Carle was born October 29, 1949. He graduated from Watchung Hills Regional High School, New Jersey, in 1968. Mr. Carle received his Bachelor of Science in Forestry and Wildlife from the University of Vermont in 1972 and began graduate work at Virginia Polytechnic Institute and State University as a research assistant on a biological survey of the Upper James River, Virginia. He was married to Carol Jane Greenwood in 1973. He later worked as a biological consultant and became field coordinator for an evaluation of stream channelization in Virginia. Mr. Carle received his Master of Science in Wildlife and Fisheries at Virginia Polytechnic Institute and State University in 1976 and began doctoral work in the Department of Entomology at the same institution. He was granted a U.S. patent for the Circular Depletion Sampler in 1978 and has published several scientific papers on aquatic sampling and on the taxonomy of aquatic invertebrates.



Frank Louis Carle

A CONTRIBUTION TO THE KNOWLEDGE OF THE ODONATA

by

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(ABSTRACT)

Theories concerning the origin of insect wings and flight are reviewed and a new scenario for their origin proposed. It is suggested that environmental conditions of the small stream were responsible for the evolution of insect flight, and that thermoregulation as well as respiration was important in the preadaptation of wings. The possibility that the five paired convex-concave vein systems each represented a dorsal-ventral blood channel is suggested.

Odonate wing vein homology and nomenclatural systems, and phylogeny are reviewed. The process of vein loss is evaluated in the Palaeoptera and a new system of odonate wing vein homologies proposed. The odonate wing mechanism is analyzed and the heretofore overlooked discal nodus characterized. Reevaluation of the comparative morphology of fossil and recent Odonata indicates that Protozygoptera and Protanisoptera represent evolutionary side branches, that the Anisozygoptera is polyphyletic, and that Isophlebiidae and Calopterygoidea are the most generalized Odonata known.

Previous scenarios explaining evolution of the unique odonate copulatory process are reviewed. Considering the copulatory behavior of the Calopterygoidea generalized supports evolutionary trends toward male domination and in-flight completion of the process. Assuming direct

sperm transfer the original odonate mode requires that originally oviposition be in tandem and that sperm transfer to and from male anterior abdominal sterna be accidental. In contrast, assuming an original indirect transfer of sperm leads to a copulatory sequence similar to that of the Odonata. The proposed scenario differs from others in that extraordinary postures are not envisioned, the process is completed at rest, and the odonate tandem hold is developed prior to copulation.

Anisopteran morphology and phylogeny are reviewed and reliable identification keys developed for North American families and genera, and for 180 anisopteran species collected in Virginia and vicinity. Each species is described and photographed, including seven new species. The biogeography of Virginia Anisoptera is best explained by overlapping biotic regions, the fauna being a mixture of eastern North American, boreal, and tropical elements. New efficient methods for collecting, preserving, and rearing Odonata are described.