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THE STRAWBERRY LEAF ROLLER COMPLEX IN TENNESSEE[1,2]

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2. This paper is being published with the financial assistance of the Agricultural Experiment Station, University of Tennessee.

Introduction

The strawberry leaf rollers are small leaf-feeding larvae representing three families of Lepidoptera, namely the Tortricidae, Olethreutidae, and Phaloniidae. The species and subspecies that devour and roll leaves in the Tennessee complex are, in the order of their importance, *Ancylis comptana fragariae* (Walsh and Riley), *Ptycholoma peritana* (Clemens), *Olethreutes cespitana* Hübner, *Sparganothis sulfureana* Clemens, *Choristoneura rosaceana* (Harris), *Platynota flavedana* Clemens, *Tortrix paleorana* (Robinson), *Argyrotaenia velutinana* (Walker), *Archips argyrospila* (Walker), *Ancylis muricana* Walsingham, and *Phalonia angustana* Clemens.

These species are sporadic in their occurrence. In some years they are relatively rare, while in others, one or more species may reach such numbers as to cause considerable damage to strawberry plantings.

Damage by leaf rollers in all strawberry producing areas of Tennessee during 1955 and 1956 resulted in the joint decision by the Department of Entomology and the Administrative Staff of the Tennessee Agricultural Experiment Station to inaugurate a program of study of the strawberry leaf roller in the state. The importance of this decision was enhanced by the fact that strawberry production in Tennessee is approximately a five million dollar industry annually. (Strawberry fruit production amounts to about three and one-half to four million and plant production to about one and one-half million dollars.) In addition to commercial acreage in the larger strawberry areas of the state, small Tennessee farms get a good cash return on small acreage or even fractions of an acre.

After a preliminary study, made in late 1956, it was apparent to the author that not one, but a complex of several species of leaf rollers was involved. The study was broadened in 1957 to determine the species composition, the economic significance of each, and the biology of the more important species in the complex. During the course of study, efforts were made to find the best control methods under Tennessee conditions. Morphological studies were made in order to present diagnostic characteristics that would allow easier identification. A comprehensive study was made of the life histories of the three species and subspecies considered most important from an economic standpoint: *Ancylis comptana fragariae, Ptycholoma peritana,* and *Olethreutes cespitana.* Biological notes from field observations are recorded concerning the remaining eight species in the complex.

Natural enemies of the strawberry leaf rollers were intensively studied during the entire period. This study led to the discovery of numerous parasites that aid in leaf roller control.

ACKNOWLEDGEMENTS

The author expresses deep gratitude to his committee chairman, Dr. A. C. Cole, Jr., for his guidance and helpful suggestions throughout this study. Appreciation is extended to the following co-workers during the course of study: Mr. W. W. Stanley, for photographic help; Dr. S. G. Breeland, for help in the field and laboratory; and Mr. Charles Wagner, for valuable technical assistance. Recognition is here made of Dr. R. B. Neiswander of Ohio, Dr. R. G. Rosenstiel of Oregon, and Dr. C. H. Hill of Virginia for the exchange of pinned leaf roller specimens. I wish to thank Dr. Paul W. Oman, Chief of the Insect Identification Section, Agricultural Research Service, USDA, Beltsville, Maryland, who was responsible for identification of specimens.

IDENTIFICATION OF ADULTS AND LARVAE

The key to the adults for the eleven species in the complex is based on the presence or absence of wing markings. When markings are present, their pattern, when the wings are closed, is used to identify species. The key serves for field identification of the species in the Tennessee complex, the purpose for which it was designed.

The pictorial key to the larvae, based on characteristics of the anal comb (number and shape of teeth), covers nine of the eleven species in the complex (Fig. 1). Two species, *Ancylis muricana* and *Phalonia angustana,* were reared from field collected larvae only twice during the course of study and no opportunity to observe larval characteristics presented itself.

LIFE HISTORY AND HABITS OF SELECTED LEAF ROLLERS

I. LIFE HISTORY AND HABITS OF *Ancylis comptana fragariae* (WALSH AND RILEY)

General Distribution and Habits

Distribution. The strawberry leaf roller, *Ancylis comptana fragariae,* is of European origin. It has been present in this country for almost a century. Riley reports this species as a problem in Illinois as early as 1869, and Garman, in Kentucky in 1890. By other authors this species is reported all across the northern United States from the Atlantic to the Pacific Coast and from Canada southward to California and Virginia. It occurs all over Kentucky and Tennessee and undoubtedly in other strawberry producing states to the south. The observed distribution in relation to production areas in Tennessee is shown in the map (Fig. 2).

Type of Injury. The injury by this subspecies, and leaf rollers in general, is usually in the form of rolled leaves into which the worm retreats when disturbed (Fig. 3). Occasionally, leaves are webbed to the rolled hiding place and fed upon. This

KEY TO THE LEAF ROLLER ADULTS FOUND ON STRAWBERRIES IN TENNESSEE

1. Without marking on wings ----------  *Tortrix pallorana*

With markings on wings ---------- 2

2. Markings forming transverse bands ---------- 3

Markings not forming transverse bands ---------- 4

3. Two dark brown bands ----------  *Argyrotaenia velutinana*

Two light bands ----------  *Olethreutes cespitana*

4. Markings in the center of wings forming a diamond ----------  *Phalonia angustana*

Markings other than diamond-shape ---------- 5

5. Markings on wing chevron-like ---------- 6

Markings on wing other than chevron-like ---------- 7

6. Chevrons of 2 stripes ----------  *Ptycholoma peritana*

Chevrons of 3 stripes ----------  *Choristoneura rosaceana*

7. Markings on wings forming an X ----------  *Sparganothis sulfureana*

Markings on wings not forming an X ---------- 8

8. Markings in middle band. purplish-scales forming raised portion ----------  *Platynota flavedana*

Markings in middle band, not forming raised portion ---------- 9

9. Markings on wings whitish slashes and dots ----------  *Archips argyrospila*

Markings on wings not in the form of white slashes and dots ---------- 10

10. Anterior portion of wings marked with rust, giving a half-disk shape ----------  *Ancylis comptana fragariae*

Anterior portion of wings marked with deep blue lyre-like marking directed posteriorly ----------  *Ancylis muricana*

KEY TO LEAF ROLLER LARVAE FOUND ON STRAWBERRIES IN TENNESSEE

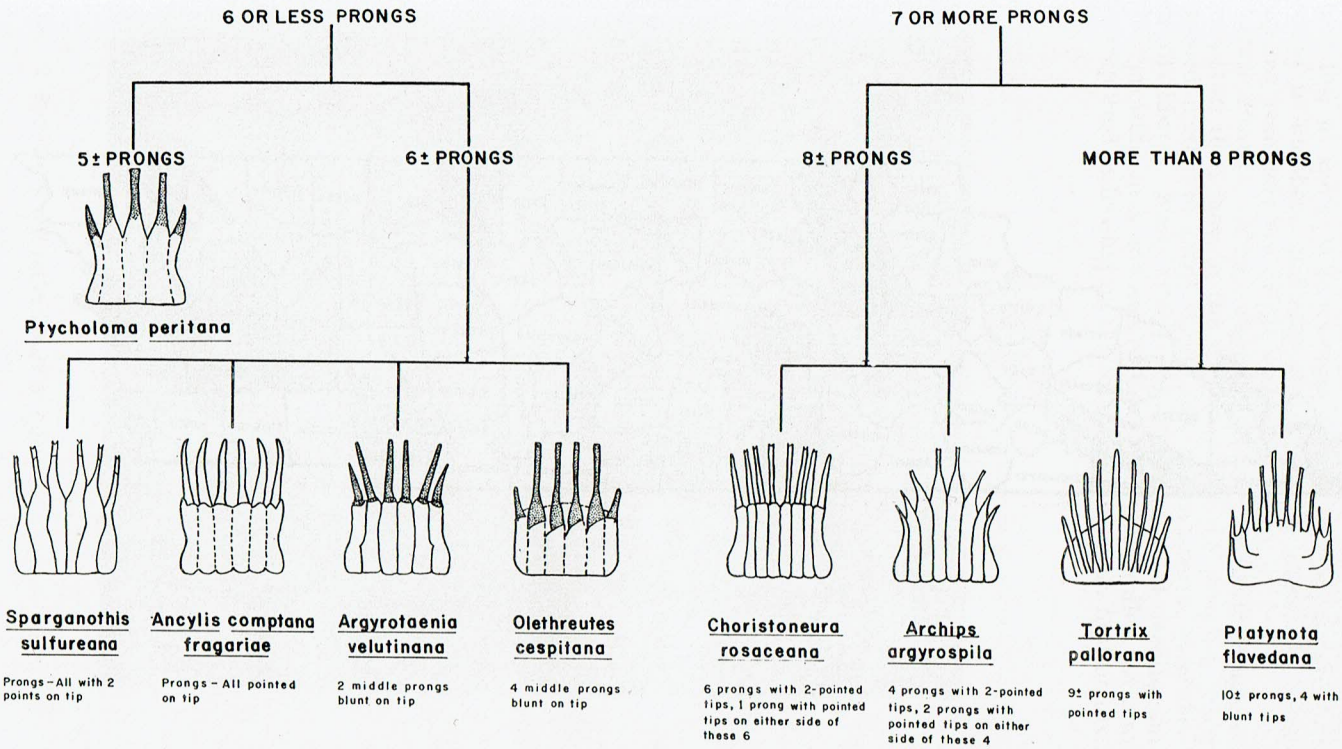


Fig. 1. Pictorial key to leaf roller larvae based on characteristics of the anal comb.

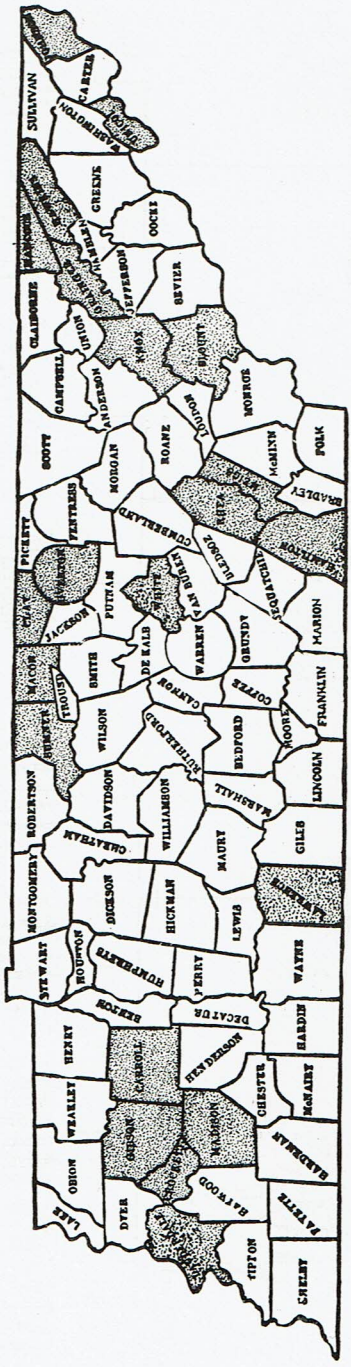


Fig. 2. Distribution of *Ancylis comptana fragariae* in relation to production areas in Tennessee

leaf damage when coupled with an extremely dry period causes plant loss in spots. When several species of the complex are present in numbers, and control (natural or chemical) is not initiated, complete loss of the stand can occur.

Host Plants. This subspecies has a narrower range of host plants than most of the species within the complex, being confined mostly to small fruits such as strawberry, raspberry, and blackberry. Fink (1932) reported finding it feeding on clover growing in a strawberry field. This leaf roller has also been reported as feeding on the following European host plants:

Fig. 3. Strawberry leaf roller injury to foliage.

Poterium sanguisorba, Thymus serpyllum, and *Teucrium.* In Tennessee it was collected only from strawberry plants during the course of study.

The Moth

Descripton. The moth averages a little more than 1 cm. in wing expanse. The general color is a reddish hue with markings of dark brown and white lines (Fig. 4). Drawings of the genitalia are presented in Fig. 5. Characteristic wing markings of the adult are shown in the key on page 324.

Emergence and Mating. The adults emerged from the pupae and fed on the sugar water plugs that covered the container in which they were kept. Mating, which usually took place within

Fig. 4. The adult of *Ancylis comptana fragariae* (natural size).

twenty-four hours in the laboratory, was not observed in the field.

Oviposition. The eggs are deposited on the underside of strawberry leaves in the field. In the laboratory they were deposited on the sides of the container, and on the sugar water plug until improved methods were devised. A satisfactory method which allowed study and easy removal of the eggs was the construction of a container of four slides, bound with Scotch tape (Fig. 6). The female normally deposits the eggs singly but occasionally two or three eggs are found in close proximity.

The number of eggs deposited varies with different females.

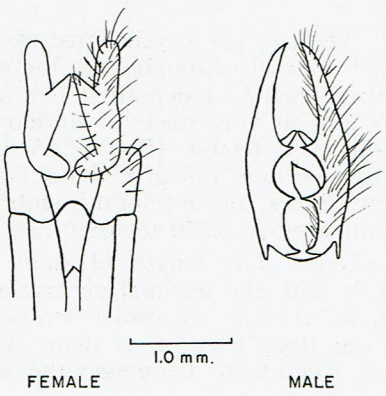


Fig. 5. Genitalia of *Ancylis comptana fragariae*. The left half of each is denuded.

The total number of eggs laid by a single female ranged between 19 and 45, and averaged 30.

Longevity. The range of longevity in days for this subspecies was 2-9. The average adult life for the male of this species was 3.4 days and for the female 6.5 days.

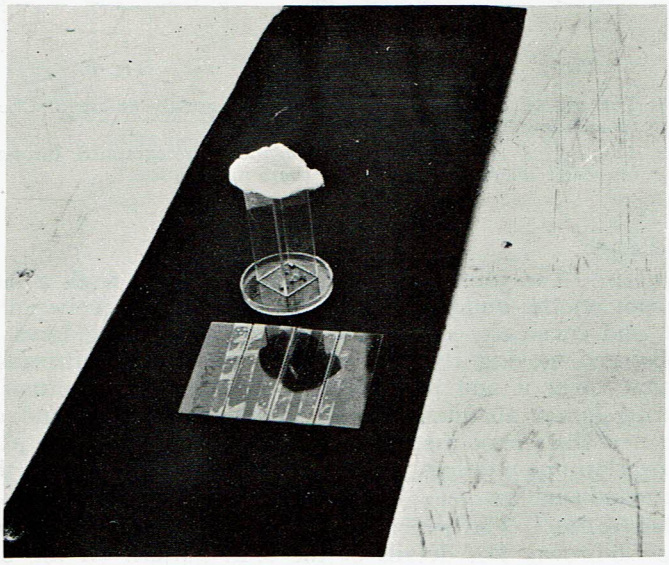


Fig. 6. A container constructed of glass slides for egg laying.

The Egg

Descrption. The egg has a reticulated chorion and appears irridescent when viewed through the binocular microscope. It is a pale green when first deposited but in a short time it turns yellowish and at this stage of development looks very much like a shriveled lemon (Fig. 7). A photograph taken through a microscope does not give the details of the chorion reticulations, but shows the developing embryo (Fig. 8). The egg measurements average 0.370 to 0.640 mm.

Incubation Time. The length of time in the egg stage varies consderably with the seasonal generation. In late March or early April, as a result of cooler temperatures, the time passed in the egg stage may be as many as twelve days. In June, July, and August in Tennessee the egg stage may be as brief as three days.

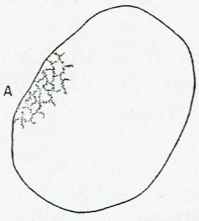


Fig. 7

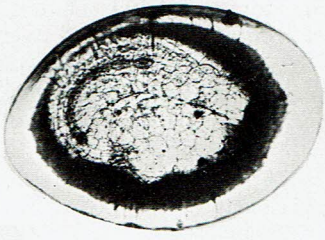


Fig. 8

Fig. 7. The egg of *Ancylis comptana fragariae,* greatly enlarged. Chorion reticulation indicated at A.

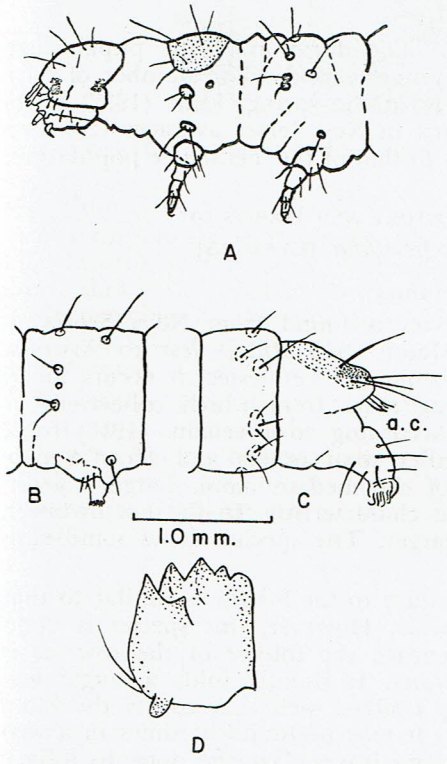
Fig. 8. The egg of *Ancylis comptana fragariae* photographed through a binocular microscope. About 45 times natural size.

The Larva

Habits. The young larva, following eclosion, finds a favorable spot on the undersurface of the leaf, usually between the veins, and constructs a tube-like shelter. The young larva can be observed moving its head to and fro spinning threads of silk that cover it and pull the leaf together. Quite often the maturing larvae abandon the old funnel-like shelters and construct new shelters of the same type, or web together two leaves that overlap one another. They feed on leaves adjacent to their constructed shelters.

Description. The general body color of the mature larva is grayish-brown. For details of the setal pattern on the head and body segments and characteristics of the anal comb see Fig. 9.

The average head capsule width and average duration of each stadium for each larval instar is as follows: first, 0.18 mm. and 3.2 days; second, 0.25 mm. and 3.8 days; third, 0.35 mm. and 4.6 days; fourth, 0.58 mm. and 4.4 days; and fifth, 0.74 mm. and 7.0 days. The sixth instar larval head measures 1.0 mm. This instar did not occur very often for summer broods, probably because of the constant breaking open of the covering web for observation. The average duration of the larval stadia for the summer broods was 23 days.



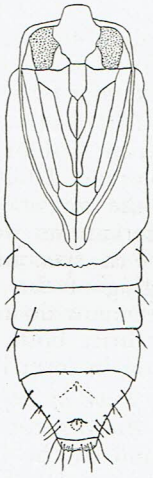


Fig. 9 Fig. 10

Fig. 9. The larva of *Ancylis comptana fragariae*. A. The head and first two thoraic segments. B. The fourth abdominal segment. C. The last two abdominal segments (a. c. anal comb). D. Mesal view of right mandible, greatly enlarged.

Fig. 10. The pupa of *Ancylis comptana fragariae*, ventral view, greatly enlarged.

The Pupa

Description. The pupa averages 8.5 mm. in length (Fig. 10). It is a light yellowish-brown color just after pupation, but gradually darkens to a general dark brown ground color before emergence of the moth. Fink (1932) reports:

> The dorsal surface of each abdominal segment with the exception of the last three bears two transverse rows of spines, those of the anterior row of each segment being stouter than those of the posterior row. Each of the last three segments has a single row of spines. In addition, the last segment bears eight slender hairs which are more or less hooked at the tips.

Sex can be determined in the pupal stage. The distance between the anal slit and gonopore is greater in the female than in the male (Breeland, 1957).

Length of Pupal Stage. The duration of the pupal stage averages six days for the summer broods. The number of days in this stage is greater early in the spring. Fink (1932) states that the pupal stage in April in New Jersey averages 12.8 days which is similar in duration to that of the Tennessee population.

II. Life History and Habits of *Ptycholoma peritana* (Clemens)

General Distribution and Habits

Distribution. This species is found from Nova Scotia to British Columbia, from Maine to Florida, west to Arizona, Colorado, Utah, and California. In Tennessee, it occurs in all of the strawberry producing areas from which collections or observations were made. According to Freeman (1958) some eastern specimens are smaller than others and show a pale edging of the inner side of the median band. Larger eastern specimens do not show this characteristic. In the northwestern localities both forms are larger. The species shows some variation in form in Texas.

Type of Injury. The injury to the foliage is similar to that of *Ancylis comptana fragariae*. However, this species is often found in the leaf litter beneath the foliage of the row, as is true for *Olethreutes cespitana*. It usually folds a single leaf into a shelter by spinning a silken web that covers the larva and pulls the leaf together. It may be found at times in a web spun between two overlapping leaves. Damage done to foliage by this species is similar to that of *Ancylis comptana fragariae* (Fig. 3).

Host Plants. This species does not appear to have a wide range of host plants. However, it has not been studied as extensively as the others. Freeman (1958) gave the typical food plant as *Fragaria*. Lockwood and Gammon (1951) reported this species as a pest of oranges in California. In Tennessee the insect has been found feeding only on strawberries.

Fig. 11. The adult of *Ptycholoma peritana,* natural size.

The Moth

Description. The moth has a wing expanse of 10-15 mm. The drawing of the moth in the identification section of this paper shows the characteristics of the wing markings. The brown markings on the wing appear to form chevrons when the wings are folded at rest (Fig. 11). Drawings of the genitalia are presented in Fig. 12.

Emergence and Mating. After emergence from the pupal case the moths fed on the sugar water plugs that covered the container. Their emergence was from the anterior end of the pupal case, as it was in all species studied. Copulation usually occurred on the same day as emergence, often quite soon after feeding.

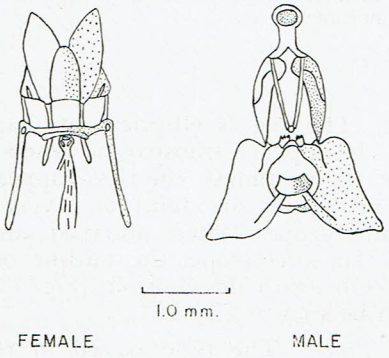


Fig. 12. Genitalia of *Ptycholoma peritana.* The left half of each is denuded.

Oviposition. The eggs were deposited on the leaves in the container and various places within the container itself. Only laboratory oviposition was observed since the eggs of this species were not found in the field. Eggs are laid singly, in twos, or occasionally in a group of four.

Oviposition records were kept on laboratory reared females. The maximum number of eggs recorded from an individual female was 66, the minimum 13, and the average 32.6 eggs per female.

Longevity. The total length of adult life in days was recorded for several individual moths. The range of adult life was 2-8 days. The average number of days of longevity for the male was 2.9 days and for the female 7.1 days.

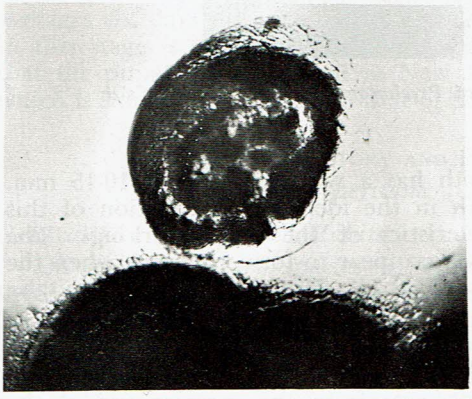


Fig. 13

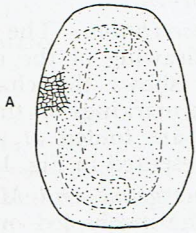


Fig. 14

Fig. 13. The egg of *Ptycholoma peritana* photographed through a binocular microscope. About 45 times natural size.

Fig. 14. The egg of *Ptycholoma peritana,* greatly enlarged. Chorion reticulation indicated at A.

The Egg

Description. The egg is elliptical in shape and flattened dorso-ventrally. It appears transparent when viewed through the microscope. It is almost colorless, appearing as a dirty white. The reticulations are faint and very difficult to see through the microscope. When observed under high power with the binocular microscope, the outline of the developing embryo is visible beneath the chorion (Fig. 13). The details of the chorion can be seen in Fig. 14.

Incubation Time. The time passed in the egg stage for the summer broods averaged 5.9 days. As is true of the other

species presented in this paper, the length of time in the egg stage averaged 14 days in the early spring.

The Larva

Habits. The larva usually finds a place on the leaf between two veins and, by spinning a silken web, covers its body while pulling the two sides of the leaf together to form a silk-lined tubular shelter. Sometimes this same type of structure is formed by an overlapping of leaves. The leaves in close proximity to the shelter are fed upon and pulled together in a mat of webbing.

Description. The general body color of the mature larva is a greenish-bronze. The head capsule, cervical shield, and anal

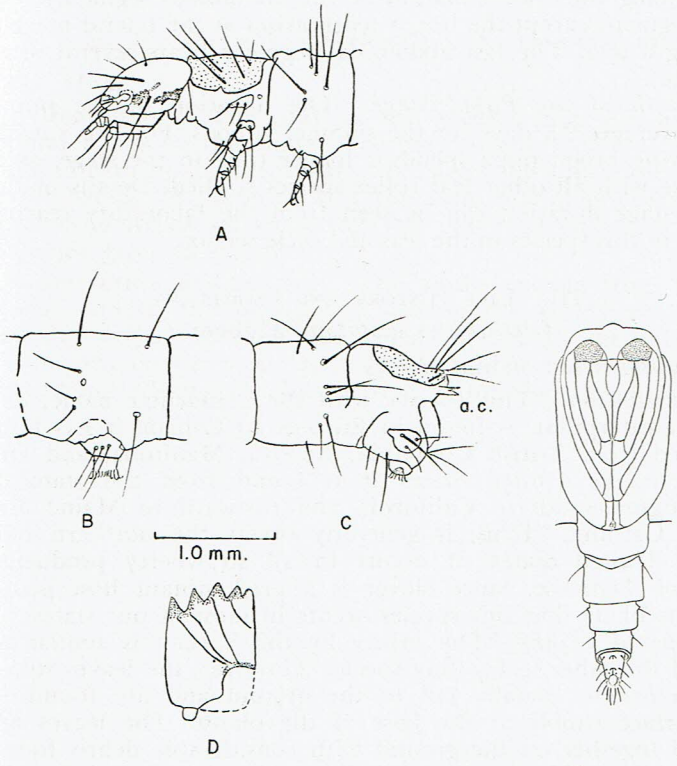


Fig. 15

Fig. 16

Fig. 15. The larva of *Ptycholoma peritana.* A. The head and first two thoracic segments. B. The fourth abdominal segment. C. The last two abdominal segments (a. c. anal comb). D. Mesal view of the right mandible, greatly enlarged.

Fig. 16. The pupa of *Ptycholoma peritana,* greatly enlarged.

shield are brown. Under magnification, micro-setae are visible over the entire body surface. The setal pattern, head capsule, details of the last two segments, and the mandible are presented in Fig. 15.

The average head capsule width and average duration of the stadium for each larval instar is as follows: first, 0.18 mm. and 3.8 days; second, 0.25 mm. and 4.2 days; third, 0.37 mm. and 5.0 days; fourth, 0.53 mm. and 5.2 days; and fifth, 0.72 mm. and 5.2 days.

The Pupa

Description. The pupa averages 5.9 mm. in length (Fig. 16). In general, it is uniformally light yellow in color. The only setae seen when the pupa is observed in full face view are those along the lateral margin of the abdominal segments. On each segment except the last, a tooth arises at the lateral margin bearing a seta. The last abdominal segment bears several setae (Fig. 16).

Length of the Pupal Stage. The duration of the pupal stage averages 9.5 days for the summer broods. For this species the spring brood pupa spends a longer time in the stage, as is the case with all other leaf roller species studied. Details of the pupal stage duration can be seen from the laboratory rearing record of this species in the seasonal cycle section.

III. Life History and Habits of *Olethreutes cespitana* Hübner

General Distribution and Habits

Distribution. This species with the vernacular name, clover-leaf caterpillar, is found in Europe. In Canada it has been reported from British Columbia, Alberta, Manitoba, and Ontario. In the United States it is found from the state of Washington south to California and eastward to Maine and North Carolina. Thus, it generally covers the northern half of the United States. It occurs in all strawberry producing areas of Tennesse. Since clover is a predominant host plant, it seems likely that this species occurs in most of our states.

Type of Injury. The injury by this species is similar to that of the other leaf-rolling species. However, the leaves rolled by *Olethreutes* usually fall to the ground and are found in the surface rubble at the base of the plants. The leaves are matted together on the ground with considerable debris found among them. They are consumed to a greater degree by this species than by other leaf rollers in laboratory rearing.

Host Plants. Wehrle (1929) reported this species feeding on red clover at Ithaca, New York. Neiswander (1955) reported the species feeding on strawberries in Ohio. The writer found the species feeding on strawberries in all parts of Tennessee where collections were made.

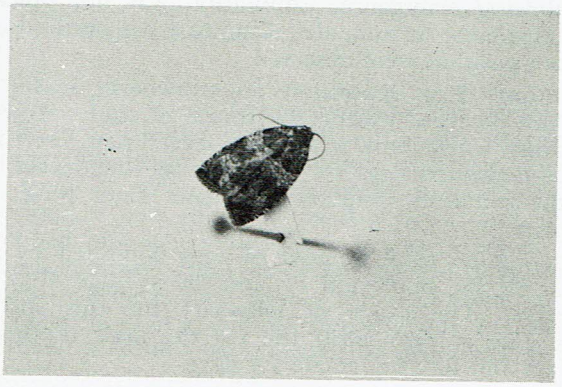


Fig. 17. The adult of *Olethreutes cespitana,* natural size.

The Moth

Description. The adult of this species (Fig. 17), has horizontal bands on the wings. The dark ground color, when contrasted with the light colored scales, gives the appearance of two light bands. Characteristics of the wing markings can be seen in the identification section of this paper. Details of the genitalia are given in Fig. 18.

Emergence and Mating. The adults emerge from the anterior end of the pupal case leaving the empty pupal case usually projecting from the rolled shelter. In the laboratory adults fed on the sugar water plugs within a few hours after emergence. Mating usually occurred within the twenty-four hour

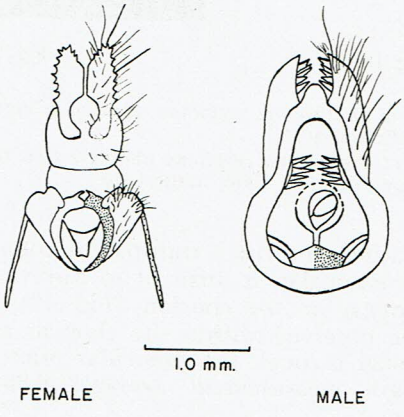


Fig. 18. Genitalia of *Olethreutes cespitana*. The left half of each is denuded.

period following emergence. Copulation was not observed in the field. However, occasionally dead pairs of moths locked in a copulatory position were observed.

Oviposition. Egg deposition on strawberry leaves in the field was not observed during the course of study. However, in the laboratory where only strawberry leaves were used as food, the female deposited eggs on each side of the leaves, on the sides of the container, and on the sugar water plug covering the container.

The maximum total number of eggs deposited by a single female was 85, the minimum 11, and the average 37.2.

Longevity. The range of longevity for this species was 2-11 days. The average adult life for the male of this species was 3.3 days and for the female 7.4 days.

The Egg

Description. The egg, although considerably longer than wide, is elliptical in outline. It is flattened on the surface by

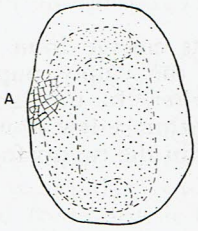


Fig. 19

Fig. 20

Fig. 19. The egg of *Olethreutes cespitana,* greatly enlarged. Chorion reticulation indicated at A.

Fig. 20. The egg of *Olethreutes cespitana* photographed through a binocular microscope. About 45 times natural size.

which it is attached and has a transparent colorless appearance. This transparency makes it difficult to discern the fine reticulations that appear on the chorion (Fig. 19). The developing embryo can be observed within the chorion as shown by the photograph taken through the binocular microscope (Fig. 20). The egg length measurement averages 0.88 mm. and the width 0.60 mm.

Incubation Time. The duration of the incubation period varies with seasonal broods. In the spring the average time

in the egg stage was twelve days. For the summer broods the egg stage averaged 4.4 days.

The Larva

Habits. The young larvae pull the leaf or leaves together with silk in much the same manner as do all the species of leaf rollers found in the Tennessee complex. However, this species seems to web together a larger number of leaves than do the others and to move rapidly back and forth within this webbed mat when disturbed. It also feeds on leaves that have been removed from the plant several days, as readily as on leaves that have been freshly removed from the plant and are still green. These habits may account for the fact that this species is found more often than others in leaf litter underneath the foliage row.

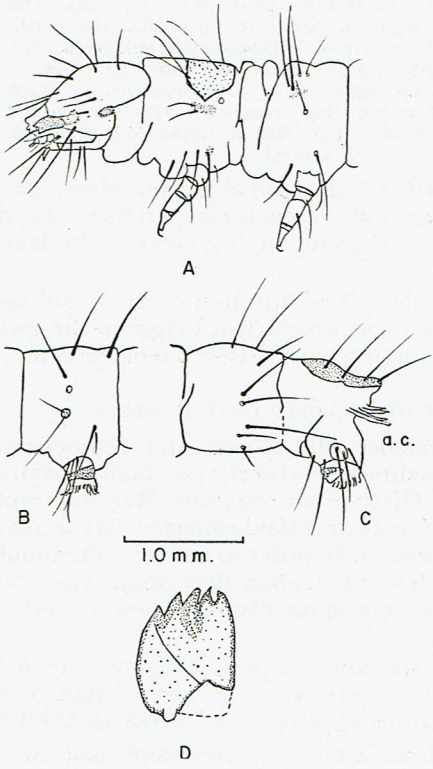


Fig. 21

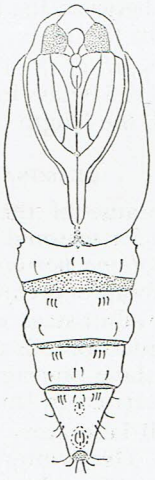


Fig. 22

Fig. 21. The larva of *Olethreutes cespitana.* A. The head and first two thoracic segments. B. The fourth abdominal segment. C. The last two abdominal segments (a. c. anal comb). D. Mesal view of the right mandible, greatly enlarged.

Fig. 22. The pupa of *Olethreutes cespitana,* venteral view, greatly enlarged.

Description. Details of the mature larva such as setal pattern, size, and characteristics of the anal comb can be easily distinguished in Fig. 21. The general color is gray. The head and cervical shield are yellow in color. The length of the mature larva is 14 mm.

The average head capsule width and average duration of each larval instar is as follows: first, 0.19 mm. and 3.0 days; second, 0.35 mm. and 4.0 days; third, 0.58 mm. and 4.4 days; fourth, 0.69 mm. and 4.6 days; and fifth, 0.84 mm. and 5.0 days.

The Pupa

Description. The pupa is about 7 mm. long (Fig. 22). The general color is yellowish-brown, the ventral surface being a lighter color than the dorsal surface. Wehrle (1929) states:

> The wing cases extend back on the fourth abdominal segment. The posterior tarsal sheaths end at the tips of the wing cases. The dorsum of each abdominal segment except the first and the tenth, is armed with two rows of transverse backward-directed teeth, one row near the anterior margin and the other row near the posterior margin. The tenth abdominal segment, or anal segment, is much narrowed and modified, forming the cremaster, which is armed with two pairs of lateral hooks. The lateral hooks are excurved, while the distal hooks are curved ventral.

Sex can be determined in the pupal stage. Here, as in *Ancylis comptana fragariae* and *Ptycholoma peritana,* the distance between the anal slit and gonopore is greater in the female than in the male.

Length of the Pupal Stage. The duration of the pupal stage averages 5.8 days for the summer broods. It is longer in the spring brood, the length of time varying with seasonal temperature.

Seasonal Cycle of Selected Leaf Rollers

Because of their prevalence, the species and subspecies selected for seasonal cycle studies were *Ancylis comptana fragariae, Ptycholoma peritana,* and *Olethreutes cespitana.* Rearing records for laboratory-reared specimens and field-collected larvae reared to the adult stage were examined in order to arrive at the number of annual broods and to determine when they occur. Correlated with these rearing records were moth counts. These records are summarized in line graphs.

All laboratory rearing was done at prevailing room temperatures. Overwintering larvae were kept in an outdoor screen house where the temperatures approximated those in the field.

Moth counts of the three selected species were made in the following manner. The rows in the strawberry planting were eighty feet long. Six rows were selected from this planting for making moth counts. Four rows separated each selected row. The person who made the counts moved slowly down the row in order to avoid disturbing resting moths. Counts were made early in the morning when moths were not very active and not

easily disturbed. Counts were begun in June and continued until the middle of September.

I. Seasonal Cycle of *Ancylis comptana fragariae*

The records of laboratory reared specimens of this subspecies (Table I) are for the summer broods. The moth counts (Fig. 23) were made in order to determine peaks of summer brood moth activity. These peaks correlate quite closely with the peak of moth emergence in laboratory reared specimens.

The earliest field collected moths were taken on a farm three miles west of Knoxville on March 15, 1957. In 1958

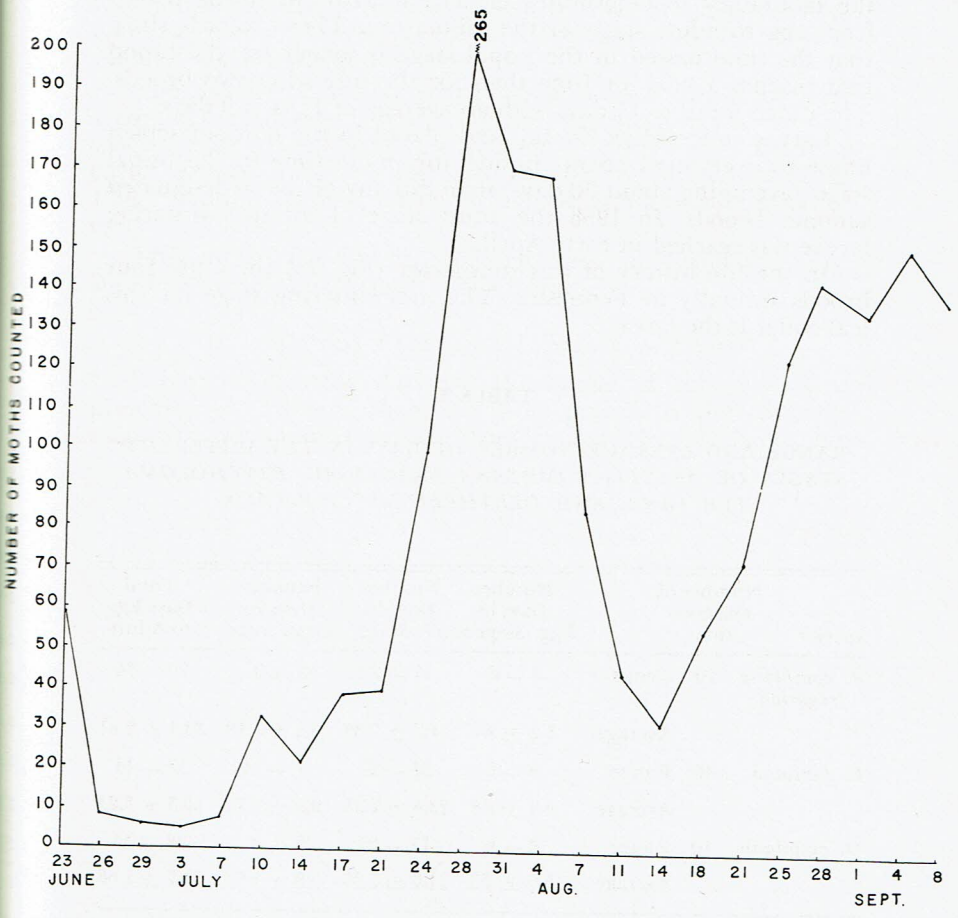


Fig. 23. Moth counts of *Ancylis comptana* for summer of 1959.

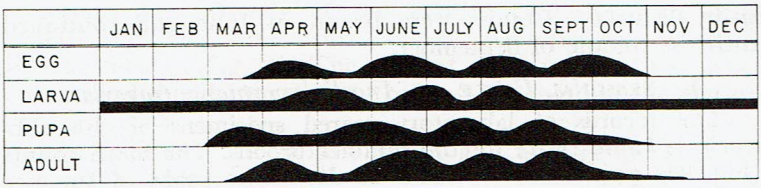


Fig. 24. Life history of *Ancylis comptana fragariae.*

and 1959 the moths of this subspecies were observed around the middle of March. (Adults were seen in the field in November of 1956 and 1957.)

Some field collected larvae were reared to the adult stage in the laboratory to determine correlation with specimens reared from egg to adult stage in the laboratory. These records show that the time passed in the pupal stage is longer for the brood that reaches a peak in June than for the following two broods. The range was 9 to 14 days with an average of 11 ± 1.9 days.

Larvae collected in the fall and placed in the outdoor screen house to overwinter spent considerably more time in the pupal stage (averaging about 30 days) than did any of the so-designated summer broods. In 1958 the adult stage of all overwintering larvae was reached in early April.

In the life history of this subspecies (Fig. 24) there are four broods annually in Tennessee. The overwintering stage for this leaf roller is the larva.

TABLE I

RANGE AND AVERAGE NUMBER OF DAYS IN THE DIFFERENT STAGES OF *ANCYLIS COMPTANA FRAGARIAE, PTYCHOLOMA PERITANA,* AND *OLETHREUTES CESPITANA*

Species	Number of Observations		Number Days in Egg Stage	Number Days in Larva Stage	Number Days in Pupa Stage	Total Days Egg to Adult
A. comptana fragariae	10	Range	4 — 6	17 — 24	5 — 9	29 — 36
		Average	5.2 ± .67	21.2 ± 2.35	6.4 ± 1.19	33.1 ± 2.81
P. peritana	10	Range	5 — 6	21 — 27	7 — 14	32 — 44
		Average	5.4 ± .48	23.4 ± 2.33	9.5 ± 2.76	38.3 ± 3.23
O. cespitana	10	Range	4 — 6	17 — 27	3 — 8	28 — 35
		Average	5.0 ± .63	21.0 ± 3.36	5.8 ± 1.54	31.7 ± 2.68

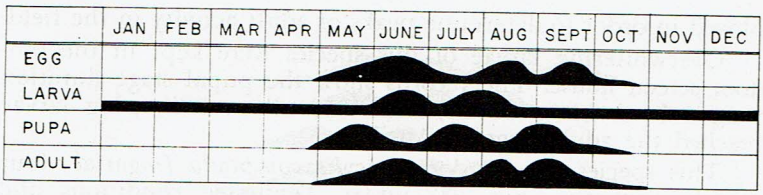


Fig. 26. Life history of *Ptycholoma peritana.*

II. Seasonal Cycle of *Ptycholoma peritana*

This species was reared in the laboratory in the same manner as were the other selected species. Rearing data (Table I) summarize the length of time passed in each stage of development for summer broods. These data correlate with the peaks of summer brood moth counts (Fig. 25).

The records of overwintering larvae of this species indicate a considerably longer pupal stage for the spring brood. In this species, time passed in the pupal stage is much longer than for either *Ancylis comptana fragariae* or *Olethreutes cespitana.* In 1959 the adult stage of all overwintering larvae was reached in early May.

This species has three broods annually in Tennessee (Fig. 26). The overwintering stage is the larva.

III. Seasonal Cycle of *Olethreutes cespitana*

Laboratory rearing data for the larvae of this species as presented in Table I show the time passed in the different stages for the summer brood. Moth counts (Fig. 27) were em-

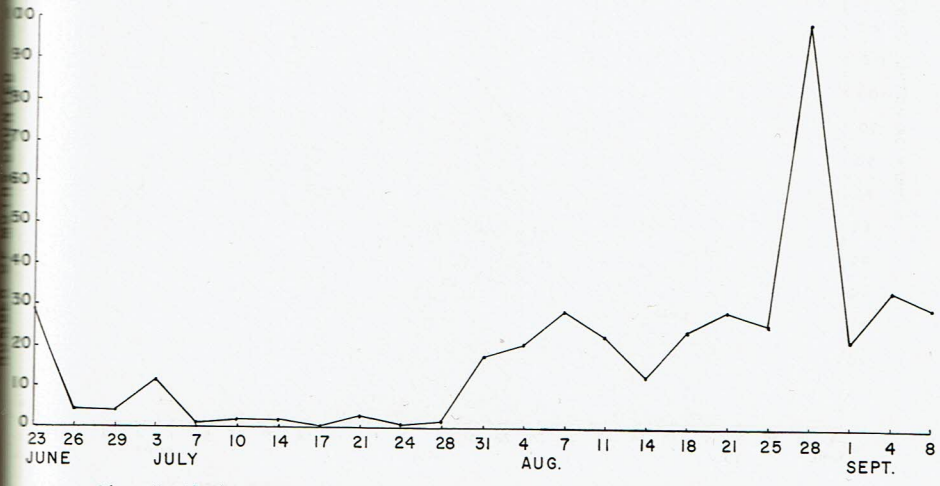


Fig. 25. Moth counts of *Ptycholoma peritana* for summer of 1959.

ployed in order to determine peaks of adult activity in the field.

Overwintering larvae of this species were kept in the outdoor screen house. The records show the pupal stage duration ranged from 13 to 21 days. In 1959 all overwintering larvae reached the adult stage in April.

This species has, as does *Ancylis comptana fragariae,* four broods annually (Fig. 28) under Tennessee conditions and overwinters in the larval stage.

Biological Notes on Eight Other Strawberry Leaf Roller Species

Sparganothis sulfureana Clemens

Host Plants and Distribution

This species which was found quite often on strawberries in Tennessee, has a great number of host plants, having been reported on the following: cranberry, apple, celery, corn, red

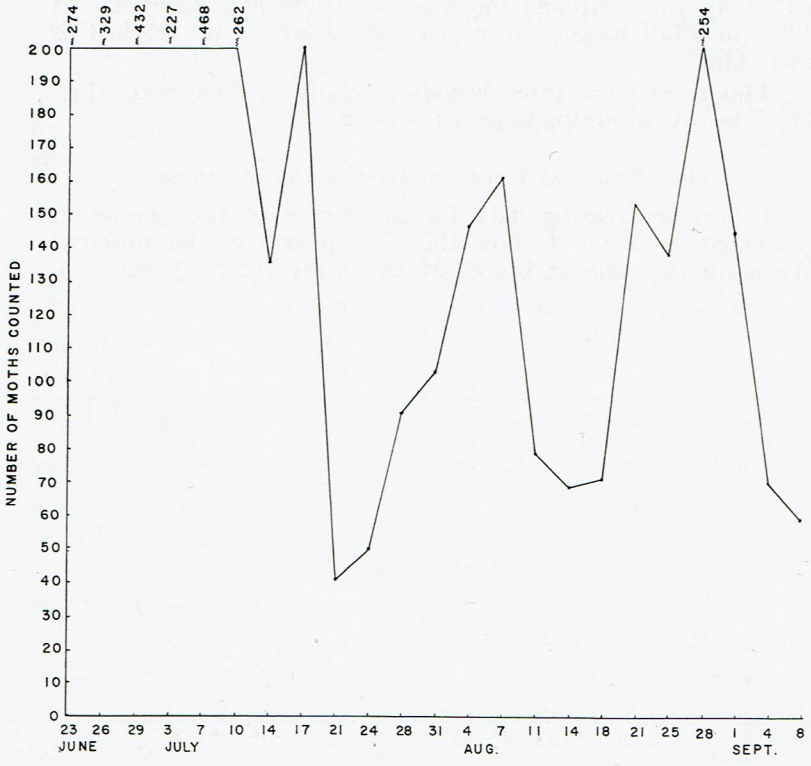


Fig. 27. Moth counts of *Olethreutes cespitana* for summer of 1959.

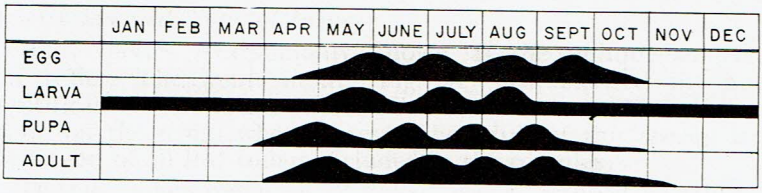


Fig. 28. Life history of *Olethreutes cespitana.*

and white clover, pitch and white pine, honey locust, willow, great burdock, tall buttercup, blue and white vervain, horseweed, larch, hawthorn, and Scots pine (Martin, 1958). It is distributed from Mississippi, Florida, Colorado, Utah, and the state of Washington northward (Beckwith, 1938).

Description and Type Injury

The vernacular name of this species is false yellow head or sulfur leaf roller. Forbes (1884) gives a general description of the moth (Fig. 29) as follows:

> This insect may be described in general terms as a brownish yellow moth, the fore wings of which are marked by two V-shaped brown bands (the apex of the angle pointing backwards), so placed that when the wings are closed these markings form an X.

Characteristics of wing markings can be seen in the identification section of this paper.

The damage from this species of leaf roller is very similar to that of the three selected species previously discussed, the only difference being that this species is a more voracious feeder, consuming a large number of leaves in a shorter time.

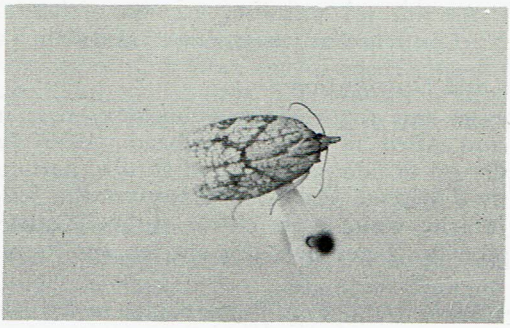


Fig. 29. The adult of *Sparganothis sulfureana,* natural size.

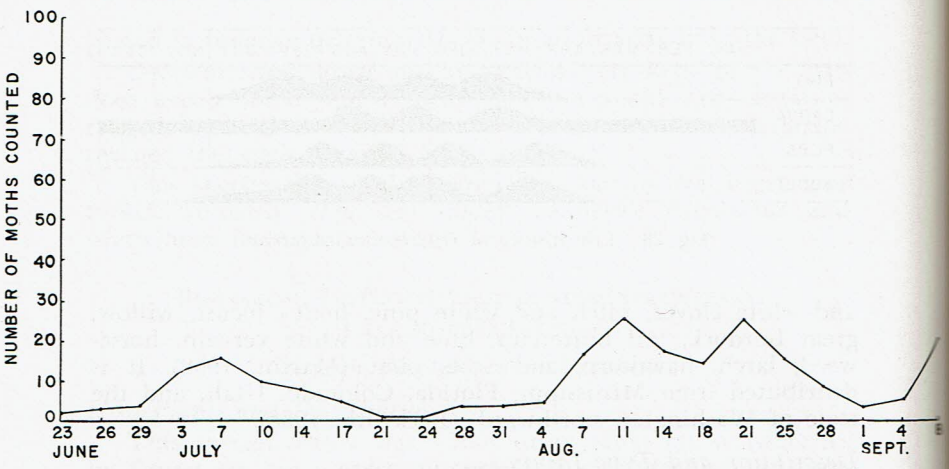


Fig. 30. Moth counts of *Sparagnothis sulfureana* for the summer of 1959.

Other Biological Observations

Records were kept on the larvae of this species as to the average head capsule width and the number of days passed in each larval instar for the August brood. These were as follows: First instar 0.18 mm. width and 4 days; second instar 0.25 mm. width and 2 days; third instar 0.48 mm. width and 2 days; fourth instar 0.66 mm. width and 3 days; fifth instar 0.18 mm. width and 3 days; and the sixth instar 1.16 mm. width and 8 days.

Longevity records were kept for different groups (ten or more to a container) of *Sparganothis sulfureana* eggs, larvae, and pupae. The range in number of days from egg to adult was 29 to 35.

The line graph of moth counts presented in Fig. 30 gives some indication concerning the number of broods. This information, coupled with rearing records obtained in the laboratory, indicates that this species has three annual broods.

Choristoneura rosaceana (Harris)

Host Plants and Distribution

This species was reported as a dewberry pest in Utah by Knowlton and Allen in 1937. Craighead (1950) lists it as a general feeder on deciduous trees and shrubs, particularly those of the family Rosaceae. Martin (1958) gives the following host plants in Ontario: white sweet clover, yellow goatsbeard, apple, and Scots pine. In Tennessee, this species was found on strawberries.

This species is found from Nova Scotia to British Columbia and throughout most of the United States (Craighead, 1950). It has also been reported from the island of Guam in the Pacific Ocean (Vandenburg, 1926).

Description and Type of Injury

This species is commonly known as the oblique-banded leaf roller. The adult moth (Fig. 31) characterized in the identification section can be identified by the chevron-like stripes found on the wings when at rest. The adult of this species is the largest of all leaf rollers included in the complex.

Damage takes the form of rolled leaves, webbed together, and quite often partially or totally consumed by the larvae. The large size of these larvae enables a small number to do considerable damage on occasions to Tennessee strawberry plantings.

Records were kept on the larvae of this species. The average head capsule width and the average number of days passed in each larval instar were as follows: first instar 0.18 mm. and 2 days; second instar 0.37 mm. and 4 days; third instar 0.55 mm.

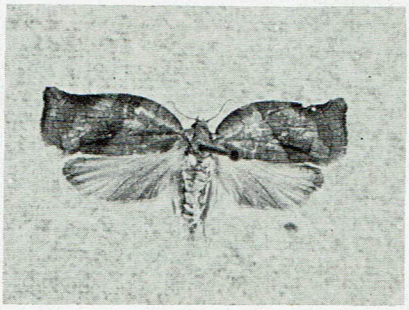


Fig. 31. The adult of *Choristoneura rosaceana,* natural size.

and 2 days; fourth instar 0.86 mm. and 4 days; fifth instar 1.30 mm. and 5 days; and sixth instar 1.90 mm. and 4 days.

Three annual broods are indicated for this species in Tennessee. This conclusion as to number is based on rearing records only. The number of days from egg to adult ranged from 28 to 36 and averaged 31.1 $\pm$ 2.52 days. The number of moths counted in the field was not large enough to give any clear-cut peaks of abundance.

Platynota flavedana Clemens

Host Plants and Distribution

This species of leaf roller was reported by Summerland and Hamilton (1954) as feeding on peaches in Indiana and as a pest of roses in New Jersey according to C. C. Hamilton (1940). Bottimer (1926) found it on yellow ray flowers of *Helianthus* sp. and *Eupatorium compositfolium* Walter, in Texas. Neiswander (1944) found this pest injuring strawberries in Ohio.

The insect has been found on strawberries in Tennessee periodically throughout the course of this study. The number present in any one year was not enough to be damaging unless present with other species of the complex. This species was also found in May, 1957, on *Begonia,* in a Knoxville, Tennessee, residence.

Platynota flavedana has been reported from New Jersey, New York, Ohio, Indiana, Illinois, Kentucky, Tennessee, and Texas. These reports indicate that it probably occurs throughout most of the United States.

Description and Type of Injury

This species has purplish scales in the middle portion of the wing that appear as a raised surface when the wings are viewed at rest. Fig. 32, a natural size photograph of the moth, supplemented by the wing markings in the identification section, facilitates recognition.

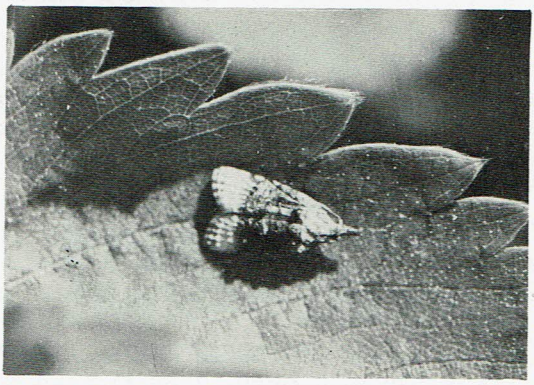


Fig. 32. The adult of *Platynota flavedana,* natural size.

The injury is in the form of rolled leaves that have been frayed, webbed together as a hiding place, and partially consumed adjacent to this rolled hiding chamber.

Tortrix pallorana (ROBINSON)

Host Plants and Distribution

This species has been reported on numerous host plants. Snow and McClellan (1951) found it to be a pest of seed alfalfa in Utah. Dean (1928) and Smith *et al* (1943) reported damage to alfalfa in Kansas. Schott (1925) reported its causing injury to roses in New Jersey. McDaniel (1936) found injury being done to young pine trees in Michigan nurseries. The pest was reported damaging strawberries early in the spring in Missouri by Smith (1941). Martin (1958) listed several host plants for southern Ontario, among which were white sweet clover,

alfalfa, yellow goatsbeard, bladder campion, goldenrod, dandelion, Scots pine, and white pine. In Tennessee it has often been found on strawberries and, on one occasion in 1958, damaging alfalfa in Knox County.

The distribution, according to Forbes (1923), is from Massachusetts to Illinois, Missouri and Texas. In the preceding paragraph on host plants, some additional areas have been added to the observations of Forbes.

Description and Type of Injury

The moth (Fig. 33) has no characteristic wing markings as do other species in the complex. The sketch of the moth in the identification section makes it possible to separate this species from other complex species.

Fig. 33. The adult of *Tortrix pallorama,* natural size.

According to Snow and McClellan (1951), the injury to alfalfa in Utah takes the form of tied racemes of flowers. The injury to alfalfa in Tennessee was similar to that reported from Utah. The damage to strawberries is not unlike that being done by other species in the complex.

Argyrotaenia velutinana (WALKER)

Host Plants and Distribution

This species has been reported as the principal insect pest of the apple by Harman (1948) in New York. It is a pest in the apple section of Virginia and West Virginia. It was found on strawberries in Knox County, Tennessee, in September, 1958, and in October, 1959. It has been reported often as a pest of all tree fruits, small fruits, truck crops, weeds, and ornamentals.

Description and Type of Injury

This species is commonly known as the red banded leaf roller.

The moth (Fig. 34) can be recognized from the sketch in the identification section of this paper. This is a fairly large moth when compared with other species of the complex. Its wing expanse is 12-15 mm.

The damage is much the same as that of other leaf roller species. On the occasions that this species was found on strawberries in Tennessee it was always in close proximity to fruit trees. The feeding damage resembles skeletonizing more than the damage typical of other species in the complex. Leaf veins are left as a framework instead of leaves being totally consumed or rolled.

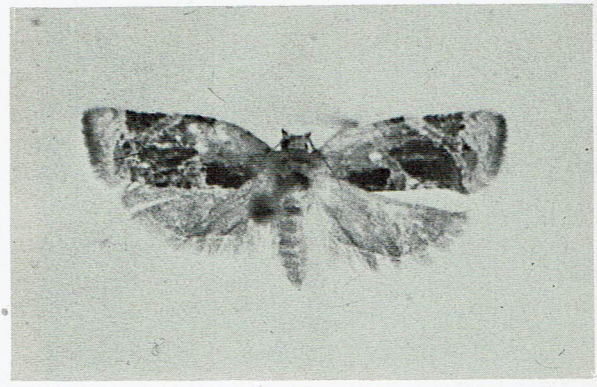


Fig. 34. The adult of *Argyrotaenia velutinana,* 3-5 times natural size.

Archips argyrospila WALKER

Host Plants and Distribution

This species attacks a large number of fruit trees. Herrick and Leiby (1915) found the larvae abundant on plum, pear, quince, apple, and cherry trees. Gillette (1892) observed this species on apple, plum, cherry, honey locust, rose, currant, gooseberry, and a species of *Cerococarpus* known as deer bush. Packard (1870) reported it on oak, black walnut, maple, cherry, and California horse chestnut. Stedman (1906) found this species on apricot, osage orange, box elder, sassafras, and hazelnut. Gill (1913) reported the entire peach crop in the vicinity of Riverside, New Mexico, desetroyed in 1909 and 1910. In Tennessee this species was collected from strawberries and peaches in 1958 and 1959.

The pest is found throughout the United States. Packard

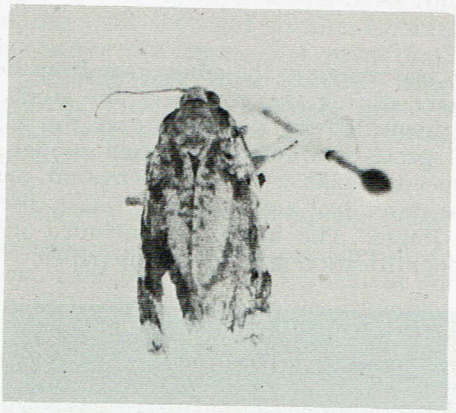


Fig. 35. The adult of *Archips argyrospila*. 3.5 times natural size.

(1885) reported it from Maine to Georgia, Texas, and Missouri, and as being not uncommon on the Pacific coast.

Description and Type Injury

This species is commonly known as the fruit tree leaf roller. The moth (Fig. 35) has silvery markings on the wings which, when the moth is at rest take the form of those found in the key to adults presented in the identification section of this paper.

The type of injury and typical rolling of leaves is much the same as those of any of the leaf roller species. This species was found also in strawberry plantings near orchards in Tennessee collections.

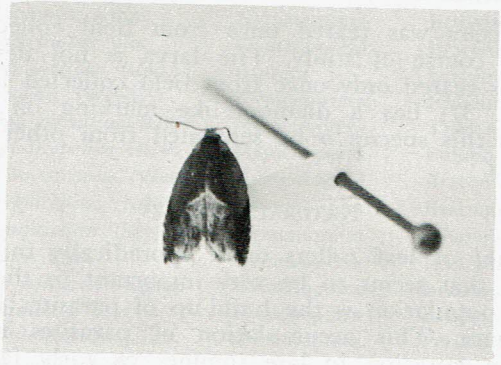


Fig. 36. The adult of *Ancylis muricana*, natural size

Ancylis muricana WALSINGHAM

Biological Note

This species was reared to the adult stage from field collected larvae only twice during the course of the study. The moth (Fig. 36) was identified by a specialist at the U.S. National Museum. The species was not reared often enough, or in large enough numbers to make a larval description possible. Since this species has never had any economic status, literature on it has not been found. The moth was included in the key to adults in the identification section of this paper.

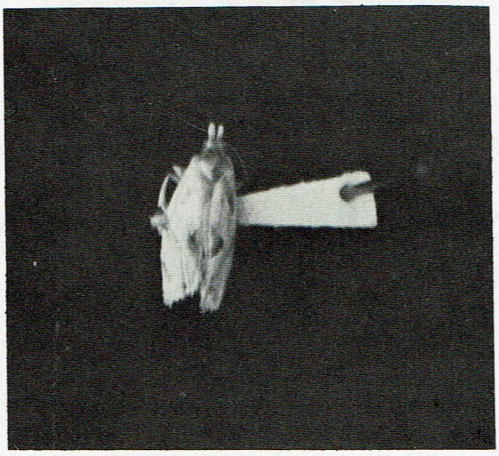


Fig. 37. The adult of *Phalonia angustana*, natural size.

Phalonia angustana CLEMENS

Biological Note

This species was reared once from field collected larvae during the course of study. The larva is not described because it was reared only once from field collected larvae. The moth (Fig. 37) has a diamond-like marking on the wings that allows this species o be separated from other species in the complex.

NATURAL ENEMIES

Outbreaks of leaf rollers occur sporadically in Tennessee. One factor that seems to be very important in the reduction in a large population is the build-up of parasites in the area of occurrence. This accumulation of parasites reaches the greatest concentration in late summer or early fall in areas where populations of leaf roller larvae have been high.

During the course of this study, leaf roller larvae were collected in the field, brought to the laboratory, and reared in order to observe the degree and parasitism, as well as the species of parasites, and their relative importance, in our area. All parasite identifications were made by specialists in different groups working for the USDA, Agricultural Research Service at Beltsville, Maryland.

Parasites of *Ancylis comptana fragariae*

A comprehensive study of the parasites of *Ancylis comptana fragariae* was made by H. S. McConnell at the University of Maryland in 1932. He found that the ichneumonid, *Cremastus cookii* Weed, was the principal parasite of this species in Maryland. This author also found that *C. cookii* is present in Tennessee and prcbably aids in the suppression of the strawberry leaf roller on strawberries. In Maryland fields where leaf roller infestations persist, this persistence is apparently the result of a reduction in numbers of *C. cookii* by secondary parasites, especially *Perilampus sp.*

Since *Ancylis comptana fragariae* is the most important leaf roller in the Tennessee complex, a more thorough study of its natural enemies was undertaken. Fifteen different species of parasites were reared from this species, most of which were primary parasites. *Meterous trachynotus* Vier and *Goniozus platynotae* Ashm. were reared from this species in the largest numbers.

TABLE II

INSECT SPECIES PARASITIC ON *ANCYLIS COMPTANA FRAGARIAE* IN TENNESSEE

Species	Order	Family
Goniozus platynotae Ashm.	Hymenoptera	Bethylidae
Meteorus trachynotus Vier	Hymenoptera	Braconidae
Anachaetopsis torticiis (Coq.)	Diptera	Larvaevoridae
Temelucha cookii (Weed)	Hymenoptera	Ichneumonidae
Trichogramma minutum Riley	Hymenoptera	Trichogrammatidae
Euplectrus plathypenae How.	Hymenoptera	Eulophidae
Oncophanes americanus (Weed)	Hymenoptera	Braconidae
Microbracon gelechiae (Ashm.)	Hymenoptera	Braconidae
Itoplectus conquissitor (Say)	Hymenoptera	Ichneumonidae
Pimpla aequalis Prov.	Hymenoptera	Ichneumonidae
Macrocentrus pallisteri Degant	Hymenoptera	Braconidae
Ascogaster mimetica Vier	Hymenoptera	Braconidae
Perilampus fulvicornus Ashm.	Hymenoptera	Perilampidae
Brachymeria ovata (Say)	Hymenoptera	Chalcididae
Brachymeria hammari (Cwfd.)	Hymenoptera	Chalcididae

The systematics of the parasite species are given in Table II. These parasites of *Ancylis comptana fragariae* are given in the order of their abundance in the Tennessee complex.

Goniozus platynotae Ashm.

The female parasite attaches the eggs to the intersegmental area of the host's abdomen. After hatching and feeding in the intersegmental area, the larvae spin cocoons attached to the host and usually cling in a series along the host's abdomen. The largest number of cocoons on one host from which the parasites emerged was seven. The cocoons are brown in color.

This species was the most numerous of any parasite reared from *Ancylis comptana fragariae*. It also parasitizes other leaf roller species in the Tennessee complex.

Meteorus trachynotus Vier

The whitish cocoons of this species are often found sticking to, or in closs proximity to, a dead leaf roller larva. This species was reared in large numbers from field collected parasitized leaf roller larvae.

Anachaetopsis tortricis (Coq.)

This species was the only dipterous parasite reared from a leaf roller. The adult emerges from the host pupa, the puparium of the parasite being constructed within the host pupal case. This species was reared from host leaf roller larvae in each of the four years of study. The leaf roller larva still feeds and pupates after being parasitized, thus a certain amount of foliage is consumed before death of the host.

Temelucha cookii (Weed)

This was the most important species in a Maryland leaf roller parasite study (McConnell, 1932). It kills the host just before pupating. The parasite larva eats its way out of the dead host and spins a cocoon. It is light brownish-gray in color. This species, a hymenopterous parasite has been recorded from other species of leaf rolling lepidopterous larvae. It was reared from larvae of the strawberry leaf roller, *Ancylis comptana fragariae,* during 1958 only.

Trichogramma minutum Riley

This insect attacks the egg stage of the leaf roller. It was collected only once during the period of study. It is a valuable parasite when present in numbers because it attacks most species in the complex and destroys the leaf roller larvae before foliage is destroyed.

Euplectrus plathypenae How.

This hymenopterous parasite was collected frequently during the period of study but never reached numbers that would cause any great reduction in leaf roller larvae.

Oncophanes americanus (Weed)

This species was reared only in small numbers from leaf

roller larvae and collected only in one year of the study, 1957.

Microbracon gelechiae (Ashm.)

According to McConnell (1932), this species stings the host larva, causing paralysis, after which it attaches its eggs. After hatching, the parasite larvae feed externally on the host. The brown cocoons spun by the parasite can be observed in a folded leaf with the dead host. Up to seven cocoons loosely connected have been observed on a single host larva. This species was present during each of the four years of this study, but never in great numbers.

Itoplectus conquisitor (Say)

This insect was present during each year of the study in small numbers. It emerges from the host pupal case.

Pimpla aequalis Prov.

This species was present during each year in small numbers. It emerges from the host pupal case.

Macrocentrus pallisteri Degant

This hymenopterous species was collected only in small numbers during one year of this study, 1957.

Ascogaster mimetica Vier

This parasite was present in 1957, but only in small numbers.

Perilampus fulvicornus Ashm.

This hymenopterous species is a secondary parasite which parasitizes *Temelucha cookii* (Weed), *Microbracon gelechiae* (Ashm.) and *Goniozus platynotae* (Ashm.), all important leaf roller parasites.

Brachymeria ovata (Say)

This parasite is also a secondary parasite according to McConnell (1932) in his Maryland study. It was collected only once from a leaf roller pupal case during the period of study.

Brachymeria hammari (Cwfd.)

This parasite was collected only once from a leaf roller pupal case by the author. The conditions under which it emerged indicate that it too is probably a secondary parasite.

Percentage of Parasitism

The percentage of parasitism is summarized by years and presented in a bar graph (Fig. 38). The number of leaf roller larvae parasitized by any one species is never very great. However, observations indicate that the total parasitism by all parasites aids greatly in helping to keep the leaf rollers in check.

The percentage of parasitism was greater for the years 1956 and 1957 than for 1958 and 1959. The number of leaf roller larvae active in the field was also greater in 1956 and 1957.

Predators

Fink (1932) reported observing two bugs, *Nabis ferus* L. and *Podisus malculiventris* Say, and a beetle *Casnonia pennsylvanica* L., feeding on *Ancylis comptana fragariae* larvae. Knowlton and Allen (1937) observed an unidentified species of spider attacking a young larva of *Archips rosaceana*. During the author's

four years of observation, spiders that had attacked leaf roller larvae were seen in the field but never identified. A wasp of the genus *Polistes* was observed attacking a leaf roller larva on a farm in Knox County in 1958. The wasp was not collected so species identification was not possible.

Discussion

Sporadic outbreaks of leaf roller larvae in Tennessee cause considerable damage to strawberries. Such outbreaks occurred in 1955 and 1956. Lack of a clear understanding of the number of species responsible, life history data, and the approaches to control (chemical and natural) resulted in poor control methods.

After intensive collection, study of collected material, review of literature, and exchange of pinned specimens with leaf roller authorities in other states, I concluded that there are eleven species and subspecies of leaf rollers present in Tennessee. These basic steps did not clarify the problem but only intensified the need for a more comprehensive study.

Morphological studies of the eleven species present were undertaken. These studies made possible the derivation of keys for identification of larvae and adults. The key to the adults was constructed in a manner that would allow growers or consulting county agents and extension personnel to make field identifications. The key to the larvae can be used effectively only by persons having some knowledge of lepidopterous larval taxonomy and those with access to a microscope or other means of magnification.

A study of the basic biology of the three more important leaf rollers in the complex was undertaken in order to observe and ssummarize their life histories in Tennessee. In conjunction with the basic biological study of these three forms, biological observations were recorded concerning the remaining eight species in the Tennessee Complex. Information gained through laboratory rearing and field study was summarized for the three selected leaf rollers in terms of description of stages and seasonal cycles, and life history charts. Pertinent biological data on the other eight species showed the importance of their status in the overall complex. Such information permits the grower to know when damaging leaf rollers might be present in his planting as well as the stage of their development.

An intensive study of leaf roller parasites was carried out during the entire four years of study. Insect parasites of leaf rollers in the complex were collected, isolated for rearing, and submitted to a specialist at the end of each year for identification. Fifteen species of parasites were found in Tennessee, all hymenopterous species but one, a dipterous paraite. These parasites exert a considerable amount of natural control. The number of species of leaf roller parasites and the number within one species increase as the leaf roller population builds up (Fig. 38). The

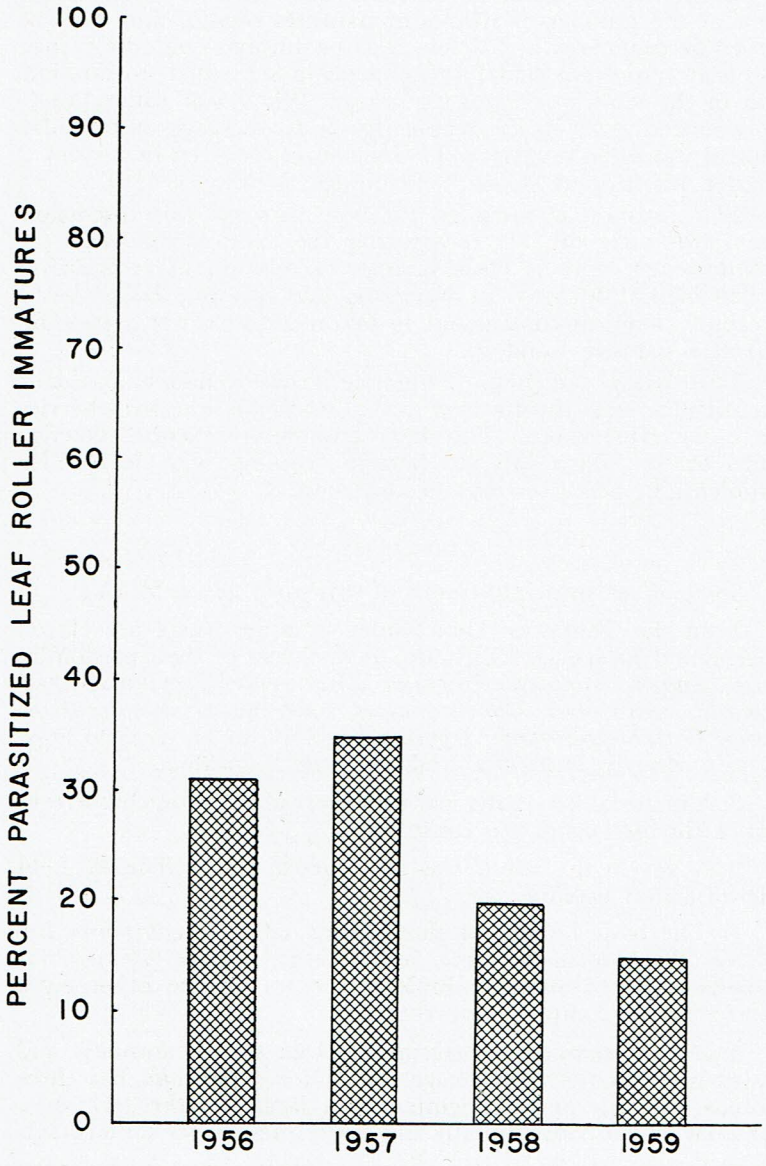


Fig. 38. Percentage of parasitism for each of the four years of study.

level of the parasite population was highest in 1957. A subsequent leaf roller decrease occurred in 1958 and 1959. All late summer and early fall field collections had a greater percentage of parasitized leaf roller larvae than early season collections. In view of the number of species of parasites present and the observed percentage of parasitism, it is the author's contention that this is an important contributing factor in leaf roller suppression late in the strawberry growing season. When leaf roller build-up occurred early in the season (prior to picking), insecticidal control was often necessary. This situation occurred in a Winter Garden planting at Decatur, Tennessee, in May of 1957.

The author has intended to show through this discussion the importance of: (1) recognizing the species involved, (2) a knowledge of their basic biology in relation to recognizing a detrimental increase in numbers, and (3) not being hasty to apply chemical control but to be on the alert for a possible effective parasite build-up.

This study can help Tennessee growers understand and successfully meet future leaf roller outbreaks on strawberries or other fruit crops. The keys and morphological descriptions of life stages can aid persons working with leaf roller problems in other sections of the country.

Conclusions

Some of the principal results of this study are as follows:

1. In the Tennessee Leaf Roller Complex there are eleven species and subspecies which are, in the order of their predominance, *Ancylis comptana fragariae, Olethreutes cespitana, Sparganothis sulfureana, Choristoneura rosaceana, Platynota flavedana, Tortrix pallorana, Argyrotaenia velutinana, Archips argyrospila, Ancylis muricana,* and *Phalonia angustana.*

2. A pictorial key to the leaf roller larvae based on characteristics of the anal comb was constructed.

3. A key to the adults was constructed that will make field identification possible.

4. The basic biology of three forms (*Ancylis comptana fragariae, Ptycholoma peritana,* and *Olethreutes cespitana)* was elucidated for Tennessee. Biological notes on the other eight species in the complex were recorded.

5. *Ancylis comptana fragariae* has four broods annually and overwinters in the larval stage. *Ptycholoma peritana* has three broods annually and overwinters as a larva. *Olethreutes cespitana* has four broods annually and overwinters in the larval stage.

6. Fifteen species of parasites of *Ancylis comptana fragariae* were reared from field collected host larvae. Some of these parasites attack other leaf roller species in the complex.

7. It is the author's contention, based on observation, that insecticidal control should be initiated only as an absolute necessity. Under normal conditions, leaf roller parasites will probably check an incipient outbreak or greatly suppress an actual outbreak.

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News of Tennessee Science

(Continued From Page 319)

Dr. A. J. Sharp, head of the Department of Botany at the University of Tennessee. relinquished his administrative duties in September, 1961, in order to devote full time to teaching and research. Since coming to UT in 1929, Dr. Sharp has made many studies of the plants in the Southern Appalachians, and has also studied the flora of Guatemala and Mexico where he spent two years as a Guggenheim fellow. Dr. Sharp has held offices in numerous botanical societies and is now President of the American Society of Plant Taxonomy. Succeeding Dr. Sharp as head of the Botany Department will be Dr. Walter R. Herndon, Jr. of the University of Alabama. Dr. Herndon received his B.S. and M.S. degrees from the University of Alabama and the Ph.D. from Vanderbilt University. He has taught at Vanderbilt and Middle Tennessee State College, and was associate professor of botany at the University of Alabama. He has spent several summers at Woods Hole, Mass., studying marine algae and is now engaged in studies on radioactive effects on algae.

Dr. Hilton A. Smith, professor of chemistry at the University of Tennessee since 1941, became dean of the UT Graduate School and Coordinator of Research on September 1.

Dr. Smith succeeds Dean Dale Wantling, who resigned in the summer of 1960 to accept a foreign assignment with the U.S. International Cooperation Administration. Since that time Dr. Herman E. Spivey has been handling the duties of graduate dean in addition to his regualr position as academic vice president.

As an adjunct to the graduate deanship, Dr. Smith will fill the newly created position of Coordinator of Research. In this capacity he will assist faculty members in obtaining appropriate sponsors for their research and, in general, will aid the administration in the development of research policies and programs.

Dr. Smith, 52, was instrumental in developing the first Ph.D. program at UT — the chemistry doctorate begun in 1945. He holds the A.B. from Oberlin College, and the A.M. and Ph.D. degrees from Harvard University. He was born in Plymouth, N.Y., and reared in Massachusetts.

Since joining UT, Dr. Smith has become nationally and internationally known as a teacher and scientist. He has carried on extensive research, specializing in the study of hydrogen isotopes, and he recently isolated tritium, a form of hydrogen, to make avaiable a low-cost radioactive isotope.

Dr. Paris B. Stockdale, head of the University of Tennessee's Department of Geology and Geography for the past 20 years, is giving up this position because of ill health.

Effective this fall, the new department head will be Dr. Harry J. Klepser, professor of geology and geography at UT, announced Dr. Kenneth L. Knickerbocker, dean of the College of Liberal Arts.