CHIONODES MEDIOFUSCELLA (CLEMENS) (LEPIDOPTERA:GELECHIIDAE), AN INDIGENOUS INSECT INFESTING THE SEEDS OF GIANT RAGWEED (AMBROSIA TRIFIDA L.)(COMPOSITAE)

by

Gary Leonard Cave

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APPROVED:

R. L. Pienkowski, Chairman

W. A. Allen

L. T. Kok

J. M. Grayson

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TO

MY PARENTS

It's a little wheel, and a long road,
and it takes a lot of turns to get there ...

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I. GENERAL INTRODUCTION

From the ecological perspective, the salient feature of man's effect on the earth is the production of disturbed soil (Bunting 1960). Even the most primitive of tribes had temporary settlements where rubbish accumulated, and where the surrounding vegetation had been cut for shelter and fire. During the daily activities around these campsites, paths became a feature of the surrounding landscape. These paths then became bordered by heliophilic trailside weeds; seeds and roots were dropped, some of which became established. Collecting areas where foods such as roots, grubs, and rodents were dug from the ground, also became infested with weeds. Fire was another potent means of disturbing the vegetation. The use of fire cleared the ground and expedited the gathering of nuts, acorns, and other foodstuffs. Fire was also used as a hunting device, and in this way, large tracts of land became modified (Sauer 1944, 1947). As populations increased, larger areas became disturbed. These modified areas became colonized by aggressive pioneer plants, many of which are classed as weeds.

In order to function as a primary invader, a plant must be endowed with special adaptations: it must be able to withstand the rigors of an open environment, i.e., the absence of shading, extreme fluctuations in temperatures,

and high surface evaporation rates; it must have an efficient means of dispersal, which may be accomplished vegetatively by rhizomes, tubers, and stolons, or by seeds; it must produce abundant seeds with a high germination capacity; it must be capable of seed set even under unfavorable conditions; its seeds must be capable of surviving unfavorable conditions, which is usually accomplished by some form of dormancy; and finally, it must have a capacity for rapid extension or regeneration of the root system after germination or disturbance (Gill and Vear 1958; Bunting 1960). These characteristics are typical of those weedy plants which compete with man, and make them candidates for some type of control.

Biological control is one such means of control. In the past 75 years, it has proven to be safe, economical, and efficient. At the present time, there are about 78 plant species under consideration for biological control (Goeden, et al. 1974). Workers in many disciplines are using a wide range of biotic agents in these control projects. Included are: mammals (Allsopp 1960; Bertram and Bertram 1962, 1964); fish (Swingle 1957; Hickling 1965; Cross 1969; Blackburn et al. 1971; Sneed 1971; Michewicz 1972; van Zon 1974); invertebrates other than insects (Seaman and Porterfield 1964; Blackburn et al. 1971); nematodes (Ivanikov 1969); plant pathogens (Wilson 1969;

Inman 1971; Charudattan 1972; Hasan 1972, 1974; Hayslip and Zettler 1972; Rintz 1972; Cullen et al. 1973; Hasan and Wapshere 1973; Chiarappa 1974); parasitic plants (Rudakov 1961); competing plants (van Zon 1974; Yeo and Fisher 1976); and insects (Holloway and Huffaker 1951; Huffaker and Kennett 1959; Frick and Holloway 1964; Zeiger 1967; Andres and Goeden 1971; Surles et al. 1974; Andres et al. 1976; and many others).

Andres et al. (1976) cited some successful projects in weed biocontrol: Pricklypear cacti (Opuntia spp.) have been reduced from over 60 million acres of Australian rangeland to just a fraction of their former density by the moth Cactoblastis cactorum (Berg); St. Johnswort or Klamath weed (Hypericum perforatum L.) has been reduced to less than one percent of its former abundance by two beetles, Chrysolina quadrigemina (Suffrain) and C. hyperici (Forster); Lantana (Lantana camara L.) has been reduced in many areas throughout the world by a variety of insects (Huffaker 1959; Wilson 1964).

The aforementioned projects have been directed toward control of perennial weeds; very few have aimed at the reduction of annual species. At the present time, several annual weed projects are underway; Emex (Emex spinosa Campd. and E. australis Steinh.) have been reduced by the weevil Apion antiquum Gyll. in Hawaii (Wilson 1964; Anon. 1968);

Puncturevine (Tribulus terrestris L.) has the possibility of being reduced by two weevils, Microlarinus lareynii (Jacq. du Val.), a seed infesting weevil, and M. lypriformis (Woll.), a stem and crown miner. Even though the effectiveness of these weevils is being reduced by native predators and parasites, they have reduced the density of the weed in some areas of California (Goeden and Ricker 1967; Andres and Goeden 1971), and Hawaii (Andres and Goeden 1971). Thistles (Carduus nutans L., and C. acanthoides L.) are currently being studied in Virginia. Their control by the introduced weevil Rhinocyllus conicus Froehl., looks promising (Surles et al. 1974).

Ambrosia spp. (ragweeds) are noxious weeds which are the primary cause of hayfever in this country. Although all the Ambrosia species are capable of causing hayfever, only four species, giant ragweed (Ambrosia trifida L.), common ragweed (A. artemisiifolia L.), southern ragweed (A. bidentata Michx.), and western ragweed (A. psilotachya Gray) are numerous enough to be important. However, the giant and common ragweed species account for more hayfever than all other plants combined (Durham 1951; Wodehouse 1971).

Biological control of ragweed by insects is desireable due to insect adaptation to the host plant, and the self-perpetuating and non-polluting characteristics of the

method. Chionodes mediofuscella (Clemens) is a possible agent for control in areas where it is not now found. Although little information is available on this insect, a review of the literature has shown that this moth is probably host specific. It is not known to be a pest of any economic crops. Therefore, the primary objectives of the present study were to describe the biology of this organism, both in the field and in the laboratory, and to develop methods for maintenance of a laboratory colony by the use of either living ragweed plants or artificial diets. A secondary objective was to establish a pollen baseline in order to evaluate the efficacy of future control efforts.

II. LITERATURE SURVEY

History of the genus Ambrosia

The name Ambrosia is familiar to most readers of classical mythology. It was this substance, which, when combined with nectar, was the principal food of the gods; it also imparted immortality to all who ingested it. The word itself is of Greek origin and means "not mortal".

The generic name Ambrosia was established by Linneaus in 1753 (Lanjouw et al. 1961), although other workers (Bauhin 1671; Hermann 1687; Plukenet 1696; Morison 1699; Tournefort 1700) had used this epithet in describing plants of the same general nature. Linneaus (1753) recorded four species of Ambrosia. In 1793, Cavanilles created the closely related genus Franseria, and subsequent workers freely exchanged specific names between Ambrosia and Franseria (Payne 1962). DeCandolle (1836) recognized 23 species of Ambrosia; Rydberg (1922) listed 21 species and 39 synonyms; the Index Kewensis (1895-1955) lists 63 species under the genus Ambrosia. Payne (1963, 1964) presented evidence that Franseria and Ambrosia were congeneric, and combined them under the generic name Ambrosia. This synonymy brought the number of species, worldwide, to 41, with 39 being American. Of these, 31 species are essentially North American, and 8 species are South American. A few of the North American species are adventives in Europe (Payne 1966,

1970; Harris and Piper 1970). Payne (1962, 1970) also presented evidence that the Ambrosia belongs in the tribe Ambrosieae (this tribe also contains the closely related genera Iva, Xanthium (Johns 1929; Payne 1970), Euphrosyne, Diocria, and Hymenoclea (Payne 1970).

Origin and Distribution of Ambrosia

Ragweed is indigenous to America (Harper 1908). Payne (1962, 1964, 1966) stated that the Ambrosia archetype originated and diversified in the Sonoran Desert region of Mexico and the extreme southwestern portion of the United States. He stated (1966) that as the regweeds evolved, they spread out, first to the less arid regions surrounding the Sonoran region, then to the northern and eastern limits of their range. Two examples will serve to show the dispersal of the ragweeds. Giant ragweed (Ambrosia trifida L.) extends from Quebec to North Carolina, and west to Colorado and British Columbia (Wodehouse 1971). Common ragweed (A. artemisiifolia L.) spans the United States, extending from the Atlantic to the Pacific through southern Canada, and as far south as southern Florida (in the east), and northern California (in the west) (Wodehouse 1971). Mexico, South America, and the West Indies are also within the natural range of ragweed distribution (Bentham 1873). Only two species, A. senegalensis DC, and A. maritima L. have been reported to be

extra-American (Payne 1966). He believed however, that this latter species is just a geographical form of A. artemisiifolia.

Several species of ragweed have been reported from different parts of the world: Walton and Dudley (1947), and Walton (1955) reported that ragweeds are moving westward across Canada; A. artemisiifolia has been collected in Italy (Volteranni 1954); France (Lewalree 1947, in Payne 1962); Bonnot 1967; Desheraud and Rochan 1969); Sweden (Simmons 1928; Helander 1960); Japan (Hisauchi 1953; Numata and Yamai 1955; Numata and Suzuki 1958); Portugal (Da Silva et al. 1971); Belgium, Germany, and Austria (Lewalree 1947, in Payne 1962); Russia (Kuvika 1956; Bezruchenko and Chukarin 1956; Vasil'ev 1959; Khvalina 1963); A. trifida from Sweden (Simmons 1928); Belgium and France (Lewalree 1947, in Payne 1962); A. bidentata Michx. from Germany (Lewalree 1947, in Payne 1962); A. aptera DC from Germany (Lewalree 1947, in Payne 1962); A. coronopifilia T. & G. from Belgium, France, Germany, and Switzerland (Lewalree 1947, in Payne 1962); A. tenuifolia Gren. and Godr. from France and Holland (Lewalree 1947, in Payne 1962); A. helenae Rouleau from France (Lewalree 1947, in Payne 1962); and A. psilotachya Gray from Italy (Vignolo-Lutati 1939).

The northward and southward radiation of the ragweeds is limited by photoperiod. Ragweeds are short day plants,

i.e., they flower when the days begin to shorten and the photophase is less than 15 hours (Arthur and Guthrie 1926; Allard 1932, 1943, 1945). In general, the ragweeds have a sparse distribution north of the 50° latitude (Allard 1943). Praeger (in Allard 1943) made no mention of ragweed in Ireland (which lies between parrallels 51° amd 55°23' north). Moss (1956), and Bassett (1959) reported common ragweed in Canada at latitude 53°30'. Maximum reproduction however, occurs between 45° and 30°-35°, provided the environment is favorable in other respects (Allard 1943).

There is evidence that suggest that the early radiation from the Sonoran Desert was a slow process. In pre-colonial times, the ragweeds occupied a recessive position. They were generally restricted to riverbanks, flood plains, deltas, erosion gullies, and disturbed areas. Thus, the ragweed were confined to small, scattered, temporary areas (Wodehouse 1971). It was the ecological exigencies of these ruderal habitats that probably selected for anemophily in these plants. By virtue of anemophily, ragweeds produced large quantities of light pollen which was widely and abundantly scattered in the areas inhabited by these plants. The great amounts of pollen also assured that these pollens would be well preserved in materials such as lake sediments and peat (Payne 1962).

The scarcity of ragweeds in prehistoric America has

been confirmed by palynological studies (Davis 1958; Martin 1958; Ogden 1960; Bassett and Terasmae 1962). These studies also confirm that the ragweeds are ancient inhabitants of America. Ogden (1960) reported Ambroseae pollen from sediments in a raised bog in Nova Scotia to be as much as 8,000 years old. Bassett and Terasmae (1962) reported pollen from Canadian sediments to be from 5,000 to 12,000 years old. Martin (1958) reported pollen from Pennsylvania to be 13,500 years old. Davis (1958) dated pollen from Massachussetts to be 10,000 years old. Additionally, Spear and Miller (1976) dated some New York pollen sediments ca. 11,000 to 12,500 years old. Payne (1962) cited data from Ontaria and Quebec that report ragweed pollen to be at least 60,000 years old.

Historical Use of *Ambrosia* Plants

Man's earliest interest in ragweed can be traced to the so called Ozark Bluff-dweller culture (Harrington 1924a, b). The bluff-dwellers are believed to be contemporaneous with the Basket-maker culture of southern Utah, which antedates the earliest Pueble culture (Gilmore 1931). The earliest Pueblo culture is dated approximately 900-1300 A. D. These people stored the seeds of *A. trifida* in cache-pits along with seeds of several species of cultivated plants (Harrington 1924a; Gilmore 1931; Blake 1939; King and McMillan 1975). It is believed, that these seeds represent

a strain of ragweed that was cultivated (Harrington 1924a; Gilmore 1931; Blake 1939). The evidence for this lies in the fact that the seeds were stored in great numbers, and were uniformly large and light colored. Based on this, plus experimental evidence, Rosseau (1944) proposed that these plants were produced by polyploid individuals, and that this was enough to constitute a new variety (A. trifida L. var. polyploidea). Payne and Jones (1962) reexamined these fruits and contested not only the polyploid nature of the plants, but also the idea that these plants had been cultivated or used as a food-stuff by the bluff-dwellers. However, they could not determine the exact use of these fruits.

Ragweeds have been reported by various authors to have uses other than as food-stuffs: Gilmore (1931), and Blake (1939) reported that A. trifida may have been used as a dye or stain by precolombian indians. Gilmore (1931) also reported that both the Arikara and Omaha Indians used the flower heads of A. trifida to make a red stain. The flowering heads were used by the Arikaras as a bait for snaring birds (Gilmore 1931). Roedel and Thornton (1942) determined the properties and composition of common ragweed oil. They stated that the oil has better drying properties than soybean oil, and could be used in paints and varnishes. They also suggested that this oil may be edible due to its

relative freedom from linolenic acid. Robinson et al. (1947) have indicated that the zinc deposits in limestone residual soils may be revealed by analyzing the zinc content of common ragweed. Tracey (1895), Peter (1896), and Dustman and Shriver (1931) suggested that because giant ragweed has a high nitrogen content, and a low percentage of fiber, it has value as forage. Peter (1903) and Ince (1915) suggested that giant ragweed would make a suitable fertilizer due to its high nitrogen and ash contents; Ince (1915) reported that one ton (green weight) of giant ragweed removes enough fertility from the soil to grow approximately five bushels of wheat. According to Schulz (1928), Early American farmers used the pith of giant ragweed to stop leaks in water tanks. Stevens (1948) reported that Indians used the bast fibers from the "bark" of giant ragweed to make coarse thread and cord. Payne (1962) stated that one specimen of A. hisipida Pursh, collected on a Caribbean Island, carries the notation that this species was cultivated in many gardens as an ornamental plant.

A number of medicinal uses have been ascribed to various ragweed species. Altschul (1973) reported that A. psilotachya Gray, A. cumanensis H. B. & K. (from El Salvador), A. velutina Schulz (from the Dominican Republic), A. tenuifolia Gren. and Godr., A. ambrosioides (Cav.) Payne, A. confertiflora DC (from Mexico), and A. artemisioides

Meyen and Walp. (from Ecuador), have aromatic properties; A. tenuifolia is used as a bitters; A. hispida is used on the Bahama Islands as a purgative; A. artemisioides, is used in Ecuador for stomach ailments; A. cordifolia (Gray) Payne is used in Mexico as a topical irritant of the skin and eyes; and A. ambrosioides is used in the treatment of women's diseases. Bausor (1937) reported that in the northeastern United States, a fluid extract of A. artemisiifolia is used as an astringent, used locally to stop bleeding, and is a bitter tonic sometimes used for indigestion. Allard and Allard (1946) stated that in the Dominican Republic, A. monophylla (Walt.) and A. paniculata Michx. are cultivated and sold for use as poultices. Uribe (1940, in Payne 1962) has reported that in Colombia, A. artemisiifolia is used as an emollient and vermifuge. Uphof (1968) and Usher (1974) have reported on the medicinal uses of many ragweed species from other parts of the world.

Economic Importance of Ambrosia

It is evident from the preceding discussion that ragweeds have been known and used by man for a long time. It is only in the past century that ragweeds and man have begun their antagonistic relationship, for the ragweeds are the primary cause of late season hayfever (medically termed allergic rhinitis)(Harris and Shure 1969).

The symptoms of hayfever were first described scientifically by an Italian, Botallus de Pavie in 1565 (Harris and Shure 1969; Rapaport and Linde 1970). But it was not until 1828 and the publication of Dr. John Bostock's treatise, "Of Catarrhus Aestivus or Summer Catarrh", that the term hayfever was first used (Harris and Shure 1969; Rapaport and Linde 1970). Bostock, a hayfever/asthma victim, noticed that his symptoms first appeared around June, and stopped in mid-July. This period coincided with the hay harvest. W. R. Kirkman (1852) and C. H. Blakley (1859) (Harris and Shure 1969; Rapaport and Linde 1970), two English physicians, were the first to demonstrate that hayfever was caused by grass pollen. Morril Wyman (Harris and Shure 1969), a Massachusetts physician was the first person to show that ragweed pollinosis was the cause of late summer hayfever in the United States. In 1907, Von Pirquet (Harris and Shure 1969; Stanley and Linskins 1974) proposed the term allergy to describe the reactions produced when a foreign substance produced a reaction in a susceptible host. Noon (1911) and Freeman (1911) were the first physicians to successfully treat allergy by desensitizing patients with pollen injections.

Since 1911, much research has been undertaken in the allergy field. These studies have revealed that allergic reactions may occur in many different tissues or organs.

The shock organ, i.e., that organ involved in the allergic reaction, may be the lower respiratory tract, lungs, bronchi, skin (urticaria), gastro-intestinal tract, central or peripheral nervous system, or the cardio-vascular system (Stanley and Linskins 1974).

For a substance to be an important cause of respiratory allergy, it must be contained in the inhaled air in relative abundance, and release a chemical antigen (allergen) which fulfills certain chemical criteria (Wittig et al. 1970, in Stanley and Linskins 1974). The antigen should: 1) be foreign to the species; 2) in general, have a molecular weight of over 10,000; 3) the molecular structure should possess a certain rigidity, as is usually conferred by aromatic groups, disulfide linkages, or double bonds; 4) the molecular surface configuration must afford polar groups for attracting antibodies and conveying specificity; 5) be metabolized by the body in a specific period of time. To this list, the following, known as Thomman's Postulates, should be added (Feingold 1973; Rudolph and Rudolph 1974): 6) the plant must be seed bearing, i.e., produce pollen; 7) must have wide distribution, or its relation to the patient's environment must be close and dominant; 8) the plant must produce large quantities of pollen; 9) pollen should be light and airborne; 10) pollen must contain the percipitating factor, i.e., be allergenic.

The hayfever season in the United States has been divided into three periods, corresponding to the pollination of the three principal plant groups causing the disease: trees, grasses, and weeds. All three last approximately two months. The tree period can begin as early as January and end as late as April. The grass period generally begins in early March, peaks in May, and may last until late June. The weed period may begin as early as June or July, or as late as August, and ends in October (Feingold 1973; Rudolph and Rudolph 1974). Feingold (1973) rated the three periods on a 1-10 scale, (10 being the most severe), according to their pollen production and allergenicity. Trees rate as a 4; grasses 7; and weeds 10. In the weed group, the most important causes of allergic rhinitis are the ragweeds.

The rapidity with which the ragweeds have increased from plants of minor importance to ones of dominance is demonstrated by the following statistics: in 1919, approximately 1½-2% of the population suffered from hayfever. By 1939, this figure had increased to 3% (Wodehouse 1939). In the period from 1951 to 1962, it was estimated that 5% to 20% of the population was afflicted with hayfever in the United States and Canada (Durham 1951; Goodwin et al. 1957; Bassett 1959; McMahon 1959; Weinstein 1959; Payne 1962). It was also estimated that 90% of these people had hayfever due to ragweed pollen (Wolf and Ahlgren 1950; Rudolph and

Rudolph 1974).

Hayfever sufferers not only endure hayfever, but many of them (30-65%) also develop asthma (Sacks 1956; Goodwin et al. 1957; Rihm 1959; McMahon 1959; Howison 1967). Additionally, the mortality among men with asthma is 64% in excess of the Basic Mortality Table (Sacks 1956). A 1935-36 National Health Survey report listed hayfever/asthma as ranking fourth in prevalence among chronic diseases (Sacks 1956; Weinstein 1959). By 1958, this disease ranked third, after cancer and heart ailments, on the chronic disease list (Rihm 1959).

In addition to asthma, hayfever sufferers may be plagued with seasonal conjunctivitis, hives or eczema. A few even develop seasonal vaginitis (Solomon 1967). Concomitantly, the swollen respiratory passages of the hayfever victim are prone to bacterial overgrowth, and disability due to infection of nose, paranasal sinuses, middle ear, and bronchi often continues long after the pollen has disappeared (Solomon 1967). Many other synergistic effects may also develop in the hayfever sufferer (see Solomon 1967).

Hayfever is a million dollar disease. It has been reported (Sanders 1970 in Stanley and Linskins 1974) that in 1969, hayfever cost U. S. industry approximately 400 million dollars in lost wages. Domestic, annual retail sales of anti-allergy medication for 1974-75 amounted to

$53,245,000 (Anon. 1976).

Ragweeds are not only big business in the medical/industrial field, but they are also important agriculturally. Several species of ragweed, but especially common ragweed, are pests of several crops in the Northeastern, North-central, and Southern United States (USDA 1972). Brubaker and Reaves (1954) reported that giant ragweed leaves an off-flavor in milk when eaten by dairy cows.

The Importance of Anemophily to Hayfever

There are two groups of plants with regard to pollination: 1) animal pollinated (zoophilic or entomophilic), and 2) wind pollinated (anemophilic). Zoophilic plants are usually of little consequence in allergic reactions. These plants usually have conspicuous, inviting flowers; nectar to attract animals; and a small amount of sticky pollen. Anemophilic plants have none of these properties. The flowers are usually simple or incomplete; they lack petals, nectaries, and frequently sepals. They may be monoecious or dioecious. The staminate inflorescence is usually a loosely balanced panicle or raceme from which pollen is dislodged easily. The pollen usually is not sticky, but is buoyant, and produced in large quantities (Durham 1951; Rudolph and Rudolph 1974).

The tribe Ambrosiaceae is of primary importance with

regards to anemophily. It has been estimated that a single common ragweed plant can produce 1 billion pollen grains during a season (Rapaport and Linde 1970). Harris and Shure (1969) claimed that one plant can produce 1 trillion pollen grains. It has been estimated (Gorlin 1948; Weinstein 1959; Harris and Shure 1969) that one acre of ragweed plants can produce 50-65 pounds of pollen per season. Allergists estimate that over 250,000 tons of ragweed pollen are blown across the nation each season (Rapaport and Linde 1970). This can be a significant factor if we consider that each person breathes 12,000-15,000 quarts of air per day (Howison 1967).

Pollen shed is not a continuous process during anthesis, but has a daily cycle. Pollen shed usually begins approximately the same time each day unless adverse weather conditions interfere. Studies have shown that pollen discharge begins between 4:00-6:00 a.m., and by 8:30 a.m., approximately 60% of the pollen has been shed. The amount of pollen shed then decreases by 12:00 noon, and remains low throughout the rest of the day and night (Durham 1951; Rapaport and Linde 1970). Certain conditions must be favorable before ragweed pollen is released: the humidity should be less than 80%; there should be abundant sunshine, and moderate temperatures (Durham 1951; Wagner 1959; Rapaport and Linde 1970).

Wind plays a major role in pollen dissemination. It has been demonstrated that if the wind velocity is low (less than 15 miles per hour), most ragweed pollen will fall to the ground within 100 meters of the source plant (Durham 1951; Dingle et al. 1957; Gill and Hewson 1958; Cole and Harrington 1967; Howison 1967). However, wind of greater than 15 miles per hour can blow the pollen for long distances (Durham 1951; Rapaport and Linde 1970; Rudolph and Rudolph 1974).

Once in the air, turbulence associated with buildings, trees, etc. can hold the pollen in suspension until it is caught in ascending thermals and carried to the upper atmosphere (Durham 1951). The pollen ceiling is determined by the upper limit of turbulent air. It is not unusual for pollen to be carried up to 10,000 feet by these updrafts (Rapaport and Linde 1970).

This pollen may then be dispersed over long distances. Tests over Lake Michigan (Durham 1951), have shown that there are almost equal concentrations of pollen in the air 30 miles from land as at the same altitude over the land. Sack (1949) reported finding ragweed pollen over the ocean as far as 525 miles from New York.

The importance of this long distance dispersal has been challenged. McMahon (1959) reported that the fresher the pollen, the greater is the severity of the allergic reaction.

Wodehouse (1958) stated that pollen exposed overnight loses half its potency.

It has been stated (Payne 1962) that ragweed pollinosis seems to be exclusively an American disease. There is evidence in the literature, however, that disputes this. Helander (1960) reported that 0.5-1% of the Swedish population suffers from allergic rhinitis caused by Ambrosia pollen. Volteranni (1954) stated at A. artemisiifolia is common enough in the Piedmont of Italy to be a hayfever problem.

Ragweed Control

Ragweed control has usually been confined to mechanical, cultural, or chemical practices. It is generally agreed that ragweeds are serious pests, but at the same time, there has arisen a conflict of interests. Even though these plants present a serious menace to the hayfever victims, they serve as food for wildlife (Grigsby 1945a, 1946), have some value in preventing soil erosion, and serve as cover for bare and unattractive vacant lots. Therefore, a method was needed whereby the plant could be rendered sterile without killing the vegetative portion. 2,4-D (2,4-dichlorophenoxyacetic acid) solved this problem. In the proper concentrations, the vegetative portion of the plants remained unharmed while flower and pollen production was inhibited (Grigsby 1945a,

b; Gorlin 1946; Howison 1967). When the need arises, 2,4-D is also used to kill ragweed plants, especially the giant and common ragweed species (Everson 1949, 1950; Gorlin 1946; Curran 1948; Wolf and Ahlgren 1950; Dengler 1951; Morrill 1951; Sargent 1951; Dotto 1966; Stegeman 1968; Foote and Himmelman 1971; and many others). Common ragweed is not only a hayfever menace, but is also a serious crop pest. Many chemicals have been used successfully to combat it: 2, 4-D (Hamner and Tukey 1944; Gorlin 1946; Curran 1948; Warren and Furtick 1953; Campagna 1954; Mondello 1954; Dotto 1966; Miller 1968; and many others); G-412 (di-nitro-secondary-butyl phenol)(Grigsby 1945a; Gorlin 1946; Fletcher 1956); G-410 (penta-chlor-phenol), kerosene, refinery residues (Grigsby 1945a; Gorlin 1946); Metribuzin combinations (Bayer 1977); pre-emergence treatment of linuron or metribuzin (Lynn et al. 1977).

Other methods of control include hand pulling (Wolf and Ahlgren 1950; Warren and Furtick 1953; Howison 1958); plowing or discing, other mechanical methods (Grigsby 1945a; Warren and Furtick 1953); crop rotation or competitive plants (Wodehouse 1958).

B. Ambrosia trifida

Latin Synonymy

Ambrosia trifida L.

A. trifida var. integrifolia (Muhl.)
A. integrifolia Muhl.
A. trifida heterophylla Kuntz

Colloquial Synonymy

giant ragweed, giant ambrosia, trifid ambrosia, great ragweed, great bitterweed, horseweed, kinghead, buffaloweed, horsecane, wild hemp, bitterweed, richweed, roman wormwood, tall ambrosia (Nuttall 1818; Britton and Brown 1898; Johns 1929; Dustman and Shriver 1931; Rydberg 1932; Fernald 1950; Payne 1962; Small 1933; Coon 1974).

Distribution

Ambrosia trifida L., giant ragweed is a widespread annual, herbaceous plant abundant in much of the eastern and central United States. The species is most profuse in the Mississippi and Missouri River drainages. Giant ragweed is a ruderal, found in rich alluvial soils, stream and ditchbanks, cultivated grounds and waste places.

Description

The plant is tall, ranging in size from 2-5 meters in height. The leaves are rough, broad, and three to five cleft, the trifid conditions being the most commonly encountered form; the plants are monoecious, rarely dioecious, the staminate inflorescence are borne on long spikes, or racemes at the terminus of the primary, secondary, tertiary, or quaternary branches, while the pistillate involucres are found in clusters in the leaf axils at the base of the

staminate spikes (Fig. 1a, b)(Nuttall 1818; Elliott 1824; Torrey and Gray 1841; Britton and Brown 1898; Small 1933; Rydberg 1932; Gleason 1952; Payne 1962; Coon 1974).

The achenes, are 7-8 mm long, ovoid or oboviod in shape, with 6 or 8 ridges which end in short conic spines (Britton and Brown 1898; Rydberg 1932; Small 1933).

The pollen is a small, spherical cell 16-19u in diameter, composed of a tough outer covering, the sexine, and a thin inner layer, the nexine. The sexine is divided into two layers, the ectosexine and the endosexine. The ectosexine is covered with many short, sharp spines (Fig. 2). The ectosexine also has three openings or germinal pores (Fig. 3), which may be used during the fertilization of the ovule (Durham 1951; Payne 1962).

Dissemination of Seeds

The dispersal and perpetuation of giant ragweed is accomplished only by seeds. Gebben (1965) has shown that wind plays an insignificant role in the dispersal of common ragweed seeds. This could be postulated for giant ragweed also, as the seeds of this species are larger and heavier than those of common ragweed. Animals and water, however, may be more significant agents in seed dissemination. Payne (1962) kept an English sparrow caged for several days, and fed it the seeds of common ragweed. In two days, thirteen

Fig. 1a. Staminate spike of a giant ragweed plant.

Fig. 1b. A terminal branch of a giant ragweed plant showing the newly formed seeds replacing the pistillate flowers at the base of a senescent staminate spike.

Fig. 1a

Fig. 1b

Fig. 2. Electron micrograph of Ambrosia trifida pollen showing the spines covering the ectosexine (magnified 5000x).

Fig. 2

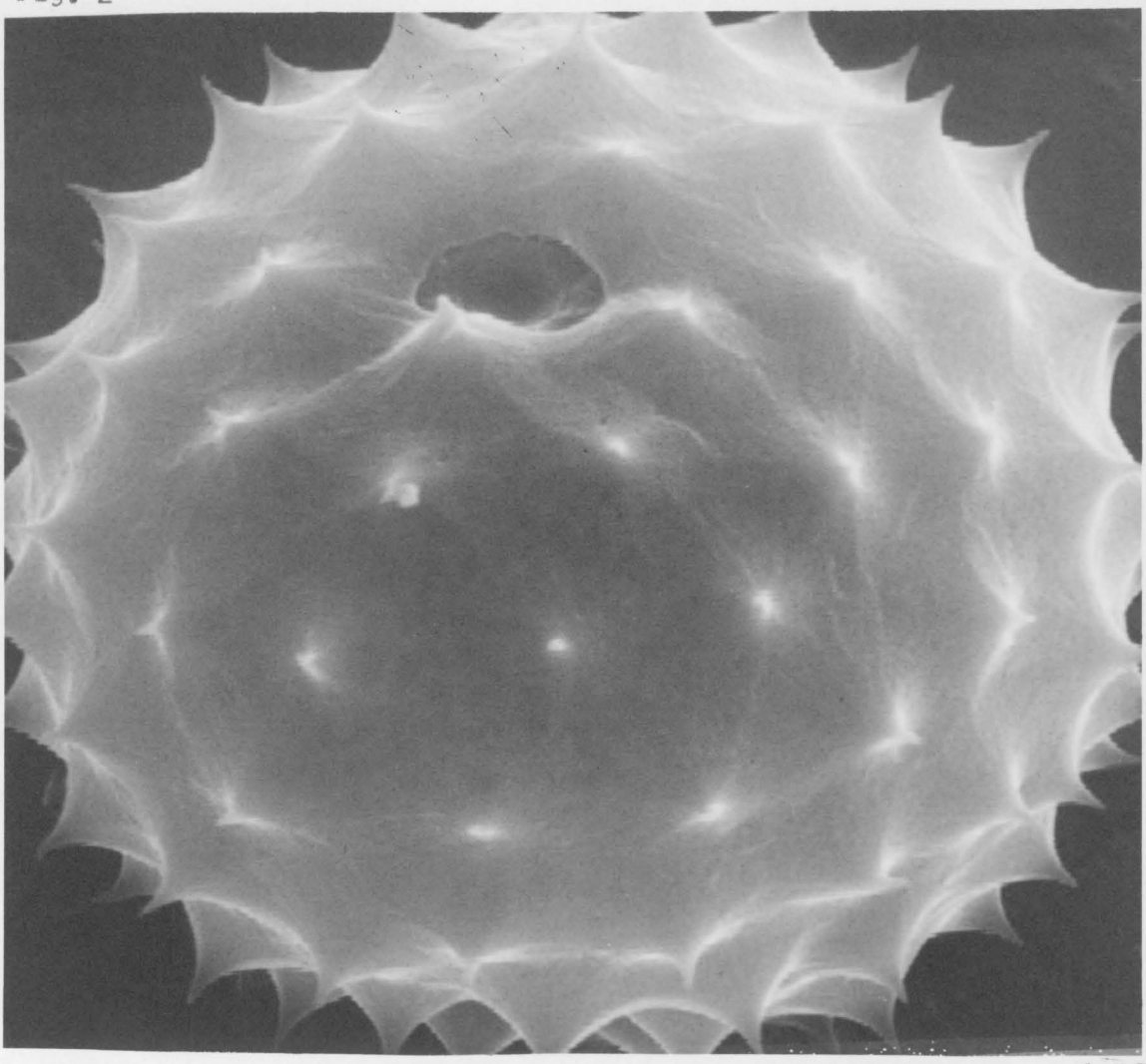
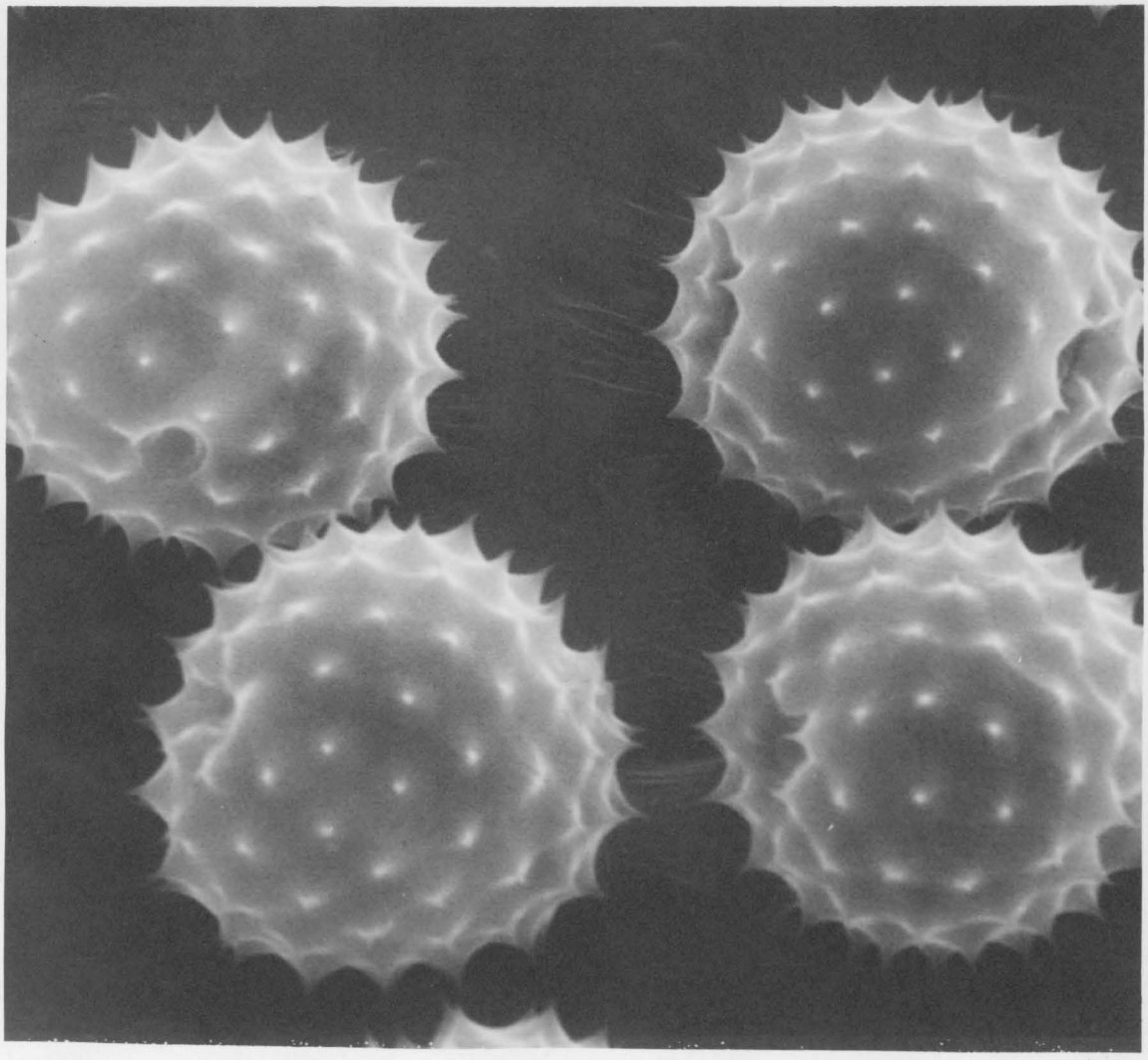


Fig. 3. Electron micrograph of Ambrosia trifida pollen showing the germinal pores (magnified 2000x).

Fig. 3



apparently undamaged seeds were collected from the bird's droppings. When planted, three germinated and produced mature plants. Judd (1905), Schulz (1928), Martin (1935), Davison (1942), Baldwin and Handley (1946), Korschgen (1948), Martin et al. (1951), Baumgartner et al. (1952), Bookhout (1958), and Robel and Slade (1965) reported that giant ragweed is utilized for food to a limited extent by quail, and is probably also dispersed by quail. Martin et al. (1951), Parmalee (1953), Davison (1961), Payne (1962), and Robel and Slade (1965) reported on the utilization of ragweed seeds by many species of non-game birds and mammals. Michael and Beckwith (1955) reported that harvester ants compete with game birds for ragweed seeds.

Ragweed propagules may also be disseminated by water. This may be especially true for giant ragweed, which is a plant of lowlands, and floodplains. McAtee (1945), Rydberg (1930, in Payne 1962), and Gebben (1965) reported on the aquatic transport of common ragweed seeds. Guppy (1917, in Gebben 1965) believed that A. artemisiifolia (A. hispida) has been carried to different islands on logs.

Man is also an important agent for the dissemination of ragweed propagules. Agricultural, road-building, and other types of machinery may act as an efficient means of spreading ragweed seeds. Seeds are also carried in seed crops (Benedict 1959, in Payne 1962); in feeds (Paffrey

1955a, b, 1958; Lindsay 1957; Rogers 1957); in ship's ballast (Lewalree 1947, in Payne 1962); and in pack animal fodder (Schacklett, in Payne 1962).

Once the pollen has been shed and the seeds disseminated another aspect of ragweed tenacity arises--seed dormancy. It has been reported that giant ragweed seeds had a 6% germination after a 21 year burial (Goss 1924). Thus, dormancy gives ragweed a perennial character, because, once an area is infested, it tends to remain so.

Insects

Several surveys of Ambrosia insects have been conducted in the last 70-80 years. Many authors have reported on aphids which feed on giant ragweed: Williams (1891); Davis (1909); Soliman (1927); Hottes and Frison (1931); Gillette and Palmer (1932, 1934); Patch (1938); Kring (1955); Robinson and Bradley (1965); Leonard and Bissell (1970); Knapp (1972). Hack (1935) observed nearly 200 species of insects on giant ragweed in Kansas and Illinois. Pienkowski and Kok (unpublished data) have conducted surveys of ragweed feeding insects in Virginia. Amatangelo (1974) reported on some coleopterous and dipterous species infesting the seeds of giant ragweed. Kendall (1959) and Neck (1973) reported on a butterfly, Chlosyne lacinia (Geyer), whose larvae feed on giant ragweed foliage. Neck (1973) reported that 14 of the

16 food plants of C. lacinia belong to the subtribes Ambrosiinae and Verbesiinae of the family Compositae. Wheeler (1940); Poos and Wheeler (1943), and Wolfe (1955) reported on some leafhoppers associated with giant ragweed. Harris and Piper (1970) collected ragweed insects in Ohio and Ontario, and searched the literature for reports of ragweed insects. Stegmaier (1971) reported on some Lepidoptera, Diptera, and Hymenoptera associated with common ragweed in Florida. Lobdell (1930) reported on some mealybugs of Ambrosia sp. in Mississippi. B. A. Foote (1965, and personal communication) reported on some tephritid species in giant ragweed seeds. Goeden and Ricker (1947a, b, 1975, 1976a, b, c) reported on the insect fauna of eight ragweed species in southern California (two of the species surveyed, A. chamissonis (Lessing) Greene, and A. acanthicarpa Hooker, have been judged by Payne (1964) to have the closest affinities to A. trifida). Forbes (1923) reported on the lepidoptera associated with Ambrosia. Chambers (1874) recorded a leafminer, Butalis matutella Clm. (= Gelechia ambrosiella, Busck (1903) from A. trifida.

Much of this information is not only of use to the biocontrol worker, but to others as well, as some of these insects have an economic status. Patrick (1971), and Hatchett et al. (1975) reported that the giant ragweed cerambycid, Dectes texanus LeConte, is a pest of soybeans in

Tennessee and Missouri respectively; Kennedy et al. (1962) reported on some virus diseases transmitted by aphids associated with ragweed; Wolfe (1955) reported on some agriculturally and ornamentally important leafhoppers associated with ragweed. In most of these reports, these economic species were not causing any harm to the ragweed. However, ragweed may have been used as a host by the pest insects until the preferred host was available.

III. POLLEN SURVEY

A. Introduction

Before pollen surveys are initiated, it is important to know which plants are causing hayfever, and the phenology of each of the pest species. There are three sources for this information: field, laboratory, and clinical data. They complement each other, and a completely accurate picture of a pollen situation can be gained only when they are used in conjunction with each other (Wodehouse 1971). The establishment of a pollen baseline for an area permits the future evaluation of control efforts undertaken against the pest species.

There are many techniques used to collect pollens. Some of the more common methods include: vaseline coated gravity impaction slides; the aerosol collector--a modified vacuum cleaner, developed by the Swedish palynologist G. Erdtman; the rotobar sampler, and the intermittent rotoslide sampler. The standard method adopted by the Pollen and Mold Committee of the Research Council of the American Academy of Allergy for atmospheric pollen sampling is a gravity impaction sampler known as the Durham sampler. This sampler, a modification of another pollen collecting apparatus, was first described by Durham (1946).

B. Methods and Materials

The Durham sampler (Fig. 4) consists of two polished stainless steel parallel discs 22.86 cm in diameter, set horizontally 7.62-10.16 cm apart by three vertical struts. The slide holder, in our case, two L-shaped pieces of aluminum, holds the slide 2.54 cm above the center of the lower disc. The entire device is then attached to a 76.20 cm metal rod and fastened to the top of a structure or building.

The sample slide is prepared by taking a standard 25 x 75 mm glass microscope slide and making a 2.54 cm smear across the center with a light coat of silicone or petroleum jelly. The slides should then be exposed for 24 hours. Care should be taken to replace these slides at the same time each day. The preferred time is in the morning.

Examination and identification of the pollen on the slide is facilitated by the use of Calberla's solution, composed of 5 cc of glycerin, 10 cc of 95% alcohol, 15 cc of distilled water, and 2-5 drops of saturated aqueous solution of fuchsin. This solution will stain allergenic pollens red while the non-allergenic pollens will generally not take up any color. Four to five drops of this solution are placed on the petroleum jelly, covered with a square cover slip, and allowed to stain the pollen grains for 3-5 minutes prior to counting.

Fig. 4. The Durham pollen sampler at the Price Hall sampling station.

Fig. 4

a. Counting and Computation

The Pollen and Mold Committee of the American Academy of Allergy recommends that counts be reported on the basis of the number of pollen grains on one square centimeter of slide area. For counting, a 10x or 15x ocular and a 10x objective lens is used. Enumeration of the pollen is then accomplished by shifting the slide laterally from one side of the field of vision to the other. If this field of vision is 1 mm, then the distance covered each time across the slide will equal 25 mm^2. Four such trips equals 1 cm^2.

Pollen surveys were conducted during 1975 and 1976 in Montgomery County, Virginia. Two sampling stations were used both years. One was on the roof of Price Hall on the VPI & SU campus (the height was approximately 30 m), while the other was approximately 18 m above the ground on a metal tower located at the Price's Fork Entomology Quarantine Facility. These locations are separated by approximately 5 miles. Sampling was initiated the first week in September and terminated on the last day of the month. By this time, most of the ragweed inflorescences were senescent, and pollen was no longer being shed. Sample slides were recovered each day between 9:00 a.m., and 10:00 a.m.

C. Results and discussion

It can be seen from Appendix I, that for some of the

days at the Price's Fork station, the counts ran well over 100 grains/cm^2/day. These values are also reflected in Appendix II. It can be seen that the Price's Fork site consistently had a higher average pollen count than the Price Hall Station. The reason for this can be explained by the differences in the geography around the two sites. In the vicinity of the Price's Fork station are some large open areas, and ploughed fields. The continued disturbance of these fields presents an ideal situation for the growth of common ragweed. Additionally, during 1976, a small stand of common ragweed developed on a small knoll approximately 12 m from the sampling tower. In contrast, the Price Hall station is located on the VPI campus. The area surrounding this station is well maintained, and there are few disturbed areas near the building.

Bassett (1954) suggested that a count of 7 or more pollen grains/cm^2/day (= 25 yd^3) should be considered a "hayfever day." This suggestion is based upon work done by Durham (1946), who compared two types of pollen samplers; a gravity impaction slide and a calibrated volumetric sampler. He found that the average catch on the slide compared with the volumetric sampler gave a ratio of 1:3.6. Therefore, he proposed that 3.6 be the standard conversion factor when calculating volumetric incidence from slide counts. This volumetric measurement is found by multi-

plying the number of pollen grains/cm^2 by 3.6. The result is the number of pollen grains/yd^3 of air for the 24 hour period.

Using 25 grains/yd^3, I found that in the areas of the VPI campus, and the Entomology Quarantine Facility there were 3 and 14 "hayfever days" respectively for a total of 17 days in September 1975. While there were 20 such days (10 days each at the two stations) during September 1976. These results are not to be extrapolated to include the whole of Blacksburg or Montgomery County, due to the inherent errors present in the pollen sampling technique. These counts are only indicative of the sample areas on the particular sample dates. Some of the meteorological considerations in hayfever counts are presented in Dingle (1957) and Cole and Harrington (1967).

IV. CHIONODES MEDIOFUSCELLA (CLEMENS)

A. Introduction

Gelechia mediofuscella Clemens, Proc. Entomol. Soc. Phila. 2:11-12, 121. 1863.
Depressaria fuscoochrella Chambers, Can. Entomol. 4:106, 129, 147-148. 1872.
Gelechia (Lita) liturosella Zeller, Verk. k.k. zool.-bot. Gessell. Wien. 23:265. 1873.
Gelechia fuscoochrella (Chambers), Bull. U.S. Geol. and Geog. Surv. 4:143. 1878.
Gelechia vagella Wlk., Walsingham, Trans. Am. Entomol. Soc. Phila. 10:178. 1882.
Chionodes mediofuscella (Clemens) Busck, Proc. U.S.N.M. 86:574. 1939.

The genus Chionodes Hubner is holarctic but extends southward at higher evaluations in South America to Chile and Argentina. Most species occur in America, but little is known of the life histories (Sattler 1967).

Adults of this species were first described by Brackenridge Clemens (1863) under the epithet Gelechia mediofuscella. In 1939, Busck revised the genus Gelechia, and placed this species in the genus Chionodes. Clemens' description is as follows:

> "Fore-wings very pale yellowish, with a dark brown spot along the costa, extending from near the basal third of the wing to the fold, oblique on its internal edge. At its angle on the fold is a blackish-brown dot, and another of the same hue obliquely above it on the edge of the spot. Exteriorly the spot is lost along the costa in dark-fuscous dispersed atoms, with which the apical portion is dusted. Hing wings shining pale gray; cilia tinted with yellowish.
>
> Antennae annulated with dark fuscous and whitish. Head yellowish white. Labial palpi whitish, with two dark-fuscous atoms."

At this time, the larva was undescribed, and the host plant was not known.

1. Hosts

Busck (1903) reported that an adult moth emerged in mid-April from old dry cornstalks collected during the preceding Fall. He stated that this may be an accidental host, and that a larva or adult might have found these cornstalks to be a convenient place to overwinter. A specimen at the National Museum collected in 1960 in Louisiana by G. L. Smith and T. C. Cleveland carries the notation "reared from green cotton bolls." Forbes (1923) was one of the few workers to make reference to C. mediofuscella larvae occurring in the seeds of Ambrosia trifida.

2. Distribution

Forbes (1923) reported this species as common in the Atlantic states, Kentucky, and Texas. Busck (1903) stated that it was common around the District of Columbia. Chambers (1972) collected adults in Kentucky. Specimens housed in the National Museum were collected from areas of Arkansas, British Columbia, Illinois, Kansas, Kentucky, Maryland, Massachusetts, Michigan, Mississippi, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, Virginia, Washington, D. C. and Washington

state. Kimball (1965) recorded this species from Florida.

3. Adult Phenology

C. mediofuscella seems to be an early flier. Busck (1903) reported adults flying in March, April, and July; Forbes (1923) reported finding adults in early Spring, and especially, in July; Kimball (1965) reported adults as early as February, and also in March; specimens in the Na- Museum were collected from March through September.

4. Description of the Immature Stages

Other than the preceding reports, I have been unable to locate any descriptions of the immature stages of C. mediofuscella. Therefore, a part of this study was concerned with describing the various immature stages of this moth.

Morphological descriptions are given for the eggs, last instar larva and pupa. Egg: length .4-.5 mm; greatest width .2 mm. Shape ovoid, obovate, some slightly crescent shaped. Chorion shining, smooth, some with longitudinal striations running the length of the egg.

Last instar Fig. 15: the laboratory colony failed to produce progeny, therefore, the following measurements were based upon field collected larvae. Length (taken as the larva crawled across the state of a dissecting microscope):

Fig. 15. Last instar of Chionodes mediofuscella (Clemens).

Fig. 15

4.0-9.0 mm; head capsule width .6-.9 mm ($x \pm SE = .74 \pm .01$); weights ranged from 1.0 to 12.0 mgs. Pinkish brown to brown, thoracic legs brown, pinacula and anal shield dark brown; head capsule (Fig. 5) and submentum dark amber to light yellowish-brown; ocelli patterned as in Fig. 8; mandible (Fig. 6) with 4 of the 5 teeth curved and pointed at the tip; prothorax (Fig. 10) light brown, setae ε and ρ comprising the base and seta α, the apex of a right triangle; meso- and metathorax (Fig. 11): setae κ and η adjacent, seta θ is contained on a separate pinaculum and positioned posteriodorsad to κ and η; seta η slightly posteriodorsad of seta ρ; setae α, β, η, and ρ form a straight line, α being the most dorsally located seta; α-β and η-ρ contained on two separate pinacula; abdominal segments 1-8 (Fig. 12): setae α and β held on separate pinacula, with seta α holding the anteriodorsad position; seta ρ slightly posteriodorsad to the spiracle; setae κ and η on the same pinaculum, seta κ directly below or anterior to the spiracle, and directly ventrad to seta ρ; seta μ located closer to the η group than to seta η, and positioned slightly posterionentrad to seta η. Segment 9 (Fig. 12): setae α, β, ρ, κ, η, π, and σ forming a straight line. Anal shield as in Fig. 9; anal comb with 5 teeth. Prolegs: crochets arranged in uniordinal, transverse bands. Pupa (Fig. 7): length 5.2 mm (female) and 4.5-4.6 mm (males); width of thorax 1.2-1.4 mm (females)

Fig. 5. Head capsule of C. mediofuscella.

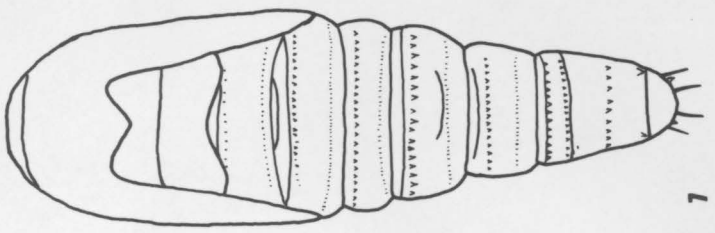
Fig. 6. Right mandible of C. mediofuscella.

Fig. 7. C. mediofuscella pupa.

Fig. 8. Ocellar pattern.

Fig. 9. Anal shield.

Figs. 5-9



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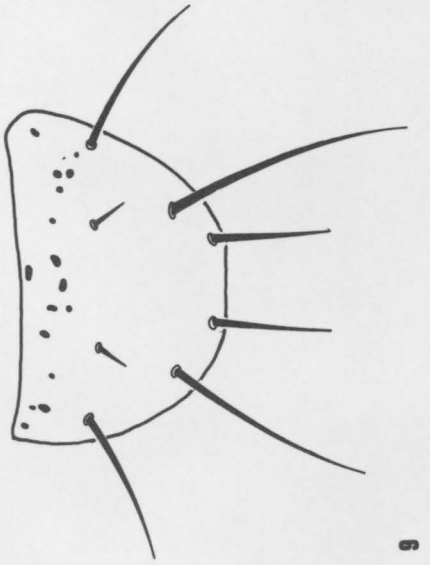

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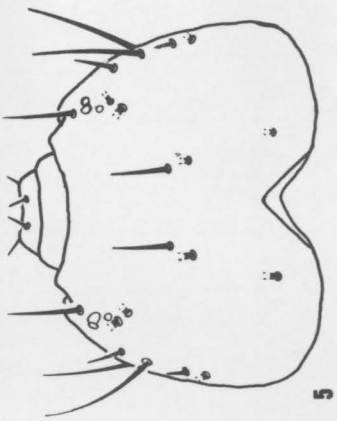

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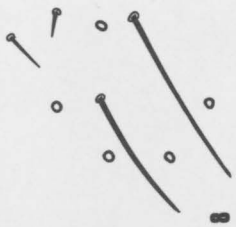

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Fig. 10. Chaetotaxy of the prothorax.

Fig. 11. Chaetotaxy of the meso and metathorax.

Figs. 10, 11

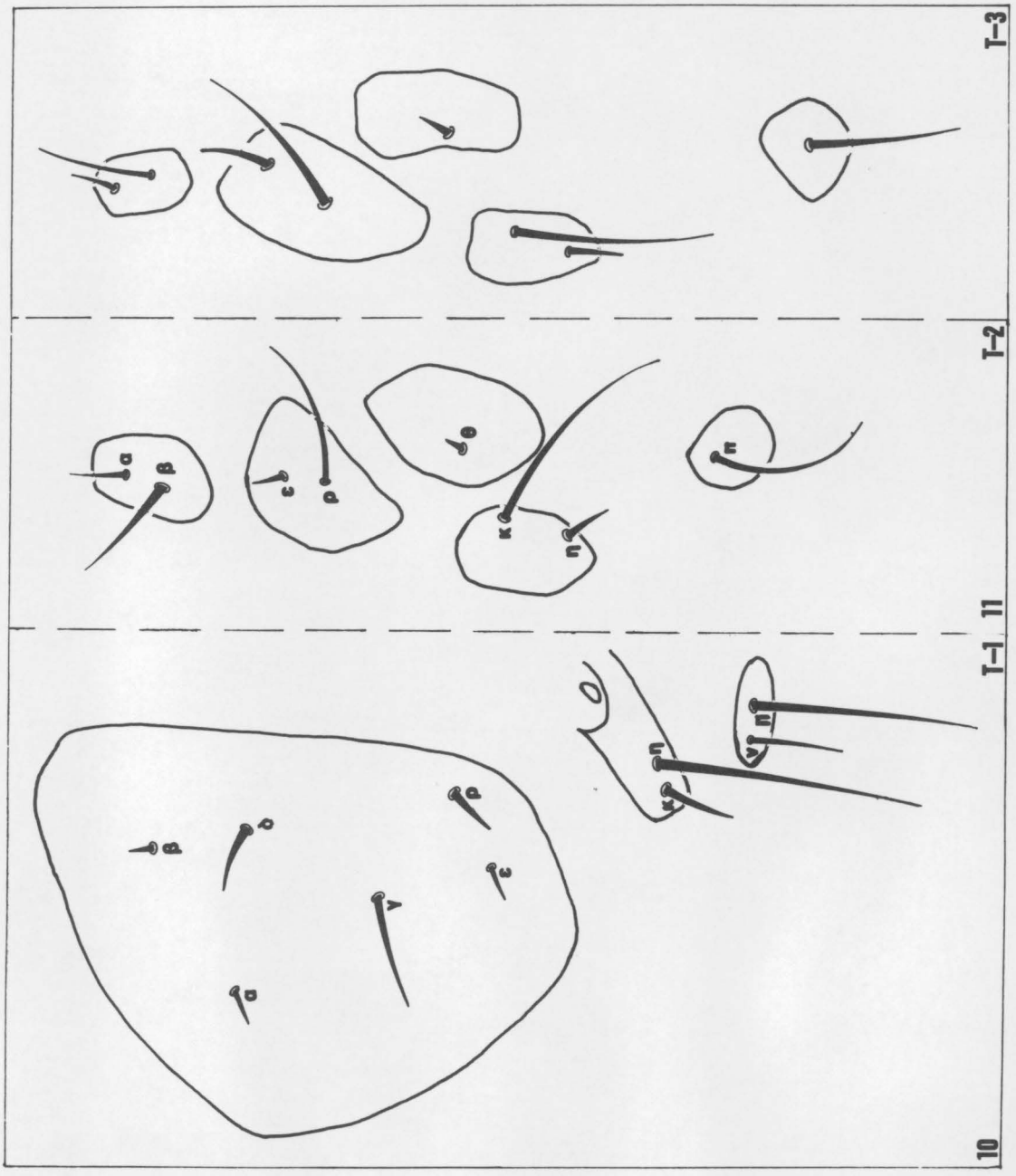
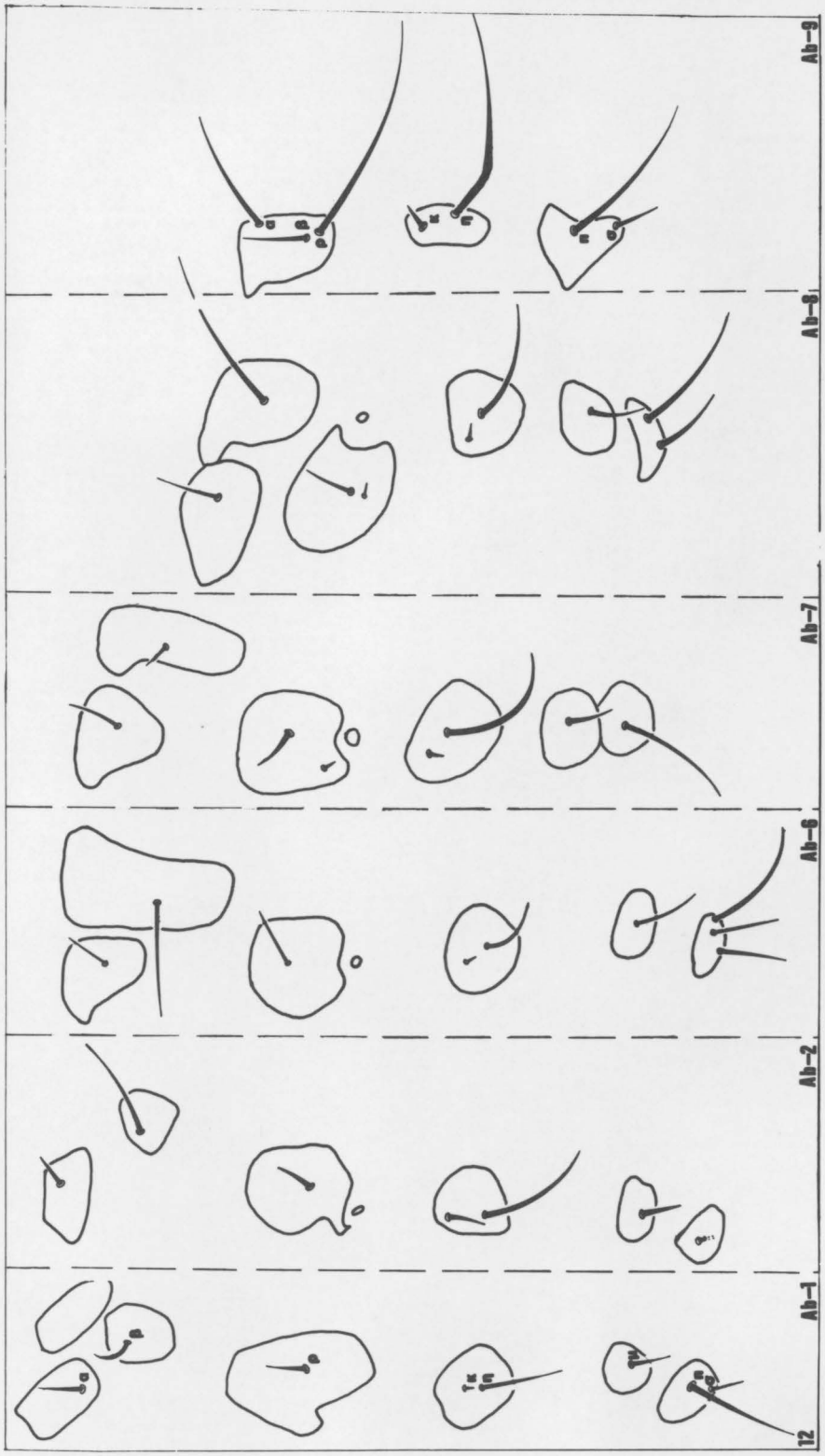


Fig. 12. Chaetotaxy of abdominal segments 1 and 2, and 6-9.

Fig. 12



and 1.0-1.1 mm (males); width of abdomen 1.4-1.8 mm (females) and 1.1-1.4 mm (males); weights 4.8-8.8 mgs (females) and 3.7-5.2 mgs (males). Amber-brown in color. Wing tips extend to the middle of the 4th abdominal segment. Spiracles conspicuous on segments 2-7. Segments 2-7 with two rows of setae, (one row located at the cephalic aspect and one row located at the caudal aspect of each segment), extending across the dorsum from spiracle to spiracle; on segment 2, the cephalic row may be almost inconspicuous; segments 2 and 3 both rows of setae are small; on segments 2-8, the cephalic row is larger than the caudal row; segment 8 with one row of 7-9 large setae, these setae are larger than any of the setae on the preceding segments; segment 9 with 3 stout setae; anal shield with 4 stout setae. Female Pupa (Fig. 13): bursa copulatrix visible on segment 9. Male Pupa (Fig. 14): Two rounded, mid-ventral pads visible on segment 9.

B. Field Studies

1. Methods and Materials

1975

a. Studies of Chionodes mediofuscella

In late Summer/early Fall, three field projects were initiated in order to find C. mediofuscella. The first project was designed to discover if C. mediofuscella was

Fig. 13. 9th abdominal segment of a female pupa showing the bursa copulatrix.

Fig. 13

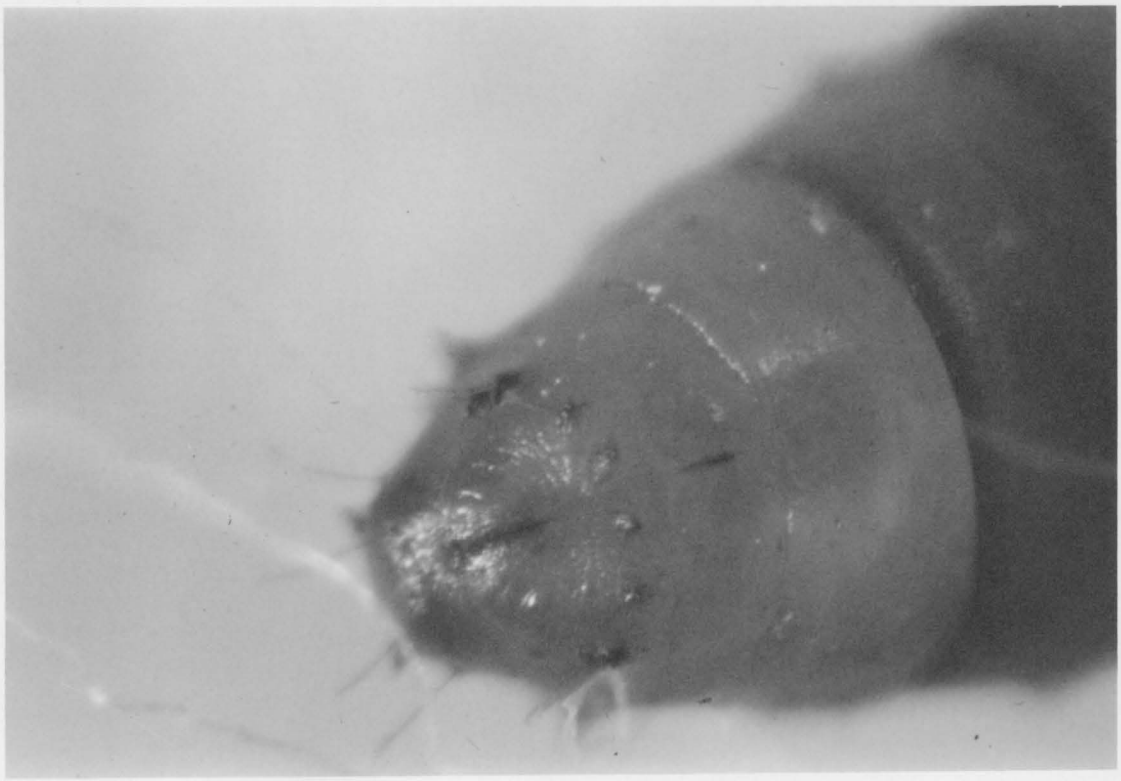
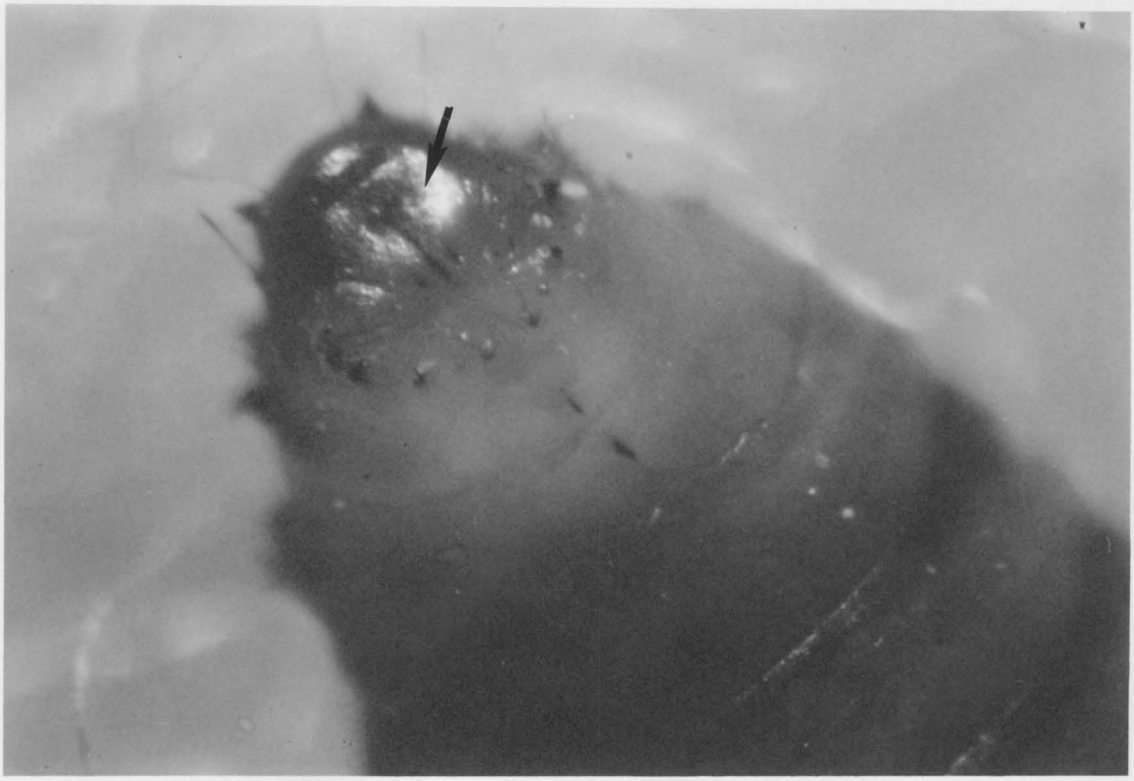


Fig. 14. 9th abdominal segment of a male pupa, showing the characteristic rounded pads.

Fig. 14



was specific to A. trifida, or if it would attack its congener A. artemisiifolia, which also occurs in Virginia. Two hundred fruiting heads of A. artemisiifolia from three sites, (50 heads each from the Horticulture Farm site, and 460 Bypass-Dairy Center site, and 100 heads from the Blacksburg Country Club), were brought to the VPI insectary and placed into 17.14 x 34.29 cm paper bags (10 lb. strength) (10 heads/bag). The end of the bag was fastened with a rubber band over a .4L ice cream container. A plastic bag was secured over the other end of the ice cream container by removing the top liner from the lid, and pushing the plastic bag inside the lid, and folding it back over the edges of the lid. These containers were subsequently placed on a shelf, and checked daily for emergence. One hundred heads were also placed in cardboard emergence drums (60L capacity) (25 heads/drum).

The second project was similar to the first, except that it involved the sampling of A. trifida. Two hundred fruiting heads were brought to the insectary from the area surrounding the Blacksburg Country Club, and placed in 1.22 x 1.22 x .61 m wooden emergence chambers. The chamber was sealed by draping heavy black plastic over the top, and then securing it tightly with duct tape. Plastic containers (.9L) were secured over a single hole on each side of the chamber. This chamber was checked daily for emergence.

Ragweed seed heads, at the Country Club, were sampled by passing the collecting net of a D-Vac suction sampler (Dietrick et al. 1959) over as many plants as could be encountered in a three minute period. Screen cages (1.22 m at the base, and 2.44 m tall) were placed over common ragweed at two sites, the 460 Bypass-Dairy Center site, and the Horticulture Farm site; and over giant ragweed at two sites, the Country Club site, and the Dickens Garden site (which is located at 1800 Glade Road, Blacksburg). The cages were set up in July at the sites in order to collect any C. mediofuscella already infesting the plants. Cages were checked weekly.

Plants were also brought back to the lab, divided into leaves, stems, and roots, and hung in plastic bags. These were checked daily for emergence.

The third project was concerned with soil sampling. It is our supposition that C. mediofuscella larvae overwinter in the soil or litter. In early September through late November, soil samples were taken every two weeks from six locations (1 sample/location) at each of two sites (for a total of 60 samples), brought to the insectary and placed in Berlese funnels. The last two sampling periods, soil was brought to the insectary and emptied into flats and placed in two .66 x .96 x .20 m organdy covered cages. Additionally, on the last sampling period, 40 extra samples

were brought back and deposited into 3.78 L ice cream containers, and placed in two plastic photoperiod chambers (20 samples/chamber) at photophase:scotophase of 18:6 and 15:5. Another phase of this project involved setting out inverted Berlese funnel emergence traps. These traps were placed on the ground, and dirt was heaped around the edges so that the only source of light was through a .16 L glass jar screwed into the funnel. Twelve traps (6/location) were set out at the 460 Bypass-Dairy Center site, and the Horticulture Farm site. Twelve traps were set out at the Dicken's Garden site.

1976

a. Studies of Chionodes mediofuscella

In 1976, soil sampling for C. mediofuscella commenced in early April and ended in early August. Fifty nine samples were collected from 5 sites.

D-Vac samples of seed heads and foliage, and collections of fruiting heads were also resumed.

During mid-July to late August, two CDC (Center for Disease Control) light traps, and a black light trap were taken to the field in order to collect any adults flying at this time. During mid-August, a trip was taken to Portsmouth, Ohio in order to survey an extensive stand of A. trifida. The CDC traps were taken in order to collect any

adults present at this time.

In mid-April, one of the primary ragweed sampling sites was ploughed and planted with alfalfa and grain. This later turned out to be fortuitous, because when the ragweed re-sprouted, it did so in a well defined area. This made it possible to conduct population estimates of larvae in this field. A 48 x 61 m quadrat was staked out on this site. The quadrat was sectioned into 80 subplots measuring 6.1 m on a side. Seventy of the 80 subplots were randomly chosen for sampling. There were two aspects to this sampling: 1) the seed heads of 10 arbitrarily chosen plants were removed from 10 of the plots, and brought to the insectary. Sampling took place over a four week period (for a total of 40 plots, and 400 seed heads). Samples were deposited in 61 L cardboard drums. A hole 1.6 cm in diameter was cut in the bottom of the drums, and a small plastic container was inserted through the hold. The top was covered with black muslin and sealed with a large rubber band. The drums were positioned under high intensity lamps, and checked daily for emergence. At the end of one week, the drums were opened, the old samples discarded, and fresh ones deposited. 2)Thirty of the plots were randomly chosen for bagging (due to a shortage of organdy, only 20 plots were actually bagged). Bagging consisted of segregating the branches into terminals and laterials. Organdy bags (37 x 20 cm) were placed over

the terminals, and remaining laterals, and secured with wire ties. These bags were collected in late November, after the first small snowfall.

The purpose of the quadrat/bagging experiment was fourfold. First, it was designed to discover if the larvae were in the seed heads. Since bagging was carried out over three consecutive weeks, this would give an idea of when the eggs were laid and hatching occurred. Second, if the time of oviposition was missed, and larvae were already contained in the seeds, then it could be discovered if the larvae left the seeds at the onset of winter. Third, since the terminals and laterals were segregated, it could be determined if any part of the plant was more heavily attacked than other parts. Fourth, using the collection information obtained over the three week period, the population density of the species could be determined.

By early October, it had become obvious that the population of C. mediofuscella was very low. Additional collections of seed heads were made from areas of Roanoke, Botetourt, Page and Warren Counties, Virginia. Approximately 500-1,000 seed heads were collected from each county. Larvae obtained from these collections were placed on artificial diets.

b. Studies of other insects attacking A. trifida

Two other projects involved three different insects which were found attacking A. trifida at two different field sites: two tephritid species, Eutreta novaebbracensis Stoltzfus (= caliptera Loew), and Strauzia longipennis (Wied.) were found at two of the sites in July and June respectively; and a curculionid, Lixus macer LeConte, was found at a third site in July. Laboratory studies were initiated to ascertain the biologies of these species on A. trifida, while a search of the literature was undertaken.

The tephritid species were confined in a .52 x .52 x .46 m plexiglass cage. The top of the cage was covered tightly with organdy, and secured with tape. The front and back of the cage had a 15 cm hole for the attachment of a sleeve. One of the sides had a 30 x 25 cm opening covered with saran screen (44 mesh) for ventilation. This cage was divided into two sections with cheesecloth in order to keep the species separated. The cage was kept in a Sherer-Gillette environmental chamber set at 15:9 photophase:scotophase, 27°/16°C, and 60-80% RH.

S. longipennis was also kept in a cage in an environmental chamber set at 21°C, and a 15:9 photo:scotophase. The cage, which consisted of two .9 L plastic containers, was constructed as follows: the middle sections of the tops of the containers was removed, and the tops glued or stapled together. The containers could then be inserted

into the tops to make the cage. One end of one of the containers had been removed and covered with organdy.

The flies were supplied with a 10% sucrose or honey-water solution for nutrition, and either a sunflower seedling or ragweed stem (for S. longipennis), or a goldenrod or ragweed stem (for E. novaebbracensis) for oviposition. Additionally, tephritid larvae were dissected from ragweed stems collected in the field, and placed on a Dacus dorsalis/ Ceratitis capitata diet.

Lixus macer was confined with a ragweed stem in the insectary at ambient conditions (approximately 27°-29°C, and 25-35% RH). The cage (.51 x .48 x .65) was covered on three sides with organdy, and had a sliding plexiglass front. The plexiglass had a hole 15 cm in diameter for the attachment of a sleeve.

2. Results and Discussion

a. Studies of Chionodes mediofuscella

The chambers containing the A. trifida seed heads were the only one that provided any larvae. These larvae were subsequently placed on experimental diets. Adults were also obtained from the wooden chambers. These adults were caged with a ragweed plant and a 10% sucrose solution in the insectary at ambient conditions. No mating was observed, and the adults died without having oviposited.

No individuals of C. mediofuscella were collected from the A. artemisiifolia emergence chambers or field cages. An examination of the seeds also failed to show any damage.

The field cages containing the A. trifida also provided negative results. The primary reason for this was due to the fact that the plants were still actively growing when confined to the cages, and as they continued to grow, the cages were filled by the foliage, and hence, I could not gain access to the interior of the cages.

The soil samples also provided almost totally negative results. The berlese emergence traps proved totally negative. The soil samples in the photoperiod chambers provided only three C. mediofuscella larvae, while none were obtained from either the flats or the berlese funnels. No insects were obtained from the plastic bags or the D-Vac samples.

The low population levels of C. mediofuscella in Montgomery County was not a local phenomenon, but was confirmed by the collections from the other four counties (a total of 52 larvae were collected from the four Virginia counties). The low levels of insects present, negated all of the bagging efforts, only five larvae were recovered from the bags. Additionally, no population estimates could be made due to the scarcity of larvae in the field. There could be at least two major contributing factors for

these low levels: 1) the abnormally low rainfall during 1976 delayed the flowering of the ragweed approximately two weeks. Hence, the majority of the females could have died without having oviposited due to lack of the proper ovipositional stimuli, and 2) the population of this species is not stable, and thus sampling may have occurred during the declining phase. Sampling has not been conducted for a sufficient length of time to demonstrate the normal population fluctuations within this species.

b. Studies of other insects attacking A. trifida.

A literature search revealed that biological studies on S. longipennis and L. macer had already been published (Westdahl and Barrett 1960 (S. longipennis); Williams 1942 (L. macer)). Therefore, research on these species was discontinued other than casual field observations to provide more time for study of C. mediofuscella.

The life history of E. novaebbracensis had already been described also. Unlike the two previous species, it had not been reported from giant ragweed. Wasbauer (1972) listed Aster laevis L., Chrysanthemum sp., Helianthus annus L., H. giganteus L., Ratibida columnaries (Pursh) D. Don, Solidago spp., Vernonia altissima Nutt., and V. interior (Small) Schub. as hosts; Thompson (1907) reported this fly from Solidago juncea A. t.; Blanton (1952) mentioned Chry-

santhemum sp. as a host; B. A. Foote (personal communication) reared this species frequently from Solidago altissima L., and occasionally from Helianthus annus L., H. tuberosus L., H. tuberosus var. subcanescens Gray, H. giganteus L., Solidago rugosa A. t., Aster laevis L., and Vernonia altissima Nutt. I have observed these flies resting on wild cherry (Prunus sp.) as well as ragweed.

It has been reported (B. A. Foote, personal communication) that a number of Eutreta species form root or stem galls in the host plant. Foote and Blanc (1963) reported that these flies overwinter as larvae or pupae in their host plants or in the soil.

C. Laboratory Studies

1. Methods and Materials

1975

C. mediofuscella larvae collected in 1975 were placed on the following experimental diets (Appendix IV, Tables I-III): 1) common ragweed pinto bean diet (5 replicates); 2) a common ragweed wheat germ diet (5 replicates); 3) a giant ragweed wheat germ diet (5 replicates); and 4) a modified Vanderzant-Adkisson cabbage looper diet (1 replicate). Fifty larvae were tested on each diet (5 larvae/cup), except for the Vanderzant-Adkisson diet, 8 larvae were placed in a single diet cup.

The diets containing larvae were held at ambient con-

ditions (approximately 18 hour photophase and 21°-24°C) for two weeks, at which time two environmental chambers became available. The infested diets were placed in these chambers at 18:6 photo:scotophase and either 21° or 26°C.

The diets were formulated as follows: field collected A. trifida leaves were lyophilized in a Virtis Universal Sub-Mobil #15 freeze dryer. At the end of 48 hours, the leaf material was removed from the lyophilization chamber, powdered in a Waring Blendor, sealed in a .9L plastic container, and stored in a freezer at -8°C until ready for use.

Diet ingredients were weighed on a Sartorius (Model #1106) balance. Those materials that needed to be sterilized were blended for two minutes in the blendor, poured into a 1.5L Pyrex beaker, and sealed with heavy duty aluminum foil. The mixture was autoclaved in an Amsco Medallion Series sterilizer for 20 minutes at 121°C and 21 psi. At the end of this time, the materials were removed from the autoclave, and allowed to cool. When cooled sufficiently (approximately 60°C) the material was poured back into the blendor, which contained the remainder of the diet constituents, and reblended. This liquid was poured into 15 ml clear plastic, friction top containers to an approximate depth of 1 cm, and allowed to cool for two hours. The modified Vanderzant-Adkisson cabbage looper diet was poured into a Lily No. 7S-BG 90 ml waxed ice-cream container. After cooling, the diets

were capped, and stored in a refrigerator at 4°C.

When ready for use, the deits were allowed to warm to room temperature, then were scored with flame-sterilized forceps, and the larvae deposited on the diets. Diets were then placed in environmental chambers and checked every 1-2 days for acceptance/rejection of the diet.

If the larvae rejected the diets for two straight days, the cups were re-opened and holes were made in the diet with flame-sterilized forceps. The larvae were placed in these holes (1 larva/hole), and the hole lightly sealed by putting pressure on the diet around the rim of the holes.

Since it was the main purpose of the diets to obtain adults to supplement those emerging from the wooden chambers, and not to determine the nutritional requirements of the larvae, larval weight was the only growth parameter measured. Weights were taken monthly.

Adults collected from the diets were confined in a lantern glass cage with a ragweed plant, and a 10% sucrose solution. This cage consisted of two lantern glasses, one stacked on the other. The top of the cage was covered with organdy and secured with a rubber band. This cage was placed over a potted ragweed plant. Adults were collected with an 8 dram vial. The vial was corked with a rubber stopper into which a piece of PVC tubing had been inserted. The vial was then wrapped with black plastic, and the end of

the PVC tubing was inserted into a hole in the pot containing the ragweed. The adults were positively phototactic, and crawled into the tubing and emerged into the cage. Two adults, one male and one female, were confined in an 8 dram vial with a crushed piece of waxpaper. It was hoped that the proximity would stimulate the pair to mate, and the female would oviposit in the crivices of the waxpaper.

1976

In 1976, two of the diets used in 1975 were retained for experimentation; the giant ragweed wheat germ diet and the modified Vanderzant-Adkisson cabbage looper diet. Later these were further modified by increasing the amount of lyophilized ragweed leaves. It was hoped that this would make the diets more attractive to the larvae. A wheat germ diet with ground ragweed seeds replacing the ragweed leaves was also tested.

Diets were made in the same manner as the previous year. Experiments were run at temperatures of 21°, 27°, and 32°C. It was also decided to test the efficacy of these diets by measuring different growth parameters such as weight, head capsule size, and later, body length.

Weights were measured on a Mettler balance. Since the larvae were mobile, a method had to be devised whereby

the larval movements were restricted prior to making body size measurements. This was accomplished by taking the top of a petri dish (9 cm diameter) and glueing three 4 cm sticks to it. This top was then set in a stacking dish filled with ice water. When this "stage" has cooled sufficiently, the larva was placed on it and covered with the friction top of a 15 ml plastic cup. The measurements were taken using an ocular micrometer viewing through the clear plastic friction top.

Some larvae were confined in plastic tube cages on seed heads in plants in the greenhouse. These tubes were 15 cm long, and 5 cm in diameter. The top was sealed with organdy, and an organdy sleeve was glued to the other end. Cages were placed over the seed heads, and a piece of twine was tied tightly around the sleeve.

2. Results and Discussion

1975

The common ragweed pinto bean diet proved unsuccessful for larval maintenance, as the diets became overgrown with yeast 11 days after larval inoculation onto the diet. When this happened, the larvae were removed from the diet, and bathed with a '00' camels hair brush dipped in mold inhibitor. Larvae were then transferred to the common ragweed wheat germ diet. In those pinto bean diets where yeast was

not a problem, the larvae died after five weeks.

The common ragweed wheat germ diet appeared promising at first, as the larvae began to feed almost immediately upon placement on the diet. After six weeks, the larvae began to leave the diet and web themselves in silken cases to the tops or sides of the cups. These were mistaken for pupae and were not disturbed. When no adults emerged, these cases were opened, and only dead larvae found. It was also discovered that at the experimental densities, i.e., 5 larvae/cup, there was some tendency toward cannibalism.

The modified Vanderzant-Adkisson cabbage looper diet also proved unsuccessful. Like the common ragweed wheat germ diet, larvae initially began to feed, but webbed themselves to the sides of the cup after five weeks.

The only diet from which adults were obtained was the giant ragweed wheat germ diet. The first pupa was discovered in the 27°C chamber at the end of December (2½ months after the larvae had been placed on the diets).

Upon pupation, the pupae were removed from the diets and placed on moist filter paper in separate 15 ml plastic cups. A 10% sucrose solution in a shell vial plugged with a piece of cotton, was placed in the cup with the pupa. This was intended to provide nutrition to the adults upon eclosition.

The first adult emerged in early January. Adults

continued to emerge until the end of January. Seven adults were collected from this chamber. Only one adult was obtained from the 21°C chamber. This adult emerged in late January (4½ months after the larvae were placed with the diet). The pupal stadium ranged from 9 to 17 days duration.

The adults taken from the diets, and those collected from the wooden emergence chambers were sexed, and caged with a potted ragweed plant. No mating was observed, and no eggs were collected. Adult longevity in the cage ranged from 7 to 27 days. Larval weights ranged from 5.2 to 10.6 mg.

1976

Larval mortality was high in 1976. In the chambers set at the higher temperatures, water evaporated from the diets. Larvae which had not tunnelled into the diet, would get trapped in the water droplets and drown. The temperatures in these chambers were lowered to 21°C in order to end the excessive evaporation. A second, unknown, factor also contributed to the mortality. Apparently healthy larvae would stop eating. Nothing could be done to induce feeding, and the larvae ultimately died. A third causative agent of mortality was parasitization. A fourth mortality factor was fungus which developed on some of the diets.

The growth parameters measured were weight, head cap-

sule size, and later body length. Larval weights ranged from 1.0-12.0 mg. The larval weights fluctuated, reflecting their feeding behavior. Head capsule measurements ranged from .6-.9 mm. The majority of the larvae had head capsule measurements of .7-.8 mm ($\bar{x}\pm SE=.74\pm.01$), while a few measured .6 or .9 mm. These measurements generally remained unchanged throughout the course of the experiments. This leads me to believe that I was working with the last instar. One larva increased its head capsule size from .8 mm to .9 mm. A dissection of the diet uncovered the exuviae.

Approximately half way through the experiments, it was decided that body lengths might be a rough indicator of growth, since the head capsule measurements had remained stable. These measurements were taken as the larva crawled across the stage of a dissecting microscope. Lengths ranged from 4-9 mm. These values were too variable to be of any use, because the larvae would not always extend to the lengths attained during previous measurements.

The larvae exhibited an interesting behavior while feeding in the diet. After tunnelling into the diet, the majority of the larvae would orient themselves in a head-up position, and enclose themselves in silken cases. These seemed to be used as protective shelters as the larvae fed, and when disturbed, they would retreat into these cases. Additionally, the opening of the tunnel was sealed with

silken threads or frass.

Due to high larval mortality, only eight adults, five females and three males, were reared from the diets. The time span of the last larval stadium ranged from two months to three and one-half months. Diet reared adults, two males and one female, were caged in a .9L plastic container. A 10% sucrose solution was provided for nutrition. A folded piece of waxpaper served as the oviposition substrate. After one week, no mating or oviposition had occurred. A small ragweed seed head from insectary grown plants was then substituted for the waxpaper. The next day, all three adults had died. No explanation could be found for this. The logbook of insectary spray schedules showed that the last time any chemical had been sprayed had been in the previous month. Spraying had been done in another room behind closed doors. Therefore, there should have been no drift. A possible explanation could be that the room containing the ragweed plants was sprayed, and that this was not logged in the spray schedule book.

No adults were reared from the larvae caged on the seed heads. No explanation could be found for this.

Since no mating occurred in the laboratory colony, an adult female was killed, and the eggs were dissected from the ovaries. Forty seven eggs were removed.

The last three larvae which pupated were females.

These individuals pupated after the last male had died. Since the larvae pupated, and adult eclosion occurred at different times, the pupae and/or adults were held in the cold room. This was to slow the metabolism, and increase the longevity in the event that any larvae that pupated later would be males. As it turned out, these three larvae were the last ones to pupate, and as one of them had already emerged as an adult, it was decided that the longevity in this cold room be investigated. These three adults had life spans of 21, 38, and 55 days at 13°-16°C.

D. Parasites

Approximately 17% of the larvae in diets were parasitized. Two of the parasitoids, Eupelmis sp. (Hymenoptera: Eupelmidae), and Pristomerus sp. (Hymenoptera:Ichneumonidae) were reared from larvae collected in Montgomery County in 1975. The other three parasitoids, Glypta sp., Diadegma compressum (Cr.), both Ichneumonids, and a braconid, Macrocentrus delicatus Cr., were reared from larvae collected in Luray, Page County, Virginia. In 1976, Pristomerus was also reared from larvae (collected in Montgomery County). The greatest amount of parasitism was caused by M. delicatus, D. compressum, and Glypta sp.

V. GENERAL SUMMARY AND CONCLUSIONS

Giant ragweed, Ambrosia trifida L., is a tall, coarse, annual. These plants are ruderals, and inhabit stream and ditchbanks, alluvial plains, and waste places. Ragweed, but especially A. trifida, and its congener, A. artemisiifolia (common ragweed), are the primary causes of allergic rhinitis (hayfever) in this country. These weeds are also adventives in other parts of the world, and their proliferation is beginning to cause "hayfever" problems there also.

The biology of Chionodes mediofuscella is poorly known. It was first described by Clemens in 1863. At this time, the larvae was undescribed. Since no life-history papers or descriptions of the immature stages have appeared, it was the purpose of this study to describe both the early stages and biology of this insect, and to establish a pollen baseline with which to evaluate future control efforts.

Field and laboratory studies were undertaken in the Summer and Fall of 1975 and 1976. In 1975, fruiting heads of ragweed were brought to the insectary on the VPI campus, and caged. Emerging larvae were placed on 4 experimental diets; adults were obtained from a giant ragweed wheat germ diet, and a modified Vanderzant-Adkisson cabbage looper diet. Adults obtained from the diets and from wooden emergence chambers were confined in a lantern glass cage, but they failed to reproduce.

Field cages were constructed in 1975 and placed over ragweed plants to compare infested and non-infested plants, and to collect adult C. mediofuscella. The cages proved unsuccessful, as the ragweed plants filled them with foliage. Because of this, I was unable to enter the cages and check for C. mediofuscella.

In 1976, fruiting heads of giant ragweed were brought to the insectary, and deposited in drums and chambers as before. Larvae were placed on experimental diets and the following growth parameters measured: weight, head capsule width, and body length. Larvae ranged in weight from 1.0 mg to 12.0 mg. Head capsule widths ranged from .6 mm to .9 mm, the majority being .7-.8 mm ($\bar{x}\pm SE=.74\pm.01$). Body lengths ranged from 4 mm to 9 mm. Pupal lengths measured 5.2 mm (females), and 4.5-4.6 mm (males). Abdominal widths ranged from 1.4-1.8 mm (females), and 1.1-1.4 mm (males). Thoracic widths were 1.2-1.4 mm (females), and 1.0-1.1 mm (males). Weights ranged from 4.8-8.8 mg (females), and 3.7-5.2 mg (males). Adult longevity was as long as 55 days at 13-16°C.

High larval mortality resulted in the production of only 8 adults from the diets. This high mortality was compounded by the fact that the larval population of C. mediofuscella in the field was extremely low in 1976. Collections were undertaken in four Virginia counties (Botetourt,

Roanoke, Page, Warren) other than Montgomery County to try to augment the number of larvae in the lab. A trip to Portsmouth, Ohio was also taken for the purposes of survey and collection. Low population numbers also negated a quadrat study at one of the collection sites in Montgomery County.

Preliminary studies were also initiated on three other insects attacking giant ragweed: a curculionid, Lixus macer LeConte; and two tephritid species, Strauzia longipennis (Wied.), and Eutreta novaebbracensis Stoltzfus. However, the biologies of all three species had previously been described.

Five species of parasitoids were reared from C. mediofuscella larvae. These were Eupelmis sp. (Eupelmidae); Pristomerus sp., Glypta sp., and Diadegma compressum (Cr.) (Ichnemonidae); and Macrocentrus delicatus Cr. (Braconidae).

From the meager information available in the literature, and from these studies, two possibilities arise: 1) this insect has an alternate host upon which it feeds until its primary host, giant ragweed is available, or 2) the insect switches to giant ragweed late in the season after its primary host has disappeared.

In conclusion, it should be stated that due to the difficulty encountered in culturing this insect, much work remains to be done. This includes: determination of the

life history; host specificity tests; and methods for mass propagation.

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VII. Appendix I. *Ambrosia trifida* seed germination tests

A. Introduction

The reproductive capacity of giant ragweed is enormous. It has been estimated (Gorlin 1951) that one well developed plant can produce up to 5,000 seeds. These seeds are dormant at maturity, and require an after ripening period at low temperatures (stratification) in order to initiate germination. However, not all seeds germinate in the first season. Those which do not, undergo another dormant period (secondary dormancy), and must be subjected to the germination conditions once again. In order to grow ragweed for experimental purposes, the dormancy must be broken.

B. Methods and Materials

Ragweed seeds were stratified in small flats of sand or vermiculite in a freezer set at 5°C for three months, and also outside of the insectary during the winter. Other seeds were soaked in distilled water, gibberellic acid (1, 100, 300, or 600 mg/L); chemically scarified with sulfuric acid or acetone; physically scarified in a mechanical scarifier at 40 psi for one minute; or surface sterilized with sodium hypochlorite or boiling water.

C. Results and Discussion

Stratification has been the most successful method in

breaking dormancy (Davis 1930; Payne and Kleinschmidt 1961; Willemsen and Rice 1972; Willemsen 1975). The other methods proved negative in breaking dormancy. However, Tieng (1962), reported that freshly harvested giant ragweed seed had a 40% germination in distilled water, and 100% germination in 600-1,000 mg/L solutions of gibberellic acid. McIntyre (1968) reported that lanceleaf ragweed, A. bidentata Michx., did not respond to distilled water, gibberellic acid, chemical or physical scarification, or surface sterilization. Willemsen and Rice (1972) found that exogenous gibberellic acid increased the germination of common ragweed seeds only slightly.

VIII. Appendix II. Raw Palynology Data for Price Hall (P), and Price's Fork (F).

Date		# grains/cm^2*	# grains/yd^3*
2,3-IX-75	(P)	0	0
3,4-IX-75	(P)	1	3.6
4,5-IX-75	(P)	13	46.8
4,5-IX-75	(F)	23	82.8
5,6-IX-75	(P)	6	21.6
5,6-IX-75	(F)	13	46.8
6,7-IX-75	(P)	2	7.2
6,7-IX-75	(F)	1	3.6
7,8-IX-75	(P)	1	3.6
7,8-IX-75	(F)	46	165.6
8,9-IX-75	(P)	2	7.2
8,9-IX-75	(F)	16	57.6
9,10-IX-75	(P)	16	57.6
9,10-IX-75	(F)	11	39.6
11,12-IX-75	(F)	51	183.6
12,13-IX-75	(P)	8	28.8
12,13-IX-75	(F)	85	306
14,15-IX-75	(P)	5	18
14,15-IX-75	(F)	19	68.4
15,16-IX-75	(P)	1	3.6
15,16-IX-75	(F)	31	111.6
16,17-IX-75	(P)	0	0
16,17-IX-75	(F)	2	7.2
17,18-IX-75	(P)	2	7.2
17,18-IX-75	(F)	0	0
18,19-IX-75	(P)	0	0
18,19-IX-75	(F)	15	54
19,20-IX-75	(P)	3	10.8
19,20-IX-75	(F)	8	28.8
20,21-IX-75	(P)	3	10.8
20,21-IX-75	(F)	15	54
21,22-IX-75	(P)	1	3.6
21,22-IX-75	(F)	5	18
22,23-IX-75	(P)	-	-
22,23-IX-75	(F)	18	64.8
25,26-IX-75	(P)	-	-
25,26-IX-75	(F)	2	7.2
29,30-IX-75	(P)	0	0
29,30-IX-75	(F)	0	0
5,6-IX-76	(P)	48	172.8
5,6-IX-76	(F)	14	50.4

* Pollen slides were lost due to high winds, or destroyed by rain, on those dates containing a dash (-).

Appendix II. Raw Palynology Data for Price Hall (P), and Price's Fork (F) (cont'd.).

Date	# grains/cm^2*	# grains/yd^3*
6,7-IX-76 (P)	167	601.2
6,7-IX-76 (F)	0	0
7,8-IX-76 (P)	3	10.8
7,8-IX-76 (F)	43	154.8
8,9-IX-76 (P)	13	46.8
8,9-IX-76 (F)	21	75.6
9,10-IX-76 (P)	30	108
9,10-IX-76 (F)	342	1231.2
10,11-IX-76 (P)	15	54
10,11-IX-76 (F)	-	-
11,12-IX-76 (P)	3	10.8
11,12-IX-76 (F)	23	82.8
12,13-IX-76 (P)	8	28.8
12,13-IX-76 (F)	172	619.2
13,14-IX-76 (P)	7	25.2
13,14-IX-76 (F)	217	781.2
14,15-IX-76 (P)	8	28.8
14,15-IX-76 (F)	68	244.8
17,18-IX-76 (P)	13	46.8
17,18-IX-76 (F)	132	475.2
18,19-IX-76 (P)	1	3.6
18,19-IX-76 (F)	0	0
19,20-IX-76 (P)	2	7.2
19,20-IX-76 (F)	6	21.6
21,22-IX-76 (P)	9	32.4
21,22-IX-76 (F)	19	68.4
22,23-IX-76 (P)	0	0
22,23-IX-76 (F)	4	14.4
23,24-IX-76 (P)	2	7.2
23,23-IX-76 (F)	4	14.4
24,25-IX-76 (P)	0	0
24,25-IX-76 (F)	0	0
25,26-IX-76 (P)	1	3.6
25,26-IX-76 (F)	4	14.4
26,27-IX-76 (P)	1	3.6
26,27-IX-76 (F)	5	18
28,29-IX-76 (P)	0	0
28,29-IX-76 (F)	0	0
29,30-IX-76 (P)	0	0
29,30-IX-76 (F)	0	0

IX. Appendix III. Ambrosia Aerial Pollen Count at 2 Collecting Stations Near Blacksburg, Virginia During 1975 and 1976.

Time Period	Location	Pollen Counts ($\bar{x} \pm SE$) Grains/cm^2	Grains/yd^3
2-8/IX/75	Price Hall	3.57 ± 1.73	12.86 ± 6.23
	Price's Fork	19.80 ± 7.45	71.28 ± 26.83
9-15/IX/75	Price Hall	7.50 ± 3.18	27.00 ± 11.43
	Price's Fork	39.40 ± 13.24	141.84 ± 47.67
16-22/IX/75	Price Hall	1.29 ± 0.52	4.63 ± 1.88
	Price's Fork	9.00 ± 2.67	32.40 ± 9.62
23-30/IX/75	Price Hall	0.00 ± 0.00	0.00 ± 0.00
	Price's Fork	1.00 ± 1.00	3.60 ± 3.60
2-30/IX/75	Price Hall	3.20 ± 1.82	11.52 ± 3.60
	Price's Fork	19.00 ± 9.63	68.40 ± 7.79
5-11/IX/76	Price Hall	39.86 ± 22.03	143.49 ± 79.31
	Price's Fork	73.83 ± 53.94	265.80 ± 194.17
12-18/IX/76	Price Hall	7.40 ± 1.91	26.64 ± 6.89
	Price's Fork	117.80 ± 38.30	424.08 ± 137.88
19-25/IX/76	Price Hall	2.33 ± 1.38	8.40 ± 4.98
	Price's Fork	6.17 ± 2.69	22.20 ± 9.68
26-30/IX/76	Price Hall	0.33 ± 0.33	1.20 ± 1.20
	Price's Fork	1.67 ± 1.67	6.00 ± 6.00
5-30/IX/76	Price Hall	15.76 ± 7.97	56.74 ± 28.72
	Price's Fork	53.70 ± 20.61	193.32 ± 74.22

X. Appendix IV. Tables

Table I. Experimental diets used to rear *Chionodes mediofuscella*: common ragweed pinto bean diet.

Ingredients[a]	
Pinto beans[b]	60.0
Sucrose	2.0
Methyl Paraben (38%) (ml)[c]	1.0
Sorbic Acid (38%) (ml)[c]	0.5
Ragweed leaves[d]	10.0
Brewer's Yeast	20.0
Wheat Germ	5.0
Agar	15.0
Water (ml)	60.0
Sodium Bicarbonate	0.5
Ascorbic Acid[e]	1.5
Potassium Hydroxide[e]	1.0

a) in grams unless specified
b) soaked overnight in 160 ml distilled water
c) in 95% EtOH
d) in a further modification, 20 gms were added
e) added after autoclaving

XI. Appendix IV. Tables (cont'd.)

Table II. Experimental diets used to rear Chionodes mediofuscella: giant ragweed, common ragweed wheat germ diet.

Ingredients[a,b]	
Wheat Germ	25.00
Ascorbic Acid	1.63
Methyl Paraben (38%) (ml)[c]	1.00
Sorbic Acid (38%) (ml)[c]	0.50
Agar	6.40
Torula Yeast	16.00
Formaldehyde (40%) (ml)	1.00
Distilled Water (ml)	320.00
Ragweed Leaves[d,e]	100.00

a) in grams unless specified
b) all ingredients mixed together and autoclaved
c) in 95% EtOH
d) common or giant ragweed leaves used
e) further modified by adding 20 gms of giant ragweed as a different diet

Table III. Experimental diets used to rear Chionodes mediofuscella: modified Vanderzant-Adkisson cabbage looper diet.

Ingredients[a]	
Agar (ml)[b]	550.00
Vanderzant-Adkisson Diet	100.00
Ragweed Leaves	20.000
Vitamin Mixture	2.250
Choline Chloride (10%) (ml)	9.000
Formaldehyde (10%) (ml)	3.750
Sorbic Acid (38%) (ml)[c]	4.500
Methyl Paraben (38%) (ml)[c]	4.500
Potassium Hydroxide (ml)	4.500
Distilled Water (ml)	100.000
Ascorbic Acid[d]	3.750
Streptomycin Sulfate[d]	0.125

a) in grams unless specified
b) autoclaved, then added to the rest of the constituents
c) in 95% EtOH
d) added after the autoclaved agar had been mixed with the other ingredients

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CHIONODES MEDIOFUSCELLA (CLEMENS) (LEPIDOPTERA:GELECHIIDAE), AN INDIGENOUS INSECT INFESTING THE SEEDS OF GIANT RAGWEED (*AMBROSIA TRIFIDA* L.)(COMPOSITAE)

by

Gary Leonard Cave

(ABSTRACT)

Ragweeds are anemophilic composites belonging to the genus *Ambrosia*, and are the most important aeroallergens in North America.

Ambrosia trifida L., giant ragweed, is a ruderal plant widely distributed throughout the eastern and central portions of North America. The greatest concentration of this species occurs along the drainage areas bordering the Mississippi and Missouri Rivers. This plant is an annual, and reproduces solely by seeds. These seeds undergo primary and secondary dormancy, and remain viable in the soil for long periods of time.

Conventional forms of control have failed to keep this species in check. Biocontrol by seed-feeding insects may provide a partial solution.

Chionodes mediofuscella (Clemens), a seed-infesting gelechiid, may provide this control in areas where giant ragweed has escaped its natural enemies. The biology and im-

mature stages of this species are poorly known. The egg, last instar, and pupal stadium are described.

Egg: .4-.5 mm in length; greatest width .2 mm. Shape ovoid, obovate, some crescent shaped.

Last instar: length 4-9 mm, head capsule .6-.9 mm in width; weights 1.0-12.0 mg.

Pupa: length 5.2 mm (females), 4.5-4.6 mm (males); thoracic width 1.2-1.4 mm (females), 1.0-1.1 mm (males); abdominal width 1.4-1.8 mm (females), 1.1-1.4 mm (males).

Field collection techniques and methods for rearing the larvae of this species are also described.