ASPECTS OF THE BIOLOGY OF SOD WEBWORMS (LEPIDOPTERA:PYRALIDAE:CRAMBINAE) AND TURFGRASS INHABITING INSECTS OF VIRGINIA

by

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This thesis is dedicated,

with love, to my parents:

Jack and Christa Tolley

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INTRODUCTION

Turfgrass is highly valued in maintaining and beautifying the environment. Estimates place the cost at a billion dollars to maintain the 3,000,000 acres of turf in 12 northeastern states, and replacement costs are nearly tenfold that amount (Nutter 1965). Turfgrass is of value to the environment in that it provides air purification, produces oxygen, modifies temperature, reduces glare and noise, acts as a dust and erosion control agent, and also serves as a waste disposal media. Turfgrass is valuable to man by providing an attractive and practical base for landscaping, recreation, and exercise (Nutter 1976).

Turfgrass is subject to attack by a variety of pathogenic organisms such as fungi, nematodes, and bacteria. Also present are plant feeding invertebrate pests such as chinch bugs, sod webworms, armyworms, scarabaeid grubs, and mites (Streu 1973).

Insects are an important group of pests of commercial and residential turfgrass. Insect pests of turf can be divided into two groups: the above ground, and the below ground pests. Some of the most important below ground pests are the billbugs and white grubs, especially the Japanese beetle (Tashiro 1973). Some important above ground pests are chinch bugs, armyworms (Baker 1981), cutworms (Baker 1981), and sod webworms (Heinrichs 1973).

The increasing importance of turfgrass insect pests such as the Japanese beetle, masked chafer, the *Ataenius* beetle, mole crickets, and chinch bugs has prompted research on their biology, distribution, and control. Sod webworms are common in turfgrass throughout eastern and southeastern U.S., and have reached pest status in some areas (Schmidt, personal communication). However, there has been no research on the sob webworms associated with turfgrass in Virginia. Similarly, there has been little research on habitat preferences of other turfgrass insect pests.

The research presented here was undertaken to evaluate the sod webworm species complex and habitat preferences of turf inhabiting insects of Virginia in general. The objectives were to: 1) determine habitat selection preferences of common turf inhabiting insects; 2) to construct pictorial keys for the sod webworm species complex and 3) determine their geographical distribution, seasonal occurrence, and degree-day relationships, and 4) determine adult resting site preferences of the sod webworm species in Virginia.

LITERATURE REVIEW

Taxonomy

The Nearctic subfamily Crambinae, of the family Pyralidae, is composed of a large number of species and genera. Fernald (1896) described 10 genera and 75 species, while Holland (1968) stated that 14 genera and over 80 species exist. Klots (1961) stated that many of the Holarctic genera, especially *Crambus* (Fabricius), originated in the Nearctic and spread to the Palaearctic via Alaska and Siberia. He stated that the origins of the endemic species and genera are from the eastern U.S. and in Florida, California, Mexico, Arizona, and New Mexico.

The species in the Crambinae were placed by Linnaeus under the genus *Tinea*. Hübner (1796) also placed the European species under this genus. In 1798, Fabricius established the genus *Crambus* with 62 species. In 1811, Haworth established the genus *Palparia* for the species usually placed under *Crambus*. Zincken, in 1817, placed most of the *Crambus* species under the genus *Chilo* (Zincken). In 1882, Hübner placed the *Crambus* species into 10 genera under the family Crambidae; and Walker in 1863 adopted the family Crambidae with several genera including *Crambus*. Fernald (1896) reviewed the history of the subfamily Crambinae.

The taxonomy of this subfamily is in disarray. The family Crambidae has been reduced to subfamily rank (Crambinae) in the Pyralidae (Borror 1971). Bleszynski (1959) and Klots (1942, 1968) have attempted to revise the genera and species of the Crambinae. The latest taxonomic information of the North American Crambinae is an unpublished manuscript by Klots (personal communication).

Geographical Distribution

Sod webworm species distributions are known for New York (Forbes 1923), North Carolina (Brimley 1938, 1942), Florida (Ainslie 1923c, 1927b; Kimball 1965), Tennessee (Matheny and Heinrichs 1975), Oregon (Prescott 1965), and Iowa (Decker 1943). Sod webworm species differ on a regional basis. Grote (1880) lists 42 species in North America, while 41 species are known to occur in Florida (Ainslie 1923c, 1927b), 17 in Tennessee (Ainslie 1924), and 14 in Virginia (Robinson and Tolley 1982). Matheny and Heinrichs (1975) reported collecting 32 species with black light traps in Tennessee.

Black Light Trapping

Black light traps have often been used to monitor sod webworms for their distribution (Matheny and Heinrichs

1975), seasonal abundance (Ainslie 1917; Robinson and Tolley 1982; Heinrichs and Matheny 1970; Matheny and Heinrichs 1975), and flight activity of the sexes (Banerjee 1967).

Degree-Day Relationships

Degree-day relationships have been applied to several turf insect pests, including *Ataenius spretulus* Haldeman, *Blissus leucopterus hirtus* Montandon, and *Pediasia trisecta* (Walker). Wegner and Niemczyk (1981) used degree-days in models to predict *A. spretulus* activity and development. Liu and McEwen (1979) have also applied degree-days to time sampling and chemical applications for *B. leucopterus hirtus*, and Banerjee (1969) calculated the number of degree-days for one generation of *P. trisecta*.

Variables Affecting Turf Insects

Host Grass Species

Insects inhabiting turfgrass are influenced, in part, by abiotic and biotic variables. Some of the most important variables are temperature, soil moisture, thatch, pH, and host grass species. Murdoch and Tashiro (1976) showed that there is no preference for host grasses as oviposition sites for *Herpetogramma licarsisalis* (Walker). Ainslie (1930) stated that *Parapediasia teterrella* (Zincken) larvae prefer bluegrass while *P. trisecta* and *Crambus praefectellus*

(Zincken) prefer grasses and grains (Ainslie 1927a, 1923a); *Pediasia mutabilis* (Clemens) prefers grasses only (Ainslie 1923b). Krehoff (1974) has shown that such habitat selection can lead to the separation of sympatric species. Wegner and Niemczyk (1981) reported the host grasses of the beetle *A. spretulus* as *Poa annua* L., *P. pratensis* L., and *Agrostis* spp. Tashiro and Personius (1970) indicated that the bluegrass billbug prefers bluegrass as its host. Morrill (1975), and Morrill and Dobson (1978) report that Japanese and June beetles prefer fescue sod and are often noted to emerge from it.

Moisture

Soil moisture often influences the activity of turf inhabiting insects. Gaylor and Frankie (1979) indicate that very wet or dry soils prevent oviposition by *Pyhllophaga crinita* (Burmeister). Eggs and first-instar larvae of the Japanese beetle show resistance to moisture extremes (Regniere, et al. 1981). Ladd and Buriff (1979) reported that high soil moisture content mitigates the effect of larval feeding on bluegrass. Soil moisture conditions can affect sod webworm larvae. Ainslie (1923b) stated that *P. teterrella* and *P. mutabilis* larvae cannot tolerate excessively wet or dry conditions. Ainslie (1930) has shown that when conditions are hot and dry, populations of

P. teterrella decline but increase again following periods of rain.

Temperature

Moisture content of the habitat and insect development rates are often dictated by temperature. Vittum and Tashiro (1980) have shown the optimum temperatures for *P. japonica*, and European Chafer, *Rhizotrogus majalis* (Razoumowsky) larvae to be 25-30°C and 25°C, respectively. Fox (1935) reported the lethal soil temperature to *P. japonica* larvae as -9.4°C when snow does not act as an insulator. Banerjee (1969), Heinrichs and Matheny (1960), and Matheny and Heinrichs (1971), have shown that sod webworm eggs show significant differences in percentage hatch when exposed to varying temperature extremes.

Soil pH

The effect of soil pH on some white grub populations has been studied by various workers with conflicting results. Vittum and Tashiro (1980) show no reduction in populations of *P. japonica* and European Chafer larvae at normal pH levels in summer temperature conditions while Polivka (1960a, 1960b) shows that *P. japonica* larval populations increase in low pH soils. Vittum and Tashiro (1980) claim the optimum pH is 6-7 for *P. japonica* while Wessel and Polivka (1952) report it as 4.5 or less. Briggs

(1980) found no correlation between pH and white grub populations in corn fields.

Thatch

The affects of thatch on insects in turfgrass has not been studied extensively. Beard (1973) and Madison (1970) reported that thatch acts as a microenvironment which can harbor disease causing organisms and insect pests. Niemczyk (1973) showed that thatch can tie up pesticides and thus hinder control measures for both diseases and insects. Randall (1976) stated that thatch can increase the survival of turf insect pests by acting as a protective zone which makes detection by predators difficult and acts as an insulation layer against temperature extremes.

MATERIALS AND METHODS

Distribution and Seasonal Occurrence

The distribution of sod webworms in Virginia was determined by examining date/locality labels of museum specimens. Crambinae species were examined at the American Museum of Natural History, the U.S. National Museum of Natural History, and in the Department of Entomology insect collection of the Virginia Polytechnic Institute and State University (VPI & SU).

Two Ellisco® black light traps and two New Jersey type light traps were used to monitor the sod webworm species present in Montgomery County and Virginia Beach (city), Virginia, respectively. Seasonal occurrence was determined from light trap collections. One Ellisco® trap was located next to a utility building on the VPI & SU Turfgrass Research Center. Another Ellisco® trap was placed next to a utility barn near the center of the VPI & SU golf course (1981). In 1982 the golf course trap was moved to a utility building approximately 70m from the utility barn. The Turfgrass Research Center area sampled consisted of approximately 90% ryegrass and 10% bluegrass. The golf course area sampled consisted of about 70% bluegrass, 25% red fescue, and 5% bentgrass. The light trap in Virginia Beach was located on a residential lawn.

One half of a Vapona Insect Strip per trap was used as the killing agent in the light traps. Traps were emptied once or twice weekly, and total adult moths recorded. Traps were operated from May to October, 1981, and from April to October, 1982.

Pictorial Key

The pictorial key was constructed by examining patterns on the forewings of the sod webworm species known to occur in Virginia. Thirteen species are described from specimens collected in the light traps, three other species are described from museum specimens. Wing patterns and descriptions of these three species were taken from The Crambidae of North America (Fernald 1896). Voucher specimens of 13 species are located in the VPI & SU Department of Entomology insect collection.

Degree-day Relationships

Maximum-minimum temperature data for the degree-day analysis was obtained from an Agro-environmental Monitoring System weather station about 150m from the light trap on the VPI & SU Turfgrass Research Center. Accumulated degree-days were calculated via a computer program utilizing the 2-point sine wave method (Baskerville 1969). The lower developmental threshold of *P. trisceta* (10°C) was utilized in the analysis in determining accumulated degree-days (Banerjee 1969), no upper threshold was used. This developmental threshold was assumed to be the same for all sod webworm species sampled. Cumulative percentage emergence of six species of sod webworm adults was transformed to probits to linearize the sigmoid nature of the curve. Degree-days (DD) were transformed to log DD. The transformed data was analyzed via the General Linear Models method of the Statistical Analysis System (SAS).

Habitat Preferences of Common Turfgrass Insects

Six plots served as sampling sites for turfgrass insect pests. Two plots were *Festuca arundinaceae* L. (tall fescue), 2 *Poa pratensis* L. (kentucky bluegrass), and 2 *Lolium perenne* L. (perennial ryegrass). One tall fescue plot (Plot 1) was adjacent to a ryegrass plot (Plot 2) while one bluegrass plot (Plot 4) was adjacent to another ryegrass plot (Plot 3). Plots 1-4 were all in close proximity to each other. About 1.5km from plots 1-4 was located one tall fescue plot (Plot 5) adjacent to a bluegrass plot (Plot 6). All 6 plots were located on the VPI & SU Turfgrass Research Center.

Plots were sampled by randomly removing selected cores with a golf course cup cutter (10.5cm diameter x 6.5cm length). Samples were collected from May to August, 1982. The number of core samples taken from each plot were: tall fescue Plots 1 and 5 (N = 8/week), ryegrass Plots 2 and 3 (N = 7/week), bluegrass Plot 4 (N = 7/week), and bluegrass Plot 6 (N = 5/week). Samples were taken for 12 weeks.

A soil thermometer was used to monitor the temperature of the top 3.5cm of soil profile next to each core sample. A soil probe was used to sample soil next to each core sample for moisture content. Soil probe samples were placed into soil moisture cans. Cans were weighed five hours after the samples were taken, then oven dried at 100°C for about 30 hours. Percentage soil moisture was determined by the formula:

$$\frac{\text{wet weight-dry weight}}{\text{dry weight}} \times 100 = \%\ \text{moisture}$$

Core samples were placed in plastic bags for transport to the laboratory for inspection. Grass was sheared off of each core and the core inverted onto a flat surface. A 1kg weight was placed on top of the core and the compressed thatch thickness was measured (NE-57 Tech. Res. Comm. 1977) (Figure 1). Cores were torn apart manually and inspected

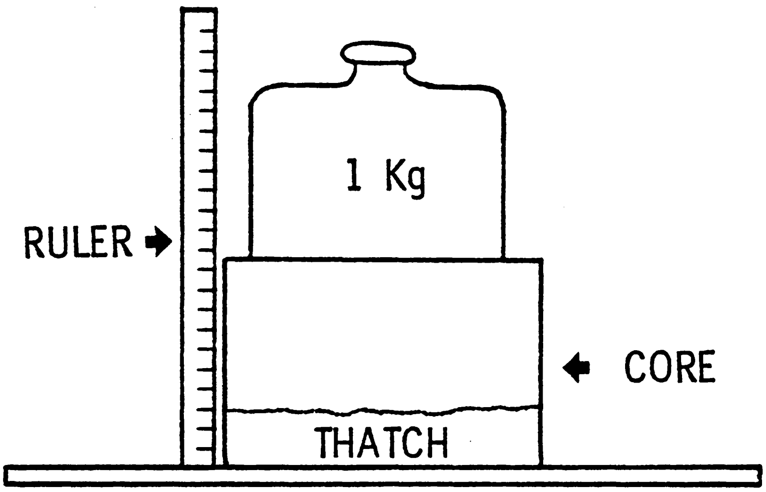

Figure 1. Method used to measure thatch thickness.

for insects. Insects found in each core were stored in ethyl alcohol and identified.

RESULTS AND DISCUSSION

Distribution

Museum and light trap data indicate that a complex of 16 sod webworm species is nearly evenly distributed over the Appalachian, Piedmont, and Coastal Plain regions of Virginia (Figure 2). The distribution of individual species is difficult to determine due to a lack of data for all counties (Table 1). However, one evident trend is that *Crambus praefectellus* (Zincken), *Parapediasia decorella* (Zincken), *Crambus laqueatellus* Clemens, and *Crambus perlellus* (Scopoli) were caught in traps in the Appalachian (elevation 700m) but not Coastal Plain region of Virginia.

Matheny and Heinrichs (1975) showed that some sod webworm species occur above elevations of 1333m in Tennessee. Sod webworm species found adapted to such elevations were *Crambus pascuellus floridus* Zeller, *Pediasia mutabilis*, *Chrysoteuchia topiaria*, *Agriphila ruricolella*, *Crambus agitatellus*, and *Crambus caliginosellus*. The last four species were also found present in the Appalachian region of Virginia (elevation 700m). Such data can indicate that the sod webworm species complex is not limited to one region of Virginia and that particular species might be adapted to particular ranges in elevations.

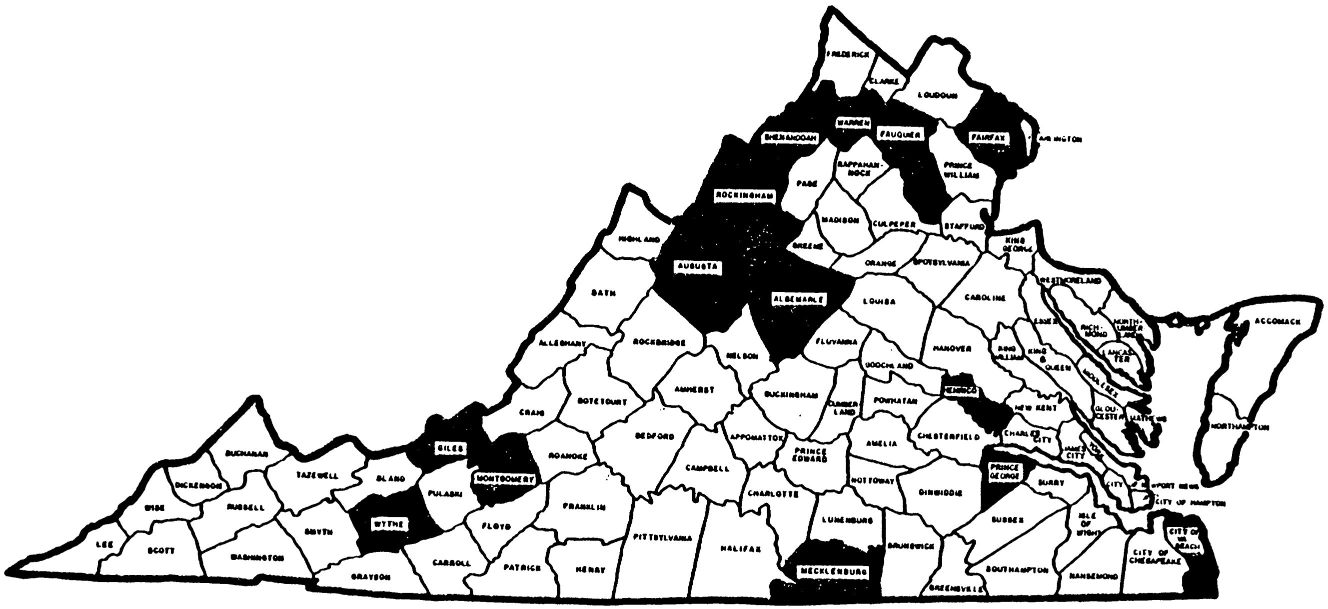

Figure 2. Known distribution of the sod webworm species complex in Virginia - 1982.

TABLE 1. The occurrence of sod webworm species in counties of Virginia.[1]

Species	County
Crambus praefectellus (Zincken)	Wythe
	Montgomery
Crambus albellus Clemens	Warren
Crambus caliginosellus Clemens	Fairfax
	Shenandoah
	Mecklenburg
	Fauquier
	Montgomery
Crambus luteolellus Clemens	Shenandoah
	Rockingham
Crambus laqueatellus Clemens	Giles
	Montgomery
Crambus leachellus (Zincken)	Augusta
	Va. Beach
Crambus agitatellus Clemens	Montgomery
	Va. Beach
Crambus perlellus (Scop.)	Montgomery
Parapediasia decorella (Zincken)	Albermarle
	Montgomery

[1]More detailed distribution records are in appendix 1.

TABLE 1. (continued)

Species	County
Parapediasia teterrella (Zincken)	Montgomery
	Va. Beach
	Giles
	Shenandoah
	Warren
Pediasia trisecta (Walker)	Montgomery
	Augusta
	Giles
	Prince George
	Va. Beach
Microcrambus elegans (Clemens)	Montgomery
	Va. Beach
Agriphila vulgivagella (Clemens)	Augusta
	Montgomery
	Henrico
Agriphila ruricolella (Zeller)	Va. Beach
	Montgomery
Chrysoteuchia topiaria (Zeller)	Montgomery
Urola nivalis (Drury)	Montgomery
	Va. Beach

Seasonal Occurrence

The 14 sod webworm species collected in light traps in Virginia are listed in Table 2. Of these, *Chrysoteuchia topiaria*, *Microcrambus elegans*, *Crambus agitatellus*, and *Crambus perlellus* are new state records. The seasonal occurrence of the more numerous species caught is indicated in Figure 3. *Parapediasia teterrella*, *M. elegans*, and *Pediasia trisecta* were the most abundant moths sampled and are all multivoltine. The other eight species appear to be univoltine. Three rare species, represented by less than 6 specimens caught in Virginia, are *Parapediasia decorella* (Zincken), *Crambus leachellus* (Zincken), and *C. perlellus*.

The species present throughout most of the spring to late summer are *P. trisecta*, *P. teterrella*, and *M. elegans*, other species are present during the spring, summer, or fall only. *P. teterrella* was the most abundant moth sampled, reaching a peak of about 5,000 moths per week in mid-June. It has two generations per year in the Appalachian region, with adult flight peaks occurring during mid-June and August. *M. elegans* was the second most abundant moth collected. It has two generations per year with adult flight peaks during mid-June and early September. *P. trisecta* appears to have two or three generations per year,

TABLE 2. Sod webworm species collected in light traps in Virginia.

Species
Crambus praefectellus
Crambus caliginosellus
Crambus laqueatellus
Crambus leachellus
Crambus agitatellus
Crambus perlellus
Parapediasia teterrella
Parapediasia decorella
Pediasia trisecta
Agriphila ruricolella
Agriphila vulgivagella
Urola nivalis
Chrysoteuchia topiaria
Microcrambus elegans

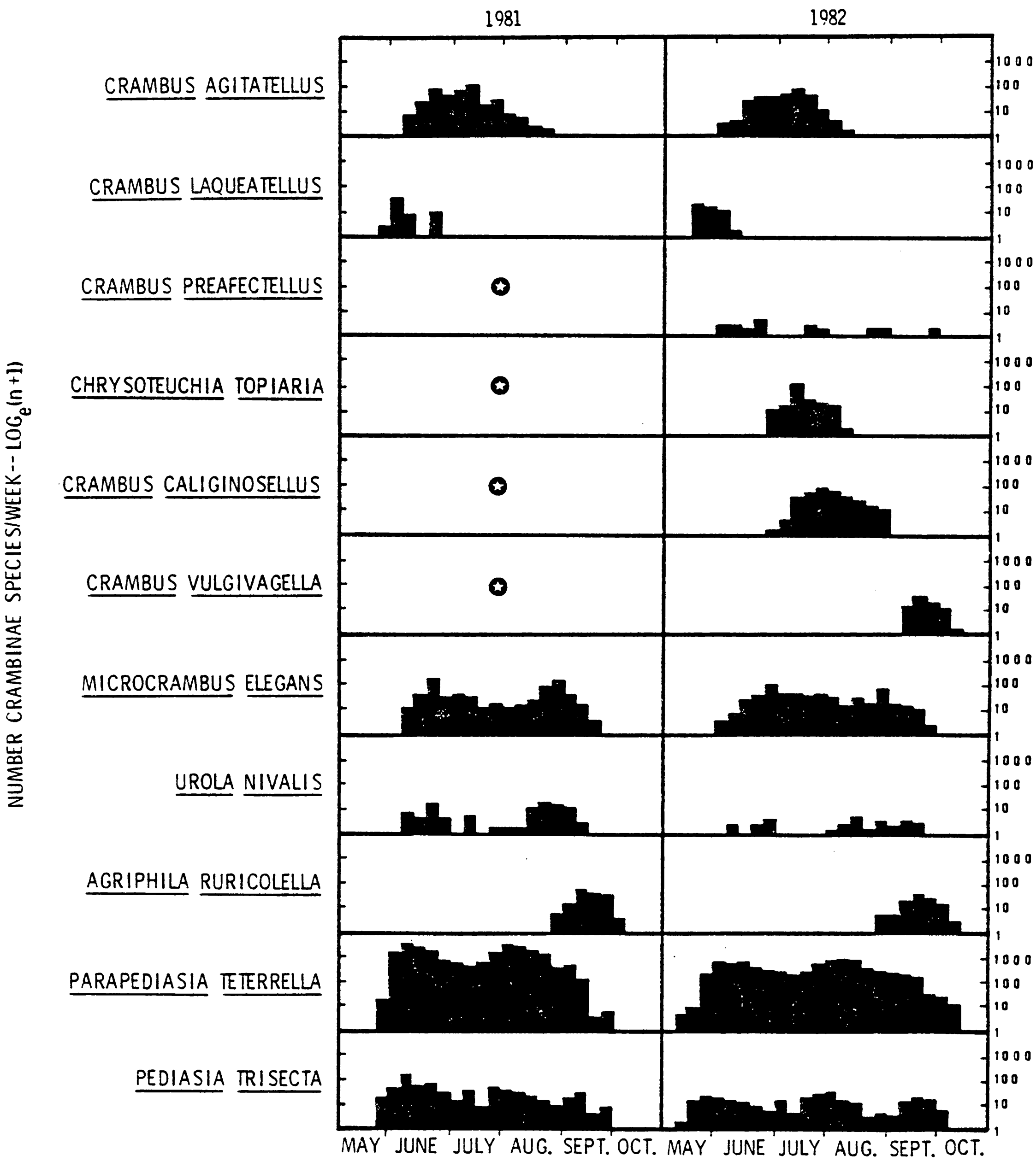

Figure 3. Seasonal occurrence of the more numerous sod webworm species in Virginia. ✪ Data not available. Actual numbers of moths caught are shown in appendix 2 & 3.

with adult flight peaks during mid-June, early August, and mid-September. *C. agitatellus* has only one generation per year, with its flight peak occurring during early June. Trap data from Virginia Beach indicates that these periods of activity can be expected to occur about two weeks earlier for all species. This is probably due to warmer temperatures occurring earlier in the year.

It is evident from this data that a sod webworm species complex is present throughout the turfgrass growing season, from spring to late fall. Most of the species were sampled in low numbers except *P. teterrella*. Although sampled in low numbers, the corn-root webworm, *Crambus caliginosellus* Clemens, has been known to attack corn in Virginia (Roberts, personal communication). This species is also a pest of tobacco in Virginia (Metcalf and Flint 1939).

Pictorial Key

Members of the subfamily Crambinae are medium to small in size, most have wingspans less than 3.5cm. Moths are generally light colored with forewings being either yellow, brown, or white, metallic markings are often present. The forewings are generally long and narrow and are rolled around the abdomen when the insect is at rest. Most species, except *Urola nivalis* (Drury) and *Crambus perlellus*, have long labial palpi.

The 16 sod webworm species found to occur in Virginia have distinct and unique color patterns on their forewings. Forewings are either predominately white, brown, gold, or gray. Fringes are often white or gold. Four of the 16 species have a horizontal white stripe(s) extending the length of the wing. The nine species without a stripe(s) differ by having either gold or no golden fringes on the wings. Other species have longitudinal inner and outer lines, and some species possess terminal dots with or without terminal lines. Various combinations of these patterns allow for the identification of sod webworm adults to species level (Figure 4).

Degree-day Relationships

Regression equations for six sod webworm species in the Appalachian region of Virginia are shown in Table 3. The 1982 regression equations were used to validate those generated in 1981. The 1981 and 1982 equations were compared to each other to determine whether significant differences exist within species. Equations were tested for differences in their residual variances, slopes, and intercepts, as is outlined in Snedecor and Cochran (1967). No significant differences ($p > .05$) were found to occur between the 1981 and 1982 equations for *C. laqueatellus*,

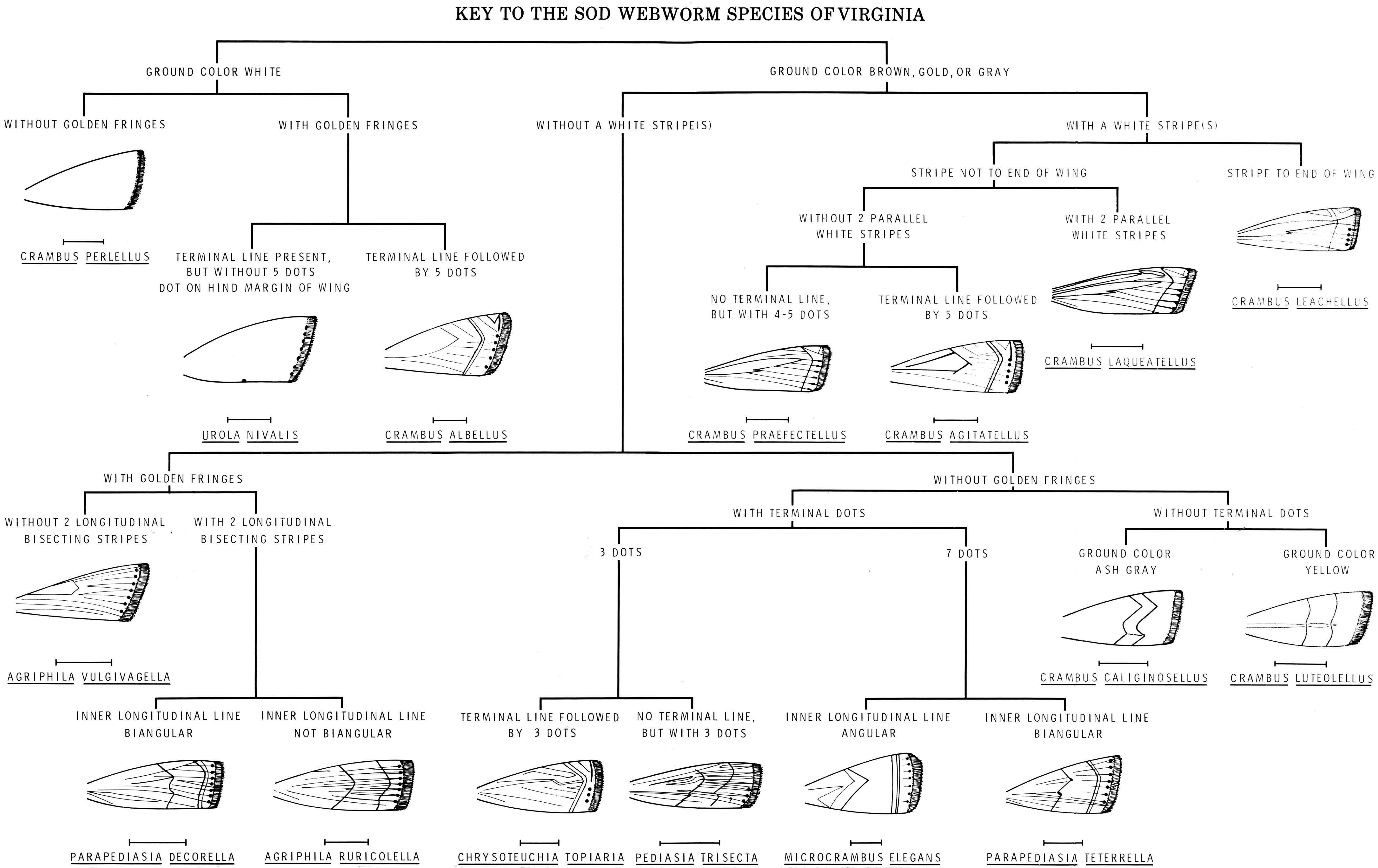

Figure 4. Pictorial key to the forewing patterns of the sod webworm (Lepidoptera:Pyralidae:Crambinae) species in Virginia.

TABLE 3. 1981 and 1982 regression equations for Crambinae adults in Virginia.

	Year					
	1981			1982		
Species	Regression equation	R^2	S.E. Slope	Regression equation	R^2	S.E. Slope
C. agitatellus	$y^b = -29.660 + 12.114X^c$ ✪	.99	.32	$y = -33.398 + 13.461X$ ✪	.98	.53
M. elegans (1)[a]	$y = -29.455 + 12.167X$	.97	.75	$y = -26.835 + 11.057X$	.96	.68
(2)	$y = -116.124 + 38.741X$	.97	3.22	$y = -109.658 + 36.559X$	.95	3.31
C. laqueatellus	$y = -35.177 + 15.478X$	.93	2.12	$y = -54.096 + 23.593X$	.96	3.29
P. trisecta (1)	$y = -28.282 + 12.545X$	.97	.88	$y = -20.752 + 9.714X$	.93	.91
(2)	$y = -38.642 + 14.583X$	.94	1.37	$y = -48.808 + 17.805X$	.97	1.15
(3)	$y = -189.119 + 61.271X$	.87	12.02	$y = -312.081 + 99.272X$	.98	7.17
P. teterrella (1)	$y = -28.128 + 12.286X$ ✪	.99	.55	$y = -19.521 + 9.032X$ ✪	.97	.48
(2)	$y = -53.327 + 19.162X$ ✪	.97	1.01	$y = -39.045 + 14.378X$ ✪	.96	.84
A. ruricolella	$y = -354.661 + 112.855X$	.96	13.31	$y = -215.069 + 68.985X$	.96	5.39

a/ Generation of species.

b/ Cumulative percent emergence in probits = y.

c/ $\text{Log}_{10}\ DD_{10^oC} = X$; maximum-minimum temperature for the degree-day analysis are shown in appendix 4 & 5.

✪ Equations in columns followed by ✪ are significantly different ($p < .05$).

A. ruricolella, and all generations of M. elegans and P. trisecta, respectively. Equations not significantly different were pooled to yield one predictive equation per species (Table 4).

Equations for all generations of P. teterrella and C. agitatellus were found to differ significantly ($p < .05$) in slopes and intercepts, respectively. Such differences could be attributed to many factors affecting light trap efficiency. Periods of rain, wind speed and direction, and black light intensity can all reduce the efficiency of the trap by either affecting moth mobility or attractancy. Developmental threshold differences might have contributed to differences in the regression equations because the developmental threshold of first generations can be assumed to be equal to second and third generations whose regression equations did not differ ($p > .05$). However, it is possible that differing generations of the same species might have differing degree-day requirements; in which case the predicted peak flight periods would occur earlier or later than the observed flight periods.

The predictive equations generated by SAS are in the form:

$$\% \text{ emergence (probits)} = \text{intercept} + \text{slope}(\log_{10} DD_{10^\circ C})$$

TABLE 4. Pooled 1981 and 1982 predictive regression equations for 4 Crambinae species in Virginia.

Species	Regression equation	R^2	S.E. Slope
M. elegans (1)[a]	$y^{b} = -25.467 + 10.608X^{c}$	.97	.40
(2)	$y = -105.63 + 35.250X$	.95	2.23
C. laqueatellus	$y = -32.223 + 14.452X$	.94	.25
P. trisecta (1)	$y = -20.535 + 9.500X$	.97	.41
(2)	$y = -38.877 + 14.562X$	.96	.68
(3)	$y = -142.344 + 46.205X$	.91	4.64
A. ruricolella	$y = -208.562 + 66.946X$	.98	2.54

a/ Generation of species.

b/ Cumulative percent emergence in probits = y.

c/ $\text{Log}_{10}\ DD_{10^oC} = X$; maximum-minimum temperature for the degree-day analysis are shown in appendix 4 & 5.

This equation can be used to predict the occurrence of flight peaks for particular moth species. To calculate the flight peak let y = 5 and solve for $X(Log_{10} DD_{10°C})$. By taking the antilog of X the degree-day in centigrade is obtained when the flight peak will occur. By monitoring degree-days in the environment it is possible to anticipate when a particular degree-day will occur. Such data allows for the mathematical prediction of the flight peaks of sod webworm species. Only the 1981 and 1982 pooled regression equations can be used to make predictions of sod webworm adult flight peaks since they represent 2 years worth of nonsignificantly differing populations (Table 4).

Habitat Preferences of Common Turfgrass Insects

The insects found inhabiting three species of turfgrass are shown in Table 5. Species of the families Elateridae, Curculionidae, Scarabaeidae, Formicidae, and Aphididae were found in all three species of turfgrass sampled. Sod webworms (*Crambus* sp.) and the fall armyworm, *Spodoptera frugiperda* Smith, were found in tall fescue only. However, they also can inhabit ryegrass and bluegrass. Ainslie (1930) showed that the bluegrass webworm, *P. teterrella*, prefers bluegrass as its host. The data indicate that the species in Table 5 can be found to occur in tall fescue,

TABLE 5. Insects found inhabiting turfgrass in Virginia.

Insect: Order, Family, Genus, Species	Turfgrass species[1]
Lepidoptera	
Pyralidae	
Crambus spp.	TF
Noctuidae	
Spodoptera frugiperda (Smith)	TF
Coleoptera	
Elateridae	
Aeolus mellillus (Say)	TF,R,B
Conoderus bellus (Say)	TF,R,B
immature spp.	TF,R
Curculionidae	
Sphenophorus spp.	TF,R,B
Scarabaeidae	
Popillia japonica Newman	TF,R,B
Hymenoptera	
Formicidae	
Solenopsis molesta (Say)	TF,R,B
Lasius neoniger Emery	TF,R,B
Acanthomyops claviger (Rogers)	R,B
Homoptera	
Aphididae	
Geoica squamosa Hart.	TF,R,B

1/ TF = Tall fescue (*Festuca arundinaceae* L.), R = Perennial ryegrass (*Lolium perenne* L.), B = Kentucky bluegrass (*Poa pratensis* L.).

ryegrass, and bluegrass. However, the number of samples taken were too low to use statistical analysis in determining differences among turfgrass species.

The data indicate that there was a higher percentage of *P. japonica* and *Lasius neoniger* Emery found in the samples taken from tall fescue than from bluegrass or ryegrass (Table 6). Morrill (1975) and Morrill and Dobson (1970) report that *P. japonica* prefers as its host tall fescue sod. Tashiro and Personius (1970) indicate that the bluegrass billbug, *Sphenophorus venatus vestitus* Chittenden, prefers bluegrass. The affects of thatch and moisture on *P. japonica* and *L. neoniger* could not be analyzed statistically due to the low number of samples taken. However, the data indicate that bluegrass contains 1.68cm of thatch while percentage moisture ranged from 19-24% for the plots sampled (Table 6). Beard (1973), Madison (1970), and Randall (1976), indicate that the greater the thatch the greater the possibility of harboring insect pests. Although the data indicate that bluegrass has the thickest thatch it also harbored less *P. japonica* and *L. neoniger* than tall fescue. Since percentage moisture ranged from 19-24% for all plots sampled the differences in insect densities probably cannot be attributed to it.

TABLE 6. Results of turfgrass sampling for species and variables.

Species	Turfgrass species[1] TF	B	R
Popillia japonica Newman	18%[2]	14%[2]	11%[2]
Lasius neoniger Emery	34%[2]	13%[2]	11%[2]
Variables[3]			
Thatch (cm)	.96 ± .04	1.68 ± .05	.71 ± .04
Moisture (%)	21.91±2.29	21.09±2.52	22.52±.53

1/ TF = Tall fescue (*Festuca arundinaceae* L.),
B = Kentucky bluegrass (*Poa pratensis* L.),
R = Perennial ryegrass (*Lolium perenne* L.).

2/ Number denotes % of total sample containing either species (TF:N = 192; B:N = 132; R:N = 156).

3/ Mean ± standard error.

CONCLUSIONS

The sod webworm species complex in Virginia consists of at least 16 species which are distributed over the Appalachian, Piedmont, and Coastal Plain regions of Virginia. C. topiaria, A. ruricolella, C. agitatellus, and C. caliginosellus were found present at high elevations (700m) in the Appalachian region of Virginia. Matheny and Heinrichs (1975) also reported these species present above 1333m in Tennessee.

The 16 sod webworm adults in Virginia can be keyed to species by color patterns on their forewings. The forewings are either white, gold, brown, or gray. There is also often horizontal and or longitudinal lines on the wings, with or without terminal lines and dots. Various combinations of these patterns allow for species determination.

Of the 16 species known to occur in Virginia, 14 were sampled in light traps in Virginia. Sampled in most numbers was P. teterrella, followed by M. elegans and P. trisecta. P. teterrella was found to have 2 flight peaks occurring during mid-June and August. M. elegans also has 2 flight peaks occurring during mid-June and early September. P. trisecta has two or three peaks occurring during mid-June, early August, and mid-September. Considering all the species it is evident that a sod webworm species complex is present throughout the turfgrass growing season, from spring to late fall. The number of generations and adult flight peaks differ depending on the species.

Four of the 6 species sampled were found not to differ in predictive regression equations between 1981 and 1982. This allowed for the generation of pooled predictive models for *M. elegans*, *C. laqueatellus*, *P. trisecta*, and *A. ruricolella*. These can be used to predict an additional years worth of occurrence of adult flight peaks.

Some sod webworm species adults were also found to display certain behavioral characteristics. It was found that *M. elegans*, *P. teterrella*, and *A. ruricolella* utilize shrubs instead of turfgrass as resting sites during the day. This may be due to mechanisms to reduce detection by predators, temperature regulation, or both. In addition, 10 species of 7 families of insects were found to inhabit tall fescue, ryegrass, and bluegrass, with no preference for either turfgrass species.

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APPENDIX

SOD WEBWORM ADULT RESTING SITE PREFERENCES

Materials and Methods

Adult resting sites were studied in a turfgrass area surrounded by two types of garden shrubs; *Buxus sempervirens* L. and *Juniperus chinensis pfitzeriana* Spaeth. The turfgrass area sampled consisted of a mixture of bluegrass, ryegrass, and lawn weeds. Adults were sampled by beating shrubs with a wooden dowel (150cm long x 2.5cm diameter). Each *B. sempervirens* was sampled by beating it once in two locations (upper 1/3 and lower 1/3). Each *J. c. pfitzeriana* was beat once for every 1m of exposed perimeter area. Adults flushed into flight were counted and identified on site. Both shrubs were sampled once a day between 12:00 and 4:30 pm, during August and September, 1982.

Adults in turfgrass were sampled with a mechanical flushing device. This device consists of 4 Ladder Type Block Locks®[1] bound together and pulled by a 6m long nylon rope. This device was dragged over the turfgrass flushing moths into flight. Moths were counted and identified on site. Turfgrass was sampled once a day between 12:00 and 4:30 pm, during August and September, 1982.

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[1]Obtainable through concrete and masonry dealers.

Results and Discussion

The three species of moth sampled in shrubs and turfgrass were *M. elegans*, *P. teterrella*, and *A. ruricolella*. There was a significantly higher abundance ($p < .05$; Wilcoxon two-sample test) of all 3 species found in the shrubs than in the turfgrass sampled. In addition, no significant differences ($p > .05$) were found in the abundance of moths in either the *Buxus* sp. or *Juniperus* sp. shrubs sampled (Table 7). The data indicate that these three species of sod webworm adults tend to utilize shrubs instead of turfgrass as resting sites during the day with no apparent preferences for either shrub.

Since sod webworm adults have very erratic flight patterns, they could be easily noticed by predators, such as birds, when flying over turfgrass. By limiting their daily activity within shrubs they could conceivably be less vulnerable to predation by avoiding detection. It is interesting to note that sod webworm adults begin flying over turfgrass areas during the late evening and into the night. Such behavior patterns may have evolved due to predation pressure whereby adults are confined to shrubs during the day and fly about at night. Another hypothesis for the utilization of shrubs instead of turfgrass during the day might be some form of temperature regulation. By

TABLE 7. Number of moths sampled in three locations at one area in Blacksburg, Virginia.

Species	Location of moths			
			Bushes	
	Bushes	Turfgrass	*Buxus* sp.	*Juniperus* sp.
M. elegans	83^{A}	11^{A}	42	41
P. teterrella	77^{B}	37^{B}	37	40
A. ruricolella	280^{C}	186^{C}	137	143

Totals in columns followed by the same letter are significantly different ($p < .05$), Wilcoxon two-sample test.

M. elegans (N = 50), *P. teterrella* (N = 50), *A. ruricolella* (N = 30).

limiting their daily activity to shrubs, sod webworm adults are also shielded from the sun's radiation. Such a situation decreases their exposure to radiation which can result in lower body temperatures.

Appendix 1. Known date/locality records of sod webworm species in Virginia.

Species	Location of collection	Date of collection	Collector of specimen	Current location of specimen[1]
Crambus praefectellus	Cedar Rapids	July 8, 14, 1951	H. G. Dyar	NMNH
	Blacksburg	July 17, 1982	M. P. Tolley	VPI&SU
Crambus albellus	Skyland	July 6, 1916	H. G. Dyar	NMNH
Parapediasia decorella	Charlottesville	Sept. 6, 1916	W. T. Emery	NMNH
	Blacksburg	Aug. 11, 1981	M. P. Tolley	VPI&SU
Parapediasia teterrella	Ocean View	Aug. 9	A. N. Caudell	NMNH
	Skyland	July 5, 1911	H. G. Dyar	NMNH
	Mt. Jackson		W. F. Pennington	NMNH
	Eggleston	June 18, 1967	Straley	AMNH
	Blacksburg	June 12, 1982	M. P. Tolley	VPI&SU
	Lake Shores	Aug. 31, 1981	M. P. Tolley	VPI&SU
	College Park	Aug. 12, 1981	M. P. Tolley	VPI&SU
Agriphila ruricolella	Virginia	Sept. 16, 1880	F. C. Pratt	NMNH
	Lake Shores	Sept. 21, 1981	M. P. Tolley	VPI&SU
	Blacksburg	Aug. 29, 1981	M. P. Tolley	VPI&SU
Crambus caliginosellus	Vienna	July 11, 1910	R. A. Cushman	NMNH
	Mt. Jackson	July 24, 1915	W. F. Pennington	NMNH
	Chase City	Aug. 4, 1913		NMNH
	Plains	June 8, 1912	J. B. Benerly	NMNH
	Blacksburg	July 24, 1982	M. P. Tolley	VPI&SU
Crambus luteolellus	Mt. Jackson		W. F. Pennington	NMNH
	Harrisonburg	July 7, 1950	B. Cazier	AMNH
Crambus laqueatellus	Eggleston	May 28, 1967	G. B. Straley	VPI&SU
	Blacksburg	May 24, 1959	C. B. Nolonde	VPI&SU
Crambus leachellus	Staunton	Sept. 3, 1910		AMNH
	Lake Shores	April 21, 1981	M. P. Tolley	VPI&SU
Urola nivalis	Montgomery Co.	June 22, 1899		AMNH
	Blacksburg	June 26, 1982	M. P. Tolley	VPI&SU
	Lake Shores	Aug. 14, 1981	M. P. Tolley	VPI&SU
	College Park	Aug. 24, 1981	M. P. Tolley	VPI&SU

1/NMNH = National Museum of Natural History, AMNH = American Museum of Natural History, VPI&SU = Virginia Polytechnic Institute and State University.

Appendix 1. (continued)

Species	Location of collection	Date of collection	Collector of specimen	Current location of specimen
Pediasia trisecta	Radford	Sept. 25, 1952	Rindge	AMNH
	Staunton	Sept. 3, 1910		AMNH
	Mt. Lake	June 23, 1956	Zweifel	AMNH
	Petersburg	Sept. 1, 1959		AMNH
	Eggleston	Sept. 2, 1966	Stratley	AMNH
	Blacksburg	July 24, 1982	M. P. Tolley	VPI&SU
	Lake Shores	Aug. 17, 1981	M. P. Tolley	VPI&SU
	College Park	Aug. 26, 1981	M. P. Tolley	VPI&SU
Agriphila vulgivagella	Staunton			AMNH
	Radford	Sept. 1952	F. H. Rindge	AMNH
	Richmond	Sept. 1951, 52	F. H. Rindge	AMNH
	Blacksburg	Sept. 1982	M. P. Tolley	
Chrysoteuchia topiaria	Blacksburg	July 24, 1982	M. P. Tolley	VPI&SU
Microcrambus elegans	Blacksburg	July 3, 1982	M. P. Tolley	VPI&SU
	Lake Shores	Sept. 8, 1981	M. P. Tolley	VPI&SU
	College Park	Aug. 24, 1981	M. P. Tolley	VPI&SU
Crambus agitatellus	Blacksburg	June 26, 1982	M. P. Tolley	VPI&SU
	College Park	Aug. 14, 1981	M. P. Tolley	VPI&SU
Crambus perlellus	Blacksburg		M. P. Tolley	VPI&SU

Appendix 2. Total numbers of sod webworm adults caught/week in light traps in Blacksburg, Va. - 1981.

		Species						
Month	Week	*C. agitatellus*	*M. elegans*	*U. nivalis*	*C. laqueatellus*	*P. trisecta*	*A. ruricolella*	*P. teterrella*
May	17-21	0	0	0	0	0	0	0
	22-28	0	0	0	2	19	0	21
June	29-5	0	0	0	38	47	0	1655
	6-12	6	11	7	8	124	0	5614
	13-19	27	49	5	0	69	0	4699
	20-26	87	154	17	9	73	0	4114
July	27-3	57	39	5	0	31	0	911
	4-10	95	50	0	0	13	0	690
	11-17	111	40	6	0	34	0	443
	18-24	21	10	0	0	8	0	751
	25-31	32	20	1	0	53	0	2034
August	1-7	7	10	1	0	44	0	4691
	8-14	4	12	1	0	40	0	4127
	15-21	2	32	10	0	21	0	2440
	22-28	1	96	14	0	11	0	1524
September	29-4	0	127	13	0	8	6	452
	5-11	0	44	10	0	20	14	578
	12-18	0	15	2	0	35	72	117
	19-25	0	4	0	0	3	42	3
October	26-2	0	0	0	0	7	39	6
	3-9	0	0	0	0	0	4	0
	10-16	0	0	0	0	0	0	0

Appendix 3. Total numbers of sod webworm adults caught/week in light traps in Blacksburg, Va. - 1982.

		Species					
Month	Week	*C. laqueatellus*	*P. trisecta*	*P. teterrella*	*C. praefectellus*	*M. elegans*	*C. agitatellus*
April	10-16	0	0	0	0	0	0
	17-23	0	0	0	0	0	0
	24-30	0	0	0	0	0	0
May	1-7	0	0	0	0	0	0
	8-14	0	1	3	0	0	0
	15-21	17	15	8	0	0	0
	22-28	12	27	292	0	0	0
June	29-4	10	26	890	2	5	3
	5-11	1	15	765	2	7	4
	12-18	0	10	853	1	31	33
	19-25	0	7	539	5	45	40
	26-2	0	5	393	0	99	40
July	3-9	0	13	345	0	51	76
	10-16	0	5	309	0	54	95
	17-23	0	19	351	2	39	45
	24-30	0	34	677	1	40	10
August	31-6	0	37	854	0	34	5
	7-13	0	15	962	0	16	1
	14-20	0	12	950	0	41	0
	21-27	0	2	352	1	29	0
	28-3	0	4	304	1	78	0
September	4-10	0	3	258	0	23	0
	11-17	0	13	187	0	16	0
	18-24	0	25	146	0	10	0
	25-1	0	14	58	1	2	0
October	2-8	0	6	31	0	0	0
	9-15	0	0	11	0	0	0

Appendix 3. (continued)

Month	Week	Species				
		U. nivalis	*C. topiaria*	*C. caliginosellus*	*A. ruricolella*	*A. vulgivagella*
April	10-16	0	0	0	0	0
	17-23	0	0	0	0	0
	24-30	0	0	0	0	0
May	1-7	0	0	0	0	0
	8-14	0	0	0	0	0
	15-21	0	0	0	0	0
	22-28	0	0	0	0	0
June	29-4	0	0	0	0	0
	5-11	2	0	0	0	0
	12-18	0	0	0	0	0
	19-25	2	0	0	0	0
	26-2	3	14	1	0	0
July	3-9	0	21	5	0	0
	10-16	0	109	52	0	0
	17-23	0	50	69	0	0
	24-30	0	28	84	0	0
August	31-6	1	19	73	0	0
	7-13	2	1	52	0	0
	14-20	6	0	35	0	0
	21-27	1	0	12	0	0
	28-3	4	0	11	6	0
September	4-10	2	0	0	6	0
	11-17	4	0	0	25	17
	18-24	3	0	0	48	46
	25-1	0	0	0	26	22
October	5-8	0	0	0	15	13
	9-15	0	0	0	2	1

Appendix 4. Maximum-minimum temperatures (^{o}F) for Blacksburg, Va. - 1981.

	Months									
	Jan.		Feb.		March		April		May	
Day	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1	34	29	40	8	51	36	65	48	63	42
2	34	24	42	8	47	31	72	42	58	33
3	34	18	34	6	47	24	80	34	70	29
4	42	8	20	8	43	21	72	48	72	37
5	12	2	29	8	48	32	63	41	78	40
6	30	10	30	10	40	29	50	28	70	48
7	40	14	40	19	39	25	62	23	63	43
8	32	10	50	22	45	15	73	32	64	34
9	30	14	41	10	46	17	63	48	67	43
10	36	12	42	26	48	19	69	41	60	54
11	24	2	47	2	48	30	79	49	75	50
12	20	0	47	2	54	28	78	56	58	39
13	19	6	28	8	64	30	60	41	76	34
14	32	10	40	4	43	25	61	41	79	46
15	48	22	54	20	61	21	65	36	64	47
16	38	26	58	24	45	23	71	31	63	45
17	36	14	58	30	53	21	61	48	71	40
18	26	18	58	41	47	26	75	47	61	49
19	38	26	62	44	32	21	76	44	49	44
20	38	26	45	38	34	19	59	52	54	43
21	52	22	48	40	47	26	62	36	72	37
22	48	30	52	34	34	24	69	34	77	42
23	38	26	60	38	42	30	72	54	80	44
24	46	27	50	31	47	20	59	39	82	48
25	40	28	44	30	52	24	57	36	84	51
26	49	20	56	30	62	24	65	32	82	55
27	59	28	54	22	62	36	81	48	68	60
28	52	28	64	28	66	26	83	50	67	59
29	46	26			71	32	71	50	70	55
30	44	18			64	49	69	46	82	51
31	40	10			78	44			78	61

Appendix 4. (continued)

	Months									
	June		July		Aug.		Sept.		Oct.	
Day	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1	64	57	72	60	78	54	77	63	79	47
2	81	57	70	60	81	61	84	67	55	38
3	83	61	75	63	83	61	79	67	59	36
4	82	64	83	63	88	62	68	64	71	32
5	79	64	85	62	89	64	77	62	76	46
6	68	64	82	69	81	66	79	61	79	50
7	78	61	88	64	86	64	77	59	60	45
8	82	56	89	61	81	63	73	54	63	37
9	83	66	91	68	83	59	69	50	63	33
10	85	65	92	69	84	63	76	45	54	39
11	79	58	93	67	85	62	80	50	59	45
12	83	60	94	66	80	55	80	53	53	46
13	83	64	86	64	80	51	81	52	59	37
14	86	65	85	64	83	53	82	54	66	31
15	87	64	82	58	85	58	70	62	71	35
16	87	62	78	63	84	62	71	54	68	41
17	74	56	83	62	77	58	66	44	71	34
18	74	56	82	64	75	54	63	45	68	46
19	82	63	84	64	66	59	60	44	47	27
20	80	61	85	66	77	52	73	46	64	22
21	89	59	82	62	74	52	75	42	70	27
22	86	64	81	60	76	52	75	44	71	38
23	84	58	80	55	81	50	64	41	59	37
24	89	55	74	64	82	55	68	37	46	25
25	90	61	81	62	83	55	72	37	45	36
26	74	52	86	68	81	52	81	44	58	43
27	76	47	88	67	84	55	77	47	65	51
28	77	49	88	67	84	57	70	43	62	41
29	82	49	79	55	79	53	71	37	59	43
30	81	57	75	50	84	63	78	46	48	44
31			76	54	84	65			50	43

Appendix 5. Maximum-minimum temperatures (^{o}F) for Blacksburg, Va. - 1982.

	Months									
	Jan.		Feb.		March		April		May	
Day	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1	43	27	45	26	47	24	66	34	73	37
2	44	19	32	27	54	31	72	32	68	46
3	34	30	43	32	48	30	69	47	72	42
4	54	32	48	32	36	27	58	42	74	41
5	43	26	39	31	61	34	54	30	77	39
6	45	28	40	17	42	33	45	22	82	45
7	56	28	39	12	38	24	42	17	81	52
8	35	19	51	16	38	21	39	27	71	45
9	30	8	50	27	54	23	46	32	73	42
10	8	-8	34	19	54	30	52	30	76	41
11	10	-6	46	19	66	30	55	27	81	46
12	26	5	39	19	70	40	71	35	85	45
13	22	16	31	20	65	48	64	52	85	50
14	26	15	56	17	54	40	72	43	86	51
15	27	14	61	29	46	34	65	49	85	52
16	35	2	53	42	43	35	71	46	84	53
17	10	-12	50	31	74	39	74	47	84	53
18	35	7	32	29	76	38	63	38	81	58
19	32	26	40	30	65	42	65	35	78	59
20	46	27	58	34	51	44	63	42	78	55
21	41	31	50	33	61	44	61	38	75	58
22	31	23	36	30	54	31	57	33	80	57
23	43	23	66	28	56	29	63	26	73	60
24	37	20	72	40	63	32	71	30	72	61
25	35	17	44	25	69	34	68	35	80	63
26	24	7	33	18	45	27	71	53	73	63
27	33	3	29	22	35	21	64	50	72	63
28	45	14	40	23	48	13	64	42	80	62
29	46	19			59	20	60	33	78	60
30	51	26			68	33	67	35	84	61
31	58	41			52	50			84	63

Appendix 5. (continued)

	Months									
	June		July		Aug.		Sept.		Oct.	
Day	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1	73	52	75	53	78	59	70	60	70	43
2	76	52	81	50	78	54	80	58	77	45
3	77	57	83	61	82	61	82	56	82	50
4	64	59	82	61	86	60	78	45	80	55
5	70	57	73	61	82	65	77	32	81	55
6	63	56	81	63	88	69	76	41	79	53
7	77	56	84	59	86	66	80	43	75	53
8	81	57	84	65	82	65	81	48	77	54
9	82	57	82	64	76	66	78	55	70	58
10	77	63	86	63	82	60	75	47	71	53
11	77	58	85	66	79	58	81	46	57	49
12	71	62	81	64	77	60	80	48	58	55
13	73	57	76	65	75	59	82	52	68	50
14	75	53	82	66	80	59	78	58	62	43
15	80	51	83	65	82	57	76	62	62	42
16	85	62	86	66	84	59	86	60	66	38
17	76	61	87	65	82	63	84	48	54	27
18	75	60	87	65	77	58	82	50	56	25
19	79	58	84	64	81	59	82	50	60	28
20	77	56	82	66	80	59	65	54	67	35
21	78	53	83	63	79	55	62	43	--	--
22	74	59	87	66	75	49	68	41	--	--
23	74	54	80	66	82	57	61	36	--	--
24	73	50	81	62	81	64	66	32	--	--
25	80	56	86	61	81	57	69	34	--	--
26	82	61	86	63	76	49	70	46	--	--
27	84	61	87	64	76	55	55	45	--	--
28	86	62	85	67	78	55	67	44	--	--
29	79	65	76	62	70	47	72	40	--	--
30	80	58	79	65	78	49	70	42	--	--
31			72	66	70	62			--	--

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ASPECTS OF THE BIOLOGY OF SOD WEBWORMS
(LEPIDOPTERA: PYRALIDAE: CRAMBINAE) AND
TURFGRASS INHABITING INSECTS OF VIRGINIA

by

Mike P. Tolley

(ABSTRACT)

Turfgrass is subject to attack by a variety of insect pests. However, there has been no research on the sod webworm pests associated with turfgrass in Virginia and little research on habitat preferences of other insect pests of turf. The purpose of this research was to contribute to the basic knowledge of the biology of sod webworm species in Virginia.

There are at least 16 sod webworm species found to occur in Virginia; all can be identified to species level by forewing color patterns. The species complex is distributed nearly evenly throughout Virginia with some species adapted to higher elevations (700m).

The species complex is present from spring to late fall. The number of generations and peak flight periods differ depending on the species. Most species were sampled in low numbers except *Parapediasia teterrella* (Zincken). Accumulated degree-days can predict an additional years

worth of occurrence of *Microcrambus elegans* (Clemens), *Crambus laqueatellus* Clemens, *Pediasia trisecta* (Walker), and *Agriphila ruricolella* (Zeller), in the Appalachian region of Virginia.

Behavior patterns of *P. teterrella*, *M. elegans*, and *A. ruricolella* adults indicate the utilization of shrubs instead of turfgrass as resting sites during the day. In addition, 10 species of 7 families of insects were found to inhabit tall fescue, ryegrass, and bluegrass in Virginia.