THE UNSPOTTED TENTIFORM LEAF-MINER, *ORNIX PRUNIVORELLA* CHAMB. (LEPIDOPTERA, TINEIDAE), A NEW PEST OF THE APPLE TREE IN KANSAS

by

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INTRODUCTION

The large amount of damage to apple leaves, caused by an unknown leaf-mining insect during the summer of 1932 in the Kansas Agricultural Experiment Station orchard, prompted the selection of this problem. At that time none of the life history stages of the insect had been observed. Dr. W. F. Pickett, during the summer of 1932, found it difficult to locate apple leaves free from insect damage. In February of 1933, an investigation was begun (1) to determine the insect or insects causing the damage, (2) to study the biology of the insect or insects, and (3) to find an effective means of control. Later in the growing season of 1933, the insect causing the damage to apple, pear, and quince was determined as *Ornix prunivorella* Chamb.

Economic Importance

Ornix prunivorella Chamb. is one of the many insects of secondary economic importance. Infestations of a serious nature occur sporadically and are usually of importance for only a few years.

The foliage is injured by the larva feeding between the epidermal layers of the leaf. Another form of injury was noted as the study of this problem progressed. This type of leaf injury is "leaf burning" due to the application of arsenicals and other spray materials in the regular spray schedule for the control of other orchard pests. The insect mine is comparatively small, which serves as an entrance for spray materials. These materials will burn a large area of the leaf tissue around the insect mine. This is of special importance since this type of injury in many instances causes two or three times more damage than the insect mines.

REVIEW OF LITERATURE

Historical Considerations

A number of papers have been written that deal with the habits, description, taxonomy and control of *Ornix prunivorella* Chamb. Most of these papers are very short, since they were notes on observations that were made during the summer or a short period in late fall. Taken together they create a confused situation.

The moth is a native insect and was first described and figured by Packard(1869) as *Lithocolletes gemina-*

tella. The description and figures were incomplete and not entirely accurate. The insect was later described as *Ornix prunivorella* by Chambers(1873). In 1882b, Walsingham described the type species of *Lithocolletes geminatella* Pack. and brought out the fact that the insect as first described by Packard as *Lithocolletes geminatella*, was placed in the wrong genus and undoubtedly belonged to the genus *Ornix*.

The first and most complete life history paper dealing with *Ornix prunivorella* Chamb. was published by Brunn(1883). Forbes(1889) described the habits and life history of *Ornix geminatella* Pack. Further observations on this species were made by Haseman(1916). This work was done in Missouri and is probably the most valuable paper on life history of this insect for this state, since the ecological condition of Missouri and eastern Kansas are somewhat similar. The most recent report, however, was by Severin(1922).

Distribution

Packard(1869) reported it as being abundant in New England, Brunn(1883) and Lowe(1900) reported it as being abundant in New York, Forbes(1885) reported it from Illinois, New York, Colorado, Kentucky, Michigan, and Massachusetts. Gossard(1911) and Haseman(1916) reported it from Ohio. Haseman(1916) also reported it from Missouri and stated that it is probably found from the Atlantic States to Colorado, but had been overlooked by entomologists. Luggar(1899) reported it from Minnesota, Ross and Caesar(1920) reported it as being common in the Niagara districts and Norfolk county in Ontario, Canada, Dietz (1907) gives the habitat as the middle and northern states of the Atlantic Slope though he confused the species. Severin(1922) reported it from South Dakota. Professor Dwight Isely, of the University of Arkansas, informed the writer in March, 1935, that this insect was quite common in Arkansas.

The insect *Ornix prunivorella* Chamb. has not been previously reported from Kansas. The writer found no reference that dealt with its life history or habits under Kansas conditions.

Larvae of the insect were first collected west of Manhattan, Kansas, at the Kansas Agricultural Experiment orchard in 1933. Then larvae also were collected during the summer of 1934, near Ogden in Riley county, Kansas. During the summers of 1934 and 1935, larvae were collected from an orchard in the vicinity of Eskridge, Kansas. During the summer of 1935, larvae were collected from several orchards in the vicinity of Troy and Wathena in Doniphan county, Kansas. This area is known as the north-eastern Kansas orchard district. Also at this time, collections were made from an orchard north of St. Joseph, Missouri.

The insect has been reported to the writer as being abundant and causing extensive damage during the summer of 1935, in the Arkansas River Valley apple district, in the vicinity of Arkansas City, Kansas.

Synonymy

It is not surprising that this insect has several synonymous, scientific and common names. The micro-lepidoptera include a large number of species, some of which are the most difficult with which to work in insect taxonomy. The differentiation of species based on the characters alone of the imago, is impossible. Host plants and larval habits of these insects must be known for the differentiation of the species. Since the name and taxonomy of some of our oldest and most destructive insect pests have not become definitely fixed, it is not unusual that there are synonymous names of insect pests placed in different catagories such as families and genera.

Specimens were sent to Dr. Annette F. Braun, University of Cincinnati, Cincinnati, Ohio, who determined them to be *Ornix prunivorella* Chamb. Upon making the identification, Doctor Braun stated that *Ornix prunivorella* pupates at once after leaving the mine, while *Ornix geminatella* on leaving the mine, folds over the edge of the leaf and feeds on the leaf tissue within a folded portion of the leaf. These characteristics were later observed on an apple seedling that was infested by insects from which Doctor Braun made her identification. The writer's contention is, therefore, that these two names (*Ornix prunivorella* Chamb. and *Ornix geminatella* Pack.) are synonymous.

The name *Ornix prunivorella* Chamb. is used because the synonymous names have not been definitely established. Literature, since it deals with synonymous names, was carefully considered. Packard(1869) described an insect, *Lithocolletis geminatella* Pack., and the name he suggested is a likely synonym. Luggar(1899) also wrote a paper on *Lithocolletis geminatella* Pack. in which the common name "Pear and Apple Tree Leaf Miner" was used. In the same publication he reported a supposedly different insect as *Ornix geminatella* Pack. and gave as the common name "The Wild Cherry Leaf Miner". One of these names is evidently a misnomer since Packard did not originally describe any insect as *Ornix geminatella*. Walsingham(1882b) published a paper on the type species of *Lithocolletes geminatella* Pack. and states that "I think these may be *Ornix prunivorella* Chamb. although that author does not record the larvae as feeding on apple or pear...These specimens are not in good condition, and it is impossible in so difficult a genus as *Ornix*, to be quite certain as to what species they belong... They are the type species of *Lithocolletes geminatella* Pack. according to the labels attached to the record specimens, but they undoubtedly belong to the genus *Ornix*". Contrary to this statement, in the original description, Chambers(1873) states that the larvae, mine in leaves of apple(*Malus*) and wild cherry(*Prunus serotina*).

Chambers(1871) states that the larva of *Lithocolletis geminatella* Pack. is a pale livid reddish, unlike any known *Lithocolletis*, but not unlike some Gracillariae. *Ornix prunivorella* Chamb. was described as a new species by Chambers(1873), but no reference was made to *Ornix geminatella* Pack.

An account was written by Forbes(1889) on *Ornix geminatella* Pack., in which the common name "The Apple Ornix", was used.

The common name "The Unspotted Tentiform Mine of Apple" was used by Brunn(1883) in giving an account of *Ornix prunivorella* Chamb. that was infesting trees in the state of New York. *Ornix geminatella* is also reported by Gossard(1911) as "The Pear Leaf Miner" since it infested both pear and apple trees in Ohio. Haseman(1911) reported that *Ornix prunivorella* Chamb. was causing extensive damage to apple trees in Missouri. In this report the common name "The Spotted Tentiform Leaf Miner", was used. A more complete account, however, was written by Haseman(1916) in which was used the common name "The Unspotted Tentiform Leaf Miner" and the scientific name

Ornix geminatella Pack. He also states that *Lithocolletes geminatella* Pack. was redescribed as *Lithocolletes prunivorella* by Chambers(1873). This is an error as the reference cited is for the original description of *Ornix prunivorella* by Chambers, and the insect was never placed in the genus *Lithocolletes* by Chambers.

The term Microlepidoptera was originally used by German Lepidopterists about the middle of the last century as a literal translation of the much older popular name "Kleinschmetteringe". "At that time it was already recognized by leading workers such as Zeller, Herrich, Schaffer and Stainton that their division of Lepidoptera into Macrolepidoptera and Microlepidoptera was not a natural one, but this division has been retained in about the original sense even up to the present day in Germany... Most modern students have discarded the name Microlepidoptera as untenable; first because it is said to be a misnomer, second because it could not be sharply defined as a natural group if the original conception should be retained--...Our American pioneers in the Microlepidoptera, Brackenridge, Clemens--Chambers in a less degree--had a keen appreciation of the value of venation as a generic character--...But the terminology is the least part, the main thing is that the student should keep in mind the fact that the families of the microlepidoptera as they are used by the leading specialists of the group, are not truly equivalent entitles--" Busck(1914).

Chambers(1882a) used the term Tineina in a loose and general way under which are placed all small moths not clearly belonging to any of the higher groups. "It appears most probable that the small size, long cilia, etc. of such genera that have these characteristics are the results of degradation, not from common form, but from a variety of originals and in different directions, that the student will be greatly aided by the study of their early stages and development and that this course is most likely to give us the key to their relationship, that is to a natural classification". In a paper published in the Jour. Cincinnati Soc. of Nat. Hist., Chambers (1882b) stated that, "Mr. Stainton's system in which the name Tineidae is retained for the restricted families containing Tinea and its allies, is the best classification of the group".

Walsingham(1882a) objects to the way in which Chambers uses the term "Tineina". He states that according to the rules of nomenclature a term ending in "inae" indicates a subfamily and would be indicative of a division inferior rather than superior to the family Tineidae. Many workers recognize the names in the "Tentamen" of Hubner as does Comstock(1933), who places the genus *Ornix* in the family *Gracilariidae* and replaces this genus with the new genus *Parornix*. Leonard(1926) gives the genus *Parornix* as under the family *Gracilariidae* in "Insects of New York", but does not list the species *prunivorella* or *geminatella*. Forbes(1923) places the genus *Parornix* under the family Gracilariidae and *Parornix* *geminatella* Pack. is listed with *Parornix* *prunivorella* Chamb. as being a doubtful synonym.

MATERIALS AND METHODS

Finding the Insect

Most insects that live in the temperate zone, go into hibernation during the winter months. Efforts were made to find in hibernation, the pest causing the damage. Material was collected from the Kansas Agricultural Experiment Station orchard in which the insect probably would be overwintering. This material was collected from several sections of the orchard which was covered with a straw mulch, fallen apple leaves, grass, vetch, and also loose surface soil. This material was collected from various ecological environments so that representative samples could be obtained. The various samples of debris were placed in a "Berlese Funnel"[1] in order to collect any insects that were in the material. Many kinds of small insects were collected in this manner. Among the group were many kinds of small flea beetles, some of which belonged to a group that contained leaf-mining insects. Loose surface soil was examined by sifting, since it would pass through the Berlese funnel.

Many Coleoptera that are not able to fly, often crawl up the trunks of trees in the spring. Tanglefoot bands were put on six apple trees during March, 1933. These were examined at various times during the spring. No insects were collected that were definitely known to be leaf-miners.

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1. This is a device in which hibernation media is placed in order to collect the insects. It is a large galvanized iron funnel, the top being 30 inches in diameter, but the sides tapering so that the opening at the bottom is about an inch and a half in diameter. An electric heating coil is fastened to the lid. As heat is produced, all mobile life goes to the bottom of the

Sweepings were also made in many different locations in the orchard. A large number of small flea beetles, small Diptera and Hymenoptera were collected in this way. These insects were placed in wire screen cages with growing seedling apple trees that were located within the insectary.

In the spring before the buds had completely opened, a white sheet was placed under several trees at various times and the branches jarred to collect any beetles and other insects that might have been on the swelling buds. This work was carried on in the early morning when the insects were sluggish and would not fly readily.

Soon after banding, jarring, sweeping, and collections from ecological situations were completed, the leaves began to expand and it was decided that the most accurate method of finding the insect would be to collect the larvae in the mines. After the larvae were found, the insects could be reared to the adult stage and thus the adult insect could be identified.

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1. (Continued) funnel. A bottle containing alcohol was placed below the small end of the funnel in which to collect the insects. The coil is protected so that it cannot set fire to the material.

Biology

Insect Cages, Collecting and Rearing Larvae. Several methods of rearing the *Ornix* larvae and various kinds of insect cages were used in obtaining life history data. A large number of larvae was collected at various times in order to have material with which to carry on the life history work.

All insects used in life history studies were first collected in the larval stage. The larvae were in the mines of leaves on the host plants in the field.

The writer found a limited number of larvae infesting apple leaves during the first week of June, 1933. These were collected with the leaf in which they were feeding. The petiole of the leaf containing larvae was placed in a small glass vial which was filled with water. The leaf having the petiole submerged in water was then placed in a larger glass vial which was corked and numbered. Observations and records then were made daily (Plate I, Figure 1, See p. 16).

Infested leaves having the insect larvae in the mines, were collected and placed in numbered glass vials that were corked. It was difficult to maintain the

Plate I

1. Double glass vial insect rearing cage.

2. Glass vial insect rearing cage, end closed with cork stopper.

3. Glass vial insect rearing cage, end closed with cotton.

4. Lantern globe insect rearing cage.

5. Glass cylinder rearing cage that clamps on the leaf.

6. Cheese cloth insect rearing cage.

7. Cylindrical wire screen insect rearing cage tied on branch of tree.

8. Glass cylinder insect rearing cage.

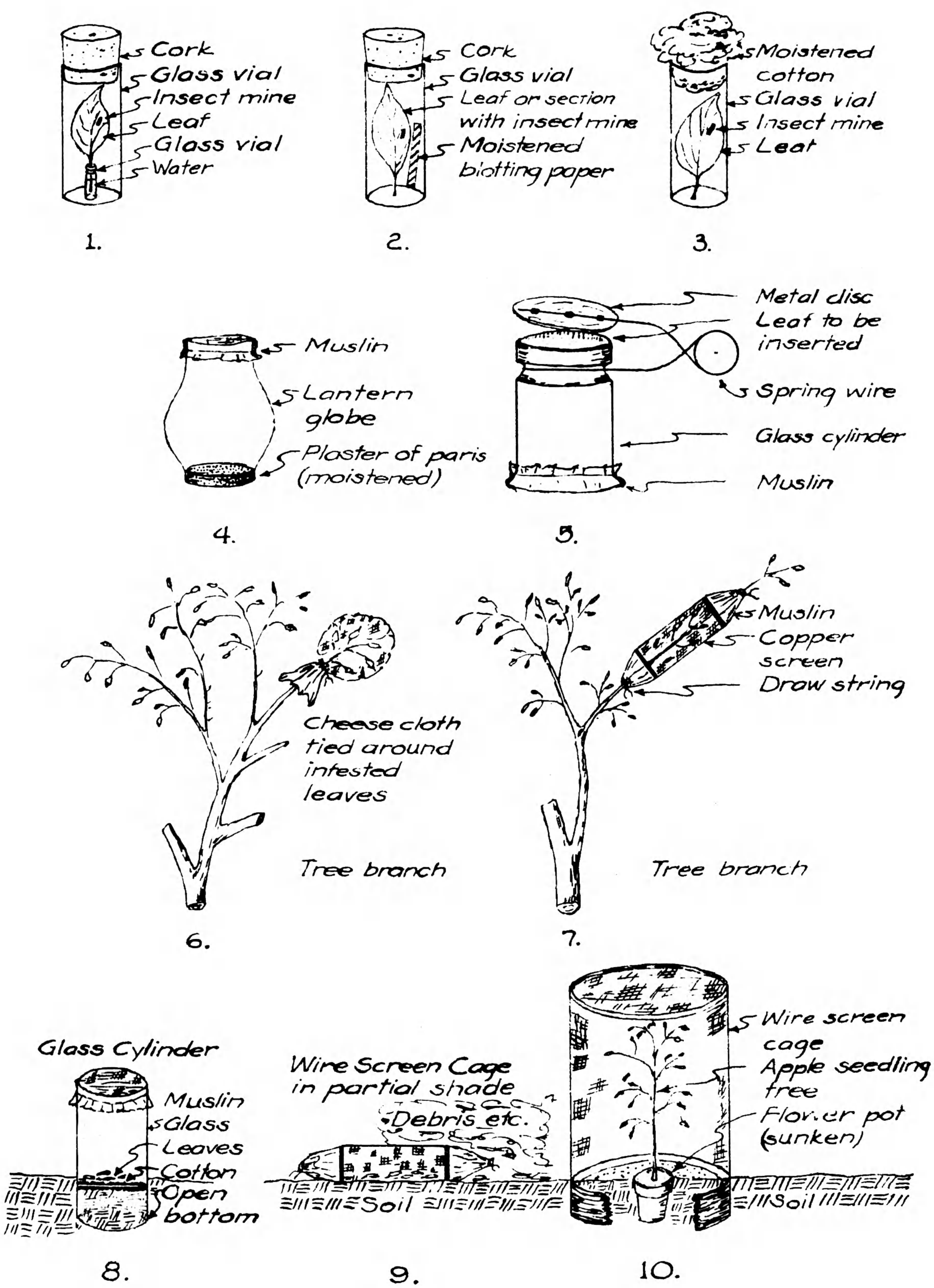
9. Cylindrical wire screen cage in contact with the soil.

10. Cylindrical wire screen cage covering potted apple seedling tree.

Plate I

INSECT REARING CAGES

Used in Life History Studies of <u>Ornix</u> <u>prunivorella</u> Chambers



correct humidity within the glass vial. Good results were obtained by placing a small piece of moistened blotting paper inside the bottle(Plate I, Figure 2, see p.16). Cotton was also used for stoppers in this type of rearing cage. The cotton in the end of the bottle had to be moistened daily with a drop of water(Plate I, Figure 3). In the rearing of larvae, there was a high percentage of larval mortality due either to the growth of moulds or the lack of water.

Another type of cage used to obtain material for life history work was an ordinary paper sack. A moist cloth or sponge was placed inside of the sack with the infested leaves. This method was the most successful, because this environment more nearly approached field conditions. The humidity could be maintained at a more uniform percentage and no mould growth occurred.

Several types of insect cages were used in the field for life history work. The first type used was merely cheesecloth covering the infested leaf and tied around the twig. Fifteen cages, in the fall of 1933, were put on trees having infested leaves(Plate I, Figure 6, see p.16).

Another type of insect rearing cage was a cylindrical fine meshed copper wire cage. Both ends of the cage were covered with muslin with a draw string so that the cage could be slipped over the twig and fastened. Twenty of these were put in trees containing infested leaves in the fall of 1933(Plate I, Figure 7, see p.16). Since the natural condition of the hibernating insect pupa is among fallen leaves on the ground, infested leaves were placed in these wire cages and covered with leaves in close contact with the soil(Plate I, Figure 9, see p.16).

An overwintering rearing cage was constructed by placing a glass cylinder upright several inches down into the soil. A thin layer of cotton was placed inside the cage which covered the soil. After the infested leaves were put into the cage, the top was covered with muslin. Several cages of this type were used. These cages were made by removing the bottom of glass vials and fruit jars (Plate I, Figure 8, see p.16).

Cylindrical wire cages were also used for life history studies in the greenhouse insectary. The cages were placed on potted apple seedling trees and the adult moths were introduced to the trees(Plate I, Figure 10, Plate II, see pp.16, 19).

Plate II

Ornix prunivorella Chamb.

Apple seedling in pot, showing injury of leaves by the leaf mining habit.

Infestation was obtained by placing 6 adult *Ornix prunivorella* moths in cage on an apple seedling.

May, 1933.

Life size.

Plate II

Host Plants

The leaves of several species of fruit trees are attacked by *Ornix prunivorella* Chamb. This paper deals especially with the infestation on apple trees(*Pyrus malus*). Apple trees are the most important fruit producing plants in northeastern Kansas, and are the most seriously damaged since they are by far the favorite host of *Ornix prunivorella* Chamb.

All varieties of quince(*Cydonia ablonga*) grown in the Kansas Agricultural Experiment Station orchard were found to be heavily infested. The quince has no economic value in the commercial orchard and is seldom grown except on back yard lots. All varieties of pear(*Pyrus communis*) grown in the Experiment Station orchard, were also found to be infested. Infested leaves also were found on sour cherry(*Prunus cerasus*) and seedling cherry stock(*Prunus mahaleb*).

No infested leaves were observed on sweet cherry (*Prunus avium*) or cultivated plum(*Prunus* sp.) (an unknown variety) trees after several careful examinations throughout the season.

Sixty-two varieties of apple(*Prunus malus*) in the orchard were found to be infested. The following is a list of varieties on which the injury was observed:

Anoka	Ingram	Palouse
Aport	Jonathan	Pennington
Arkansas Black	King David	Raburn
Arkansas	Livland Raspberry	Ralls
Bailey	Long Field	Rambo
Baldwin	Lowre	Red Astrachan
Bayard	Maiden Blush	Red Bird
Chenango	Maxwell Red	Red Rome
Collins	Minkler	Rhode Island Greening
Cortland	Missouri	Richa Red
Delicious	Newtown Pippin	Rome Beauty
Esopus	Northern Spy	Russet Sweet
Gano	Northwestern Greening	Smokehouse
Golden Delicious	Oldenburg	Stamared
Gray Red	Ortley	Stayman
Golden Russett	Ozark Queen	Summer Queen
Golden Winesap		
Grimes Golden		
Henry Clay		

Tolman	Willow	Yellow Bellflower
Wagener	Winesap	Yellow Transparent
Wealthy	Wolf River	York Imperial
White Winter Pearmain	Yates	

Character of Injury

Infestation of pear(Pyrus communus) came late in the season as indicated by the finding of no infested leaves until July 29, 1933. Three infested leaves were found on August 15, 1933 in which the larvae(completing their life history) apparently were having difficulty in maturing since one larva was dead in its mine, the second larva was in its mine which contained burned or dead tissue and the third larva was small and in its mine in the "blotch" stage. The stiff leathery texture of pear leaves apparently makes it difficult for larvae to fold the leaf or to tie the lower epidermis together so as to construct a large tentiform mine. In most of the leaves examined very little of the tissue forming the palisade cells had been eaten by the larva. It was characteristic for the lower epidermis covering of the mine to be a dark brown or black color, indicating that this tissue was dead. Only two or three infested leaves, on the average, could be found on leaves of mahaleb cherry(*Prunus mahaleb*) after making a half day search. No infestation was found in July, but in August infested leaves were found on four different occasions. No infestation was found on the mahaleb cherry seedlings(*Prunus mahaleb*) until October 19, 1933, at which time five injured leaves were collected.

Pear trees having the most numerous leaves infested were adjacent to very heavily infested apple trees. Fifteen mines containing larvae were opened in which three contained dead larvae. Attempts that were made to rear adult moths from pear leaves were not successful. All larvae found in mines of pear leaves had the four characteristic black spots on the dorsal surface of the head of the genus, *Ornix*. On October 17, 1933, all pear trees in the orchard were found to be infested. Before that time no infested leaves could be found on several of the pear trees.

Leaves of sour cherry trees(*Prunus cerasus*) and cherry seedling stock(*Prunus mahaleb*) were found to have an occasional infested leaf. This infestation of sour cherry trees was probably of an accidental nature since only a few infested leaves were found.

During the month of July, leaf counts were made to determine the relative percentage of infestation on the different varieties of apples. These counts will not be given since all varieties were heavily infested and it was not possible for one person to make representative counts for all varieties before new infestation could take place. It was observed, however, that one tree may be heavily infested while another one of the same variety in the same row and adjacent to it may be only lightly infested. Counts were made on York Imperial trees, Numbers 3 and 4 in row No. 10. Five branches on the four sides of each tree were examined from the tip of the branch back to a distance two feet from the tip and the infested leaves counted. Tree No. 3 was in a vigorous growing condition with large succulent leaves while tree No. 4 was not vigorous, the leaves were small, thin and a light green color. The vigorous tree had 116 infested leaves while the weaker tree had only 64 infested leaves. Other similar observations indicate that trees having large, succulent, hairy leaves and which send out vigorous new growth are likely to be more heavily infested than trees having thin, shining, leathery leaves which send out very little new growth.

A number of insecticides were used in the Experimental orchard during the season of 1933. The experimental plots were originally selected for research work in the testing of the various insecticides for the control of the codling moth *Carpocapsa pomonella* Linn. Several different insecticides were used, and some of these have been recommended for the control of leaf-mining insects. Counts were made late in the season to determine the effectiveness of these insecticides in the control of *Ornix prunivorella* Chamb.(Tables 3, 4, see pp. 64, 65, 67). The year, 1933, was a poor one for producing apples at Manhattan, Kansas. The spring and summer were hot and dry. The hail storm that occurred June 25, 1933, damaged the leaves, branches, and young fruit. The hail and wind broke many branches, tore the leaves, and bruised the fruit. Following this storm, there was very little rainfall until early in the fall, consequently there was an accumulation of spray material on the leaves and fruit.

No burning of tissue took place on infested seedling trees grown in the greenhouse and used for life history studies of *Ornix prunivorella* Chamb. The insect removed and consumed the leaf tissue in the mine, but the leaf tissue remained green at the edge of the mine. Burning of tissue around *Ornix prunivorella* mines, however, was observed on apple trees on the Kansas State College campus and at 214 South Manhattan Avenue, that had not been sprayed during the year. The writer's contention is that extremely high temperatures, lack of moisture, and spray residue are the factors that cause the burning of the leaf around the insect mine. When these factors were not present which affect the physiological condition of the leaf, this kind of burning was not observed.

The resulting large amount of leaf injury was due mainly to the following factors: (1) leaves that had been torn by hail and wind, allowed entrance of spray material which caused burning, (2) accumulation of spray materials upon the leaves due to lack of rainfall, (3) extremely high temperatures during the summer of 1933, (4) the leaf-mining habit of Ornix prunivorella Chamb., which injured the leaf and exposed the tissue to spray material and loss of cell sap.

Leaf sections which had a small blotch stage mine with larva were imbedded in paraffin by the N-butyl alcohol process. After the leaf section was imbedded in paraffin, sections were cut with a microtome knife, mounted on slides and stained, Zirkle(1930). The specimens taken for this study were parts of leaves that had a small blotch stage mine with the larvae inside. These sections showed a distinct area of burned tissue all around the mine, that was apparently caused by spray injury.

The purpose of this work was to make an histological examination of the injury to leaf tissue caused by both the insect larvae and by spray material.

The tissue at the edge of the mine was burned badly and did not take the stain clear enough to study the injury to cell tissue(Plate III, see p. 28). On this plate, however, one can clearly see: (a) a cross section of the insect mine, (b) hole in the lower epidermis where the larva first entered the leaf and (c) round cross section of the small larva within the mine.

Many leaves were observed during December, 1933, that had turned yellow, except for a portion of the mesophyll cells opposite the mine; these remained green. In the early stage of making the mine, the larva feeds between the epidermis and eats the mesophyll cells and the tips of the palisade cells. Then the larva eats entirely the palisade cells. The remaining green color of the mines is due in all probability to the injury of the palisade cells, which prevents the escape of the

Plate II

Ornix prunivorella Chamb.

Apple seedling in pot, showing injury of leaves by the leaf mining habit.

Infestation was obtained by placing 6 adult *Ornix prunivorella* moths in cage on an apple seedling.

May, 1933.

Life size.

Plate III

chlorophyll and thus, it dries in place.

Control

Various types of spray materials were applied in the Kansas Agricultural Experiment Station orchard during the season of 1933. This material was used for the control of plant diseases and insects. A number of different kinds of insecticides were applied primarily for collection of data on research work that was being carried on for the control of the codling moth(Carpocapsa pomenella Linn.).

Table 1, records the fungicide, stomach poison insecticide, date of application and strength of solution.

RESULTS OF EXPERIMENTAL WORK

Finding of Insect

There was no infestation observed during March, 1933, of the leaf-mining habit of the small dipterous and hymenopterous insects that were placed in insect cages, on growing apple seedlings, in the insectary.

Several species of snout beetles(Curculionidae) were collected by placing a sheet beneath the trees in the Experimental orchard, but all of these insects apparently

Table 1

Spray Dosage Chart of
Fungicides and Stomach Poison Insecticides

Date of application	Fungicide	Amount	Insecticide	Amount	Water
4/11/33	Liquid lime sulfur	3½ gals.			96½ gals.
5/1/33	" " "	3½ "	Astringent lead arsenate	3 lbs.	96½ "
5/15/33	" " "	3½ "	" " "	3 "	96½ "
5/30/33			" " "	3 "	100 "
6/26/33			" " "	3 "	100 "
7/11/33			" " "	3 "	100 "
7/31/33			" " "	3 "	100 "
8/19/33			" " "	3 "	100 "
4/1/33	Liquid lime sulfur	3½ gals.			96½ gals.
5/3/33	" " "	3½ "	Lead arsenate	3 lbs.	96½ "
5/18/33	" " "	3½ "	" "	3 "	96½ "
5/30/33	Bordeaux	6-12 to 100	" "	3 "	100 "
6/26/33			" "	3 "	100 "
7/11/33			" "	3 "	100 "
8/1/33			" "	3 "	100 "
8/26/33			" "	3 "	100 "
4/12/33	Liquid lime sulfur	3½ gals.			100 gals.
5/4/33	" " "	3½ "	Calcium arsen. Hyd. lime	2 lbs. ea.	100 "
5/22/33	" " "	3½ "	" " " "	2 " "	100 "
6/1/33	" " "	3½ "	" " " "	2 " "	100 "
6/27/33			" " " "	2 " "	100 "
7/11/33			" " " "	2 " "	100 "
8/1/33			" " " "	2 " "	100 "
8/25/33			" " " "	2 " "	100 "
4/11/33	Dry lime sulfur	7 lbs.			100 gals.
5/3/33	" " "	7 "	Lead arsenate	3 lbs.	100 "
5/16/33	" " "	7 "	" "	3 "	100 "
6/2/33	" " "	7 "	" "	3 "	100 "
6/28/33			Manganar	3 "	100 "
7/11/33			"	3 "	100 "
7/31/33			"	3 "	100 "
8/26/33			"	3 "	100 "
4/12/33	Liquid lime sulfur	3½ gals.			100 gals.
5/6/33	" " "	3½ "	Lead arsenate	3 lbs.	100 "
5/20/33			" "	3 "	100 "
6/2/33			" "	3 "	100 "
6/28/33			Dutox	3 "	100 "
7/11/33			"	3 "	100 "
7/31/33			"	3 "	100 "
8/25/33			"	3 "	100 "
4/12/33	Liquid lime sulfur	3½ gals.			100 gals.
5/6/33	" " "	3½ "	Lead arsenate	3 lbs.	100 "
5/20/33	" " "	3½ "	" "	3 "	100 "
6/2/33			" "	3 "	100 "
6/27/33			Kalo	3 "	100 "
7/11/33			"	3 "	100 "
8/1/33			"	3 "	100 "
8/25/33			"	3 "	100 "

Table 2

Spray Dosage Chart of
Fungicides and Contact Insecticides

Date of application	Fungicide	Amount	Insecticide	Amount	Water
4/12/33	Liquid lime sulfur	$3\frac{1}{2}$ gals.			$96\frac{1}{2}$ gals.
5/6/33	" " "	$3\frac{1}{2}$ "	Lead arsenate	3 lbs.	$96\frac{1}{2}$ "
5/20/33	" " "	$3\frac{1}{2}$ "	" "	3 "	$96\frac{1}{2}$ "
6/2/33			" "	3 "	$96\frac{1}{2}$ "
6/26/33			Nicotine sulphate (Black Leaf 40) Verdol emulsion	1 pt. 1 gal.	100 "
7/12/33			"	"	100 "
7/31/33			"	"	100 "
8/25/33			"	"	100 "
4/12/33	Liquid lime sulfur	$3\frac{1}{2}$ gals.			100 gals.
5/6/33	" " "	$3\frac{1}{2}$ "	Lead arsenate	3 lbs.	100 "
5/20/33	" " "	$3\frac{1}{2}$ "	" "	3 "	100 "
6/2/33			" "	3 "	100 "
6/26/33			Nicotine(Black Leaf 40) Tannate	1 pt. 3 pts.	100 "
7/11/33			"	"	100 "
7/31/33			"	"	100 "
8/25/33			"	"	100 "
4/11/33	Dry lime sulfur	7 lbs.			100 gals.
5/3/33	" " "	7 "	Lead arsenate	3 lbs.	100 "
5/16/33	" " "	7 "	" "	3 "	100 "
5/30/33	" " "	7 "	" "	3 "	100 "
6/27/33			Oleic acid-oil emulsion	1 pt. 1 g.	100 "
7/12/33			" " "	1 " 1 "	100 "
8/1/33			" " "	1 " 1 "	100 "
8/25/33			" " "	1 " 1 "	100 "

were too large to be possible leaf mining insects. The search to find the insect in hibernation was continued without success. Leaves infested by larvae of the insect were found, however, in June, 1933 at which time the biological work began.

Biology

Insect Cages, Collecting and Rearing Larvae. A series of eighteen of the double glass vial-cages as shown in Plate I, Figure 1, was prepared. After making observations on the larvae in this type of cage, the writer concluded that this was not a satisfactory type of rearing cage since the mortality of the larvae and pupae amounted to 57 per cent. It was also found that 21 per cent of the larvae collected were parasitized. Parasitism took place in the field before the collection was made. Thus, there would be only a small percentage of larvae or pupae from which to obtain adult *Ornix* moths to use in life history studies. This method of rearing was abandoned due to this fact and also to the large amount of time and equipment needed in preparing the cages.

The rearing cage consisting of a glass vial that had cotton in the end of the bottle(Plate I, Figure 3, see

p. 16), was not as satisfactory as the one in which the blotting paper was used(Plate I, Figure 2). The moisture inside the bottle was lost more quickly in the one that had a cotton stopper.

A rearing cage made of cheese cloth covering the infested leaf and tied around the twig, was not a successful insect rearing cage, because examination was difficult(Plate I, Figure 6, see p. 16).

The cylindrical fine meshed copper wire insect cage was quite satisfactory(Plate I, Figure 7, see p. 16). Two adult moths emerged from two of these cages that were placed in contact with the ground and with the soil covered with fallen leaves(Plate I, Figure 9). The insects emerged April 7, 1934.

The most successful type of insect cage for carrying the insect through the winter, was the upright glass cylinder that was placed several inches into the soil and had the top covered with muslin(Plate I, Figure 8, see p. 16).

Life History. Egg. The egg is disc-like in shape and is extremely small, slightly oblong, varying from 0.254 to 0.4 mm. in length and from 0.18 to 0.29 mm. in breadth, only slightly elevated and firmly cemented invariably to the under surface of the leaf. The exposed surface of the egg, when observed under the microscope has a checked or mottled texture, very closely resembling the surface of a codling moth egg. The eggs are laid singly, but it seems that no particular spot is chosen to receive the egg(Plate XIII, Figure 3, see p. 53).

The writer has not been able to find any life history work in which observations were made of eggs that were laid by moths while in a wire screen cage or glass vials. Haseman(1916) mentioned unsuccessful attempts to induce moths to lay eggs in glass vials.

On August 27, 1933, the writer placed 15 adult Ornix moths in a 4-inch glass vial. On August 29, 14 eggs were observed cemented to the sides of the vial. The following day the moths were taken out of the vial. The development of the embryo in the eggs was observed under a binocular microscope and on September 3, the embryonic larvae were apparently ready to leave the shell and could plainly be seen curled around inside of the egg(Plate XIV, Figure 5, see p. 55). Attempts to transfer the eggs onto apple leaves to supply food for the young larvae were not successful since the eggs were cemented very tenaciously to the sides of the glass vial. The young larvae died in the eggs about two days later, since it was not possible for the young larva to leave the egg in the normal manner and go to a leaf for food.

No insect eggs were observed that were collected in the field. The remaining egg shell was observed soon after the larva had hatched and entered the leaf. The broken egg shell could be plainly seen with a tiny hole in the side cemented to the leaf through which the insect entered the leaf tissue to start the mines(Plate XIV, Figure 7, see p. 55).

Larva. At the time of hatching, the larva is footless and resembles a newly hatched flatheaded borer. The larva breaks through the part of the shell that is cemented to the leaf, so as to obtain food and in this way, starts the construction of the protective tentiform mine. In its development it passes through four distinct instars.

In the first instar, the larva is pale with a slight yellowish tinge to the head. The larva is footless having an enlarged head and thorax. It moults when it is less than 2 mm. in length(Plate XIV, Figure 6, see p. 55).

In the second instar, the body is pale and the head is brownish. A dark spot begins to appear on the first thoracic segment. The legs are still absent and the larvae slightly over 2 mm. long.

In the third instar, the body is at first pale as in the second instar, but darkens with age and the thoracic and abdominal legs appear. The dark thoracic spot breaks up into four irregular black spots. The larva is about 4.5 mm. long(Plate IV, see p. 37).

When the larva is full grown or in the fourth instar, it is 6 to 7 mm. in length. The head is light brown and about one half as broad as the first thoracic segment, which is light yellow. The form is cylindrical with the last three or four thoracic segments of the abdomen tapering slightly. With the exception of the head and first thoracic segment, there are on the dorsal surface, four longitudinal rows of white elevations, each segment having at or near its middle, one of these elevations in each row. There are also two rows of similar elevations on each side of the larva. Toward the caudal end of the larva, the two middle dorsal rows run together. Other rows of tubercles disappear in the last abdominal segments leaving fewer white elevations on these segments, than on the others. From each of these elevations arises a hair of considerable length. On or near some of the

Plate IV

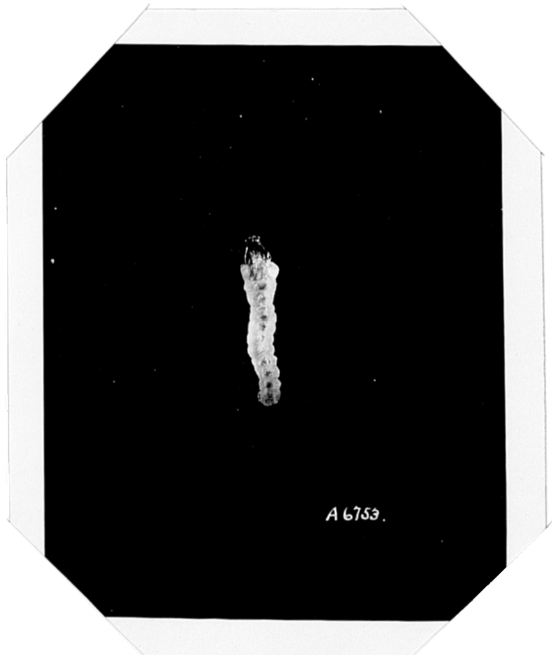
Ornix prunivorella Chamb.

Larva, slightly shrunken, third moult.

July, 1933.

15 x.

Plate IV



tubercles of the middle dorsal row, arises a second, but quite short hair, also numerous small hairs on the head, first thoracic segment and anal segment. Upon the dorsal surface of the head are 4 very black, conspicuous spots and on each lateral surface, an indistinct one. Also on the dorsal surface of the first thoracic segment are 4 similar, but larger black spots. Thoracic, abdominal and anal legs are well developed. The thoracic legs have the outer surface almost entirely black and smooth, while the inner surface is gray and furnished with hairs. The abdominal and anal legs are of the same color as the larva(Plate V, see p. 39).

"The larvae are extraordinary; when young they are very much flattened and have thin blade-like mandibles and vestigal maxillae and libium; they merely slash open the cells of the leaf and suck the cell sap..." Comstock (1933).

Chambers(1882b) stated that in the genus Ornix, the larvae leave the egg with the trophi imperfect, the maxillae, maxillary palpi, labial palpi and spineret are entirely absent, but the maxillae may be said to be present in a very rudimentary condition. However,

Plate V

Ornix prunivorella Chamb.

Larva, last moult stage.

July 14, 1933.

12 x.

Plate V

this may be at the first or some subsequent moult that the larvae exchange this first form of the trophi for the second or ordinary form in which all the organs are present. This change takes place in different species of the same genus. Thus in Gracillaria, Coriscium and Ornix, it takes place at the first moult.

Mine. The newly hatched larva makes a serpentine mine. This mine goes through a transition which corresponds to the changes of the four larval instars(Plate VI, Plate XIV, Figure 8, see pp. 41, 55).

The length of the serpentine mine varies greatly, but the average serpentine mine is from 4 to 10 mm. long. The serpentine mine usually curves upon itself, which is seemingly an outline for the future blotch mine. The blotch mine is evident about the time that the larva changes to the second instar. The blotch appears first on the under side of the leaf. The epidermis on the under side of the leaf is loosened from the palisade cells by the feeding of the flat footless larva. This loosened epidermis soon dies and turns brown. After the blotch is formed, the larva starts feeding at one end of the mine, consuming the palisade cells and all tissue between the lower and upper epidermis. The larva deposits its castings

Plate VI

Ornix *prunivorella* Chamb.

Apple leaf serpentine mines, three days after eggs had hatched.

6 *Ornix* moths were put in cage on a potted apple seedling in insectary to obtain infestation.

September 5, 1933.

3 x.

Plate VI

which are little pellets. These are tied with a web at the end of the mine, where all of the inner tissue was first removed. This inner tissue is consumed as the larva grows and changes to the fourth instar. As all of the inner tissue in the mine is removed, the thin epidermis on both sides of the leaf is translucent. There are no green spots, caused by the remaining in the insect mine of part of the tissue of the inner leaf. This habit is responsible for the descriptive part of the common name which is "unspotted". The blotch usually occupies all of the space between two of the main lateral veins and is from 1 to 2 cm. long when completed(Plate VII, see p. 43).

In order to produce the tentiform mine, the larva spins silk threads on the floor of the mine which causes the lower dead layer of the leaf to become folded lengthwise of the mine. The tentiform shape of the mine is assumed by these threads with others spun under the roof tightening as they dry, causing an upward projection of the mine. This tentiform mine is started about the time the larva changes to the fourth instar and a majority of the feeding and growth takes place in the third and fourth instars. The unspotted tentiform effect of the mine

Plate VII

Ornix prunivorella Chamb.

Apple leaf, under surface showing injury by the leaf-mining habit (the mine itself) and distortion of the leaf by rolling and tying.

July 14, 1933.

2 x.

Plate VII

Plate VIII

Ornix prunivorella Chamb.

Quince leaf--upper and lower sides showing injury(Tentiform Miner).

July 14, 1933 .

2 x .

Plate VIII

Plate IX

Ornix prunivorella Chamb.

Apple leaves, under and upper surface showing injury by the leaf miner.

July, 1933.

Life size.

Plate IX

Plate X

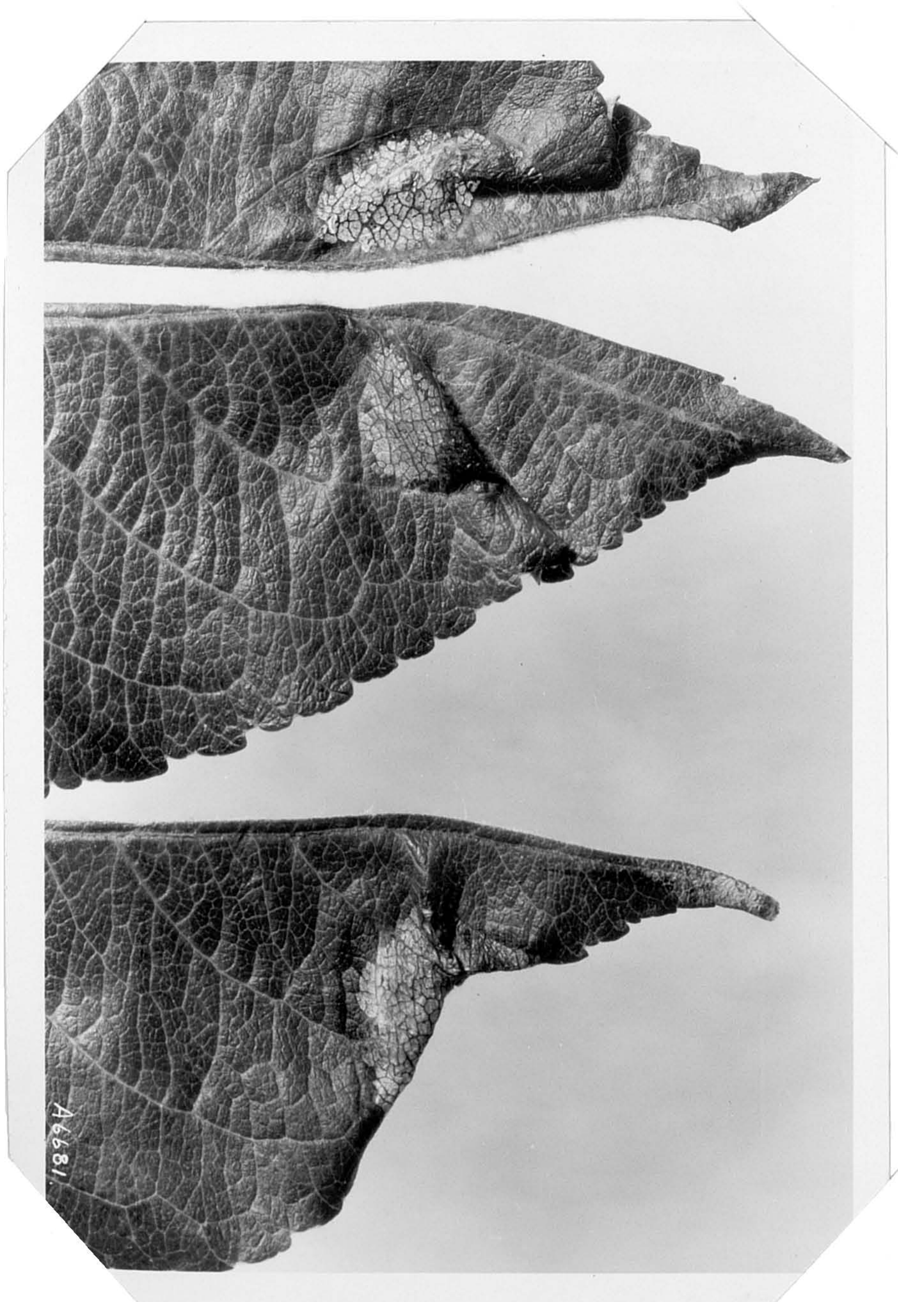
Ornix prunivorella Chamb.

Apple leaf, upper surface showing injury by leaf mining habit and characteristic location on leaf.

July 14, 1933.

2 x.

Plate X



is produced after the larva has removed all of the green parenchyma cells within the mine(Plate VIII, see p. 44).

When through eating or when all of the parenchyma within the mine is eaten, the larva leaves the mine by an opening which is made in the under surface at one end of the mine(Plate IX, see p. 45). The larva either prepares a cocoon in which to pupate on the same leaf, or goes to a different one. If not through feeding, it turns over the edge of the leaf and feeds on the infolded portion (Plate X), or may even tie two leaves together, feeding between them. During midsummer, the larval life in the mine is about ten days to two weeks.

Cocoon. After the larva leaves the mine, it goes to some portion near the edge of the leaf, either on the upper or lower surface of the leaf. It folds the edge over itself, bringing it close down to the surface of the leaf by silk and then spins around itself in this roll a delicate silken cocoon. On preparing to make the cocoon, quite often the larva rasps off and eats a small area of the upper epidermis along the edge of the leaf. This causes a withering of the leaf tissue, making it easier for the insect to tie the edge of the leaf down, when it is folded over. It takes the insect about 30 minutes to prepare the cocoon. Within this cocoon, it casts its larval skin and transforms to a pupa remaining in this condition usually throughout the winter(Plate XI, see p. 49).

Pupa. The mature larva transforms into a pupa which is about 5 mm. long. The antennal sheath extends about 1 mm. beyond the anal segment. The pupa is about 1 mm. wide at the largest part. The head is furnished with quite a prominent pointed beak. There are two rows of hairs on the dorsal surface and two on each side. The lower row on the sides is made up of two hairs placed close together on each segment. There are no hairs on the head. The color is brownish yellow with the exception of the beak which is black and the dorsal surface, which is brown to dark brown. The color of the pupa varies with age, being a light yellow when first formed, but becoming a dark brown as the time approaches for the pupa to transform into a moth. The leg, wing and antennal sheaths are all distinct. The pupal period varies from a few days to a week in midsummer(Plate XII, see p. 50).

Moth. The following is the original description of Ornix prunivorella Chamb. as described by Chambers(1873):

"Dark steel gray almost brown. Labial palpi white,

Plate XI

Ornix prunivorella Chamb.

Lower side of apple leaf.

Leaf unfolded to expose
cocoon of insect.

October 6, 1933.

10 x.

Plate XI

Plate XII

Ornix prunivorella Chamb.

Pupa, dorsal and ventral sides.

October 19, 1933.

20 x.

Plate XII

each joint tipped externally with dark steel gray. Antennae of the general hue, faintly annualate with whitish. Thorax and primaries dark steel gray, the primaries with about 9 faint whitish costal streaks, the first near the base and the last at the apex becoming gradually longer from the base to the apex, all faintly dark margined internally, the last three or four nearly perpendicular to the costal margin, crossing the wing and uniting near the dorsal margin where they are narrow and indistinct. A small black apical spot behind which are three dark hinder marginal lines in the ciliae. A l. ex. 1/3 inch. Kentucky".

The adult moth is a striking little creature after one has become acquainted with its characteristics and habits. Its full beauty is evident only in the newly-emerged specimens, because after a short time its scales become rubbed and broken. When looking at a pinned specimen, one does not have the chance to observe the proud little fellow posing in its characteristic peacock-like position. When at rest the insect sits in this position with the wings folded rooflike over the body, the head elevated and the tip of the wings and abdomen lightly touching the surface on which it rests. The body of the insect is at approximately a 35° angle(Plate XIV, Figure 2, see p. 55).

When viewed through a microscope, the full splendor of this little moth is evident as the light flashes from each scale giving it an iridescent metallic hue. To the naked eye, the moth is slate-gray with a light tinge of brown(Plate XIII, see p. 53). The rubbed specimens appear to be lighter. The ventral surface of the body is somewhat lighter in color. The markings on the prothoracic and mesothoracic pairs of legs are similar. The tarsal segments are white, tipped with black; the tibia and femur vary from dark brown to black with lighter patches; the coxae are mottled with white and dark scales. The tarsal segments of the metathoracic legs are brownish with white basal bands, while the tibia, femur, and coxa are much lighter being similar to the lower surface of the abdomen. The palpi are prominently banded with white and dark scales. The brownish proboscis is unusually long, reaching to beyond the posterior end of the abdomen. The writer has observed it feeding on water sweetened with sugar or honey. The antennae are brownish in color and annulate with whitish scales. In live specimens, the antennae are closely pressed along the sides of the body

Plate XIII

Ornix prunivorella Chamb.

Adult, showing feathery wings.

July, 1933 .

12 x .

Plate XIII

and reach to beyond the tip of the abdomen and wings.

The surface of the forewings is beautifully mottled with light and dark scales. The light scales are arranged in eight or nine more or less distinct transverse bands. It is difficult to distinguish these bands in museum specimens. Near the tip of the forewings in fresh specimens, is a distinct black patch of scales bordered on the outside by three alternating, narrow, white and black curving bands, which gives to the tip of the wings a distinct peacock spot. On the posterior margin of the front wings the black and white scales, forming the terminal peacock spot give way to long light-colored hair. This border of delicate hair ceases near the middle of the posterior margin of the wing. The hind wings are slender and have on the posterior margin a broad band of delicate light-colored hair. This band becomes narrower toward the tip of the wing. The insect is approximately 5 mm. long when at rest with the wings folded and has a wing expanse of from 7 to 9 mm.(Plate XIV, Figure 1, see p. 55).

Life Cycle. Life history data collected by the writer indicates that this insect overwinters in both the larval and pupal stages. The fourth instar larvae were observed in insect cages in the field as late as

Plate XIV

DIAGRAMMATIC DRAWINGS

Ornix prunivorella Chamb.

1. Adult moth with wings expanded showing the feather like hind wings(10 x).

2. Adult moth at rest and showing its characteristic position when resting or when the insect alights(2 x).

3. Egg highly magnified(binocular highpower) and showing the grid of cross hairs of the microscope for comparison of size.

4. Egg showing elevation and how it is firmly cemented around the edges to the leaf (binocular highpower).

5. Embryo of insect inside of egg when almost ready to hatch(binocular highpower).

6. First instar larva, showing the likeness to a very small "flat headed borer".

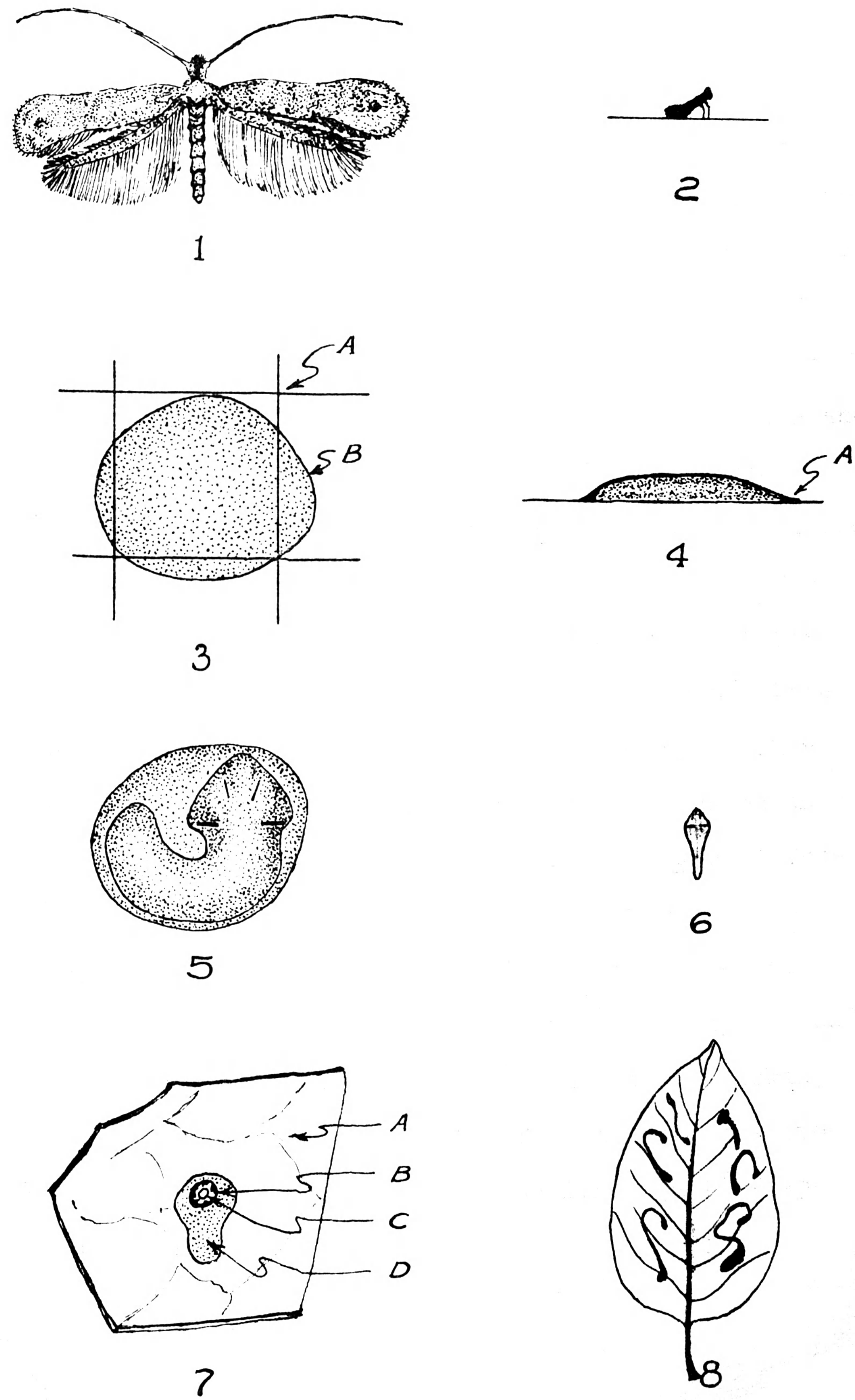
7. First stages of leaf mine, showing (A) section of leaf, (B) the old discarded egg shell still in place, (C) hole where the insect entered the leaf, (D) the very small "blotch" mine in the leaf.

8. Diagram showing the early stages of the mines. They are serpentine in shape after the first tiny blotch stage. The mature mine is a blotch tentiform mine.

Plate XIV

DIAGRAMMATIC DRAWINGS

<u>Ornix</u> <u>prunivorella</u> Chamb.



February 15, 1934. The insects were first put in the cage on October 7, 1933.

The overwintering larvae are protected in the silk lined mine of the leaf. The overwintering form is found more commonly in the pupal stage, since the pupa is protected in the carefully prepared cocoon in the folded-over portion of the leaf. The construction of these cocoons has been observed on the leaf and in cracks and crevices of insect rearing cages and in glass vials. This would indicate that the cocoon also may be constructed in cracks and crevices in the bark of trees. The writer has not been able to verify the latter statement. It takes from four to five weeks to complete the life cycle; the number of broods is determined by weather conditions. Adult moths emerged in rearing cages on April 7, 1934. It was about a month later when infestations in the field could be readily found. The broods overlap, but are fairly well defined until late fall.

Data collected by the writer during the spring and summer of 1933 and 1934, indicates that the following inclusive dates are representative for the seasonal broods, the first brood adults emerging the first part of April:

Brood 1 -- April 5-9
" 2 -- May 10-14
" 3 -- June 15-19
" 4 -- July 12-16
" 5 -- Aug. 3-7 and 25-29(broods overlap)
" 6 -- September 12-16
" 7 -- October 12-16

During November and December, 1933, infestation was heavy, but it was the result of a series of secondary infestations rather than of a well defined brood.

During the fall of 1933, the growing season was very long, due to the fact that rains came in after the prolonged summer drouth and cold weather was late in arriving. Many trees sent out a new growth of leaves and water sprouts were abundant late in the fall or early winter.

Green leaves infested with larvae were collected from apple trees in the field as late as December 19, 1933.

In the insectary six adult moths were placed on potted apple seedling trees which were enclosed in wire screen cages. The adult moths could not be found shortly after they were put inside of the cage, they had apparently died or escaped. The cage was observed daily for a week and no mines could be found. Three days later, however, well developed mines were observed.

Before being placed in the cage, mating of two of these moths was observed on August 2, 1933. The insects joined the posterior ends of their bodies in copulation and remained in this position for approximately 30 minutes. The insects were in their characteristic position of rest, that is, the tips of their abdomen were resting on the surface of the bottom of the glass vial. Their bodies were at quite an angle with the surface of the vial(Plate XIV, Figure 2, see p. 55). The heads of both insects were pointed in opposite directions. These activities took place at about 10:00 a. m. and the insects were in small glass vials.

Summarizing the life cycle, the adult female moths emerge in early spring and lay eggs on the lower surface of the leaves of the host plant. These eggs hatch into very small footless white larvae which make small serpentine mines. Each larva grows and has four instars and finally becomes in the fourth instar, an active gray caterpillar having four characteristic black spots on the first thoracic segment. There are conspicuous white tubercles on the body and six thoracic legs besides abdominal legs. As the larva grows, the mine also transforms from the small inconspicuous serpentine mine to a larger blotch mine and finally to the unspotted tentiform mine which is lined with silk. When the larva is through feeding it usually goes from the mine to the upper portion of the leaf, folds the edge over itself and constructs its cocoon, by spinning silk in which to pupate. The pupa is a light yellow at first becoming darker with age and has the leg, wing and antennal sheath all plainly visible. This pupa transforms intc the adult moth which is the small steel gray insect that emerges from the cocoon and after a short time is ready to lay more eggs to perpetuate its life cycle.

Applied Control

A study was made of the effectiveness of using stomach poison sprays and contact insecticides in the control of Ornix prunivorella Chamb.

In most cases 300 leaves were examined on each of four sides[2] of each tree and the total number of mines recorded. Some leaves examined contained several mines, while other leaves did not have any. The percentage of

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2. The sides of each tree were the four sides in the direction of the four major points of the compass, namely, north, south, east, west.

infestation was figured on the basis that one leaf with one mine would be 100 per cent infested while one leaf with three mines would be 300 per cent infested. Many of the infested leaves contained live larvae and many of them contained dead larvae. Since the counts were made late in the season, mines that contained no larvae were also counted since the larvae had already completed their growth and had caused the maximum amount of damage to the leaf tissue. No record was made as to whether the mines contained larvae or not or whether the larvae were alive or dead(Table 3, see pp. 61, 62).

A normal apple leaf that contains a mine of *Ornix prunivorella* Chamb. does not have black or burned tissue at the edge of the mine unless some physiological factor affecting the leaf causes the unprotected leaf tissue to die.

Stomach Poisons. The following stomach poison insecticides were used: Manganar(manganese arsenate), astringent lead arsenate, lead arsenate, calcium arsenate, Kalo(sodium aluminum fluoride), and Dutox(barium fluosilicate). Leaves on which stomach poison sprays were used showed a marked increase in burned leaf tissue around

Table 3

Results of Using Stomach Poison Sprays on Apple and Pear Leaves Infested by *Ornix prunivorella* Chamb.

Row No.	Tree No.	Variety, spray, and month, day and year of examination	No. of leaves examined	Side of tree	Number of Mines: Burned	Number of Mines: Not Burned	Number of Mines: Total	Per Cent of mines: Burned	Per Cent of mines: Not Burned	Remarks
57	1	Stayman Winesap	300	N	669	21	690	223	7	Max. injury on W
		Manganar	300	S	819	21	740	273	7	Aver. infesta-
		10/5/33	300	E	570	42	612	190	14	tion 245%. Nine
			300	W	894	15	909	298	5	mines to 1 leaf found.
57	2	Stayman Winesap	300	N	726	12	738	242	4	
		Manganar	300	S	372	15	387	124	5	Max. injury on N
		10/5/33	300	E	546	12	558	182	4	Aver. infesta-
			300	W	660	9	669	220	3	tion 196%.
57	11	Stayman Winesap	300	N	564	15	579	188	5	Max. injury on S
		Manganar	300	S	738	0	738	246	0	Aver. infesta-
		10/5/33	300	E	555	33	588	185	11	tion 216%.
			300	W	693	0	693	231	0	
6	1	Jonathan	300	N	342	15	357	114	5	Max. injury on W
		Astringent lead arsen.	300	S	414	9	423	138	3	Aver. infesta-
		9/12/33	300	E	240	27	267	80	9	tion 129%.
			300	W	504	0	504	168	0	
2	1	Maiden Blush	300	N	273	66	339	91	22	Max. injury on S
		Lead arsenate	300	S	375	54	429	125	18	Aver. infesta-
		9/12/33	300	E	243	48	291	81	16	tion 98%.
			300	W	108	9	117	36	3	
30	3	Wealthy	300	N	426	0	426	142	0	Max. injury on N
		Lead arsenate	300	S	339	0	339	113	0	Aver. infesta-
		10/17/33	300	E	384	0	384	128	0	tion 113%.
			300	W	310	0	210	70	0	
30	4	Wealthy	300	N	462	0	462	154	0	Max. injury on S
		Lead arsenate	300	S	483	9	492	161	3	Aver. infesta-
		10/17/33	300	E	435	0	435	145	0	tion 143%.
			300	W	330	0	330	110	0	
42	3	Rome Beauty	300	N	322	24	346	106	8	Max. injury on S
		Lead arsenate	300	S	390	6	396	130	2	Aver. infesta-
		10/1/33	300	E	309	22	331	103	7	tion 116%.
			300	W	316	4	320	105	1	

(Continued)

Table 3 (Continued)

Row No.	Tree No.	Variety, spray, and month, day and year of examination	No. of leaves examined	Side of tree	Number of Mines: Burned	Number of Mines: Not Burned	Number of Mines: Total	Per Cent of mines: Burned	Per Cent of mines: Not Burned	Remarks
42	3	Rome Beauty	300	N	322	24	346	106	8	Max. injury on S
		Lead arsenate	300	S	390	6	396	130	2	Aver. infesta-
		10/1/33	300	E	309	22	331	103	7	tion 116%.
			300	W	316	4	320	105	1	
58	11	Anoka	300	N	126	111	237	42	37	Max. injury on N
		Lead arsenate	300	S	105	33	138	35	11	Aver. infesta-
		10/5/33	300	E	186	42	188	62	14	tion 60%.
			300	W	96	66	162	32	22	
3	1	Pear	300	N	12	0	12	4	0	Max. injury on W
		Lead arsenate	300	S	60	0	60	20	0	Aver. infesta-
		10/17/33	300	E	6	3	9	2	1	tion 17%.
			300	W	123	3	126	41	1	
12	41	Winesap	300	N	108	27	135	36	9	Max. injury on W
		Calcium arsenate	300	S	210	21	231	70	7	Aver. infesta-
		10/12/33	300	E	150	60	210	50	20	tion 72%.
			300	W	269	12	281	89	4	
13	41	Winesap	300	N	180	18	198	60	6	Max. injury on N
		Calcium arsenate	300	S	159	9	168	53	3	Aver. infesta-
		10/12/33	300	E	105	15	120	35	5	tion 46%.
			300	W	69	6	75	23	6	
16	41	Winesap	300	N	177	15	192	59	5	Max. injury on N
		Calcium arsenate	300	S	90	9	99	30	3	Aver. infesta-
		10/12/33	300	E	81	27	108	27	9	tion 45%.
			300	W	123	21	144	41	7	
39	2	Winesap	300	N	102	9	111	34	3	Max. injury on E
		Kalo	300	S	150	0	150	50	0	Aver. infesta-
		10/17/33	300	E	186	0	186	62	0	tion 44%.
			300	W	84	0	84	28	0	
39	3	Winesap	300	N	210	0	210	70	0	Max. injury on S
		Kalo	300	S	258	0	258	86	0	Aver. infesta-
		10/17/33	300	E	186	0	186	62	0	tion 78%.
			300	W	228	0	228	76	0	
39	7	Winesap	300	N	104	3	107	30	1	Max. injury on N
		Dutox	300	S	74	8	82	27	2	Aver. infesta-
										tion 30%.
39	9	Winesap	300	N	108	6	114	38	2	Max. injury on S
		Dutox	300	S	126	5	131	43	1 2/3	Aver. infesta-
		9/28/33								tion 42%.
39	11	Winesap	300	N	116	4	120	40	1 3/4	Max. injury on S.
		Dutox	300	S	158	5	163	54	1 2/3	Aver. infesta-
		9/28/33								tion 49%.

the edge of the mine. In the case of Manganar, the total infestation was highest. The burning of leaf tissue was also severe on leaves that were sprayed with calcium arsenate, Kalo and Dutox.

The results of using stomach poison sprays on apple and pear leaves infested with the unspotted tentiform leaf miner are shown in table No. 3.

Contact Insecticides. The same method as previously described, was also used to determine the effectiveness of the contact sprays, nicotine tannate, oleic acid-oil emulsion and nicotine sulphate-oil emulsion, for the control of this insect.

It will be noted in table No. 4, that the infestation is remarkably lower where contact insecticides have been used, compared to stomach poison sprays. Oleic acid, however, is an exception to this. The average infestation after the use of nicotine tannate was 26 per cent while the average infestation after the use of nicotine sulphate-oil was 10 per cent. In some cases the infestation was as low as 4.5 per cent where nicotine sulphate-oil was used(Table No. 4, see p. 64).

It is believed by the writer that this low infestation was brought about by the nicotine sulphate-oil

Table 4

Results of Using Contact Sprays on Apple Leaves Infested by *Ornix prunivorella* Chamb.

Row No.	Tree No.	Variety, spray, and month, day and year of examination	No. of leaves examined	Side of tree	Number of Mines: Burned	Number of Mines: Not Burned	Number of Mines: Total	Per Cent of mines: Burned	Per Cent of mines: Not Burned	Remarks
41	3	Winesap	300	N	103	6	109	34	2	Max. injury on N
		Nicotine tannate	300	S	51	9	60	17	3	Aver. infestation
		10/1/33	300	E	73	0	73	27	0	25%.
			300	W	55	3	58	18	1	
41	4	Winesap	300	N	60	0	60	20	0	Max. injury on E
		Nicotine tannate	300	S	23	0	23	7	0	Aver. infestation
		10/1/33	300	E	76	2	78	25	2/3	17%.
			300	W	45	6	51	15	2	
41	4	Winesap	300	N	36	3	39	12	1	Max. injury on W
		Nicotine tannate	300	S	108	0	108	36	0	Aver. infestation
		10/12/33	300	E	129	3	132	43	1	36%.
			300	W	153	9	162	51	3	
40	6	Winesap	300	N	42	0	42	14	0	Max. injury on S
		Nicotine sulphate-oil	300	S	69	3	72	23	1	Aver. infestation
		emulsion 9/12/33	300	E	63	0	63	21	0	19%.
			300	W	57	0	57	19	0	
40	8	Winesap	300	N	6	0	6	2	0	Max. injury on S
		Nicotine sulphate-oil	300	S	78	0	78	26	0	Aver. infestation
		emulsion 9/12/33	300	E	15	3	18	6	1	12%.
			300	W	39	0	39	13	0	
40	6	Winesap	300	N	25	7	32	8	2 1/3	Max. injury on W
		Nicotine sulphate-oil	300	S	23	0	23	7	0	Aver. infestation
		emulsion 9/28/33	300	E	17	2	19	5	2/3	9%.
			300	W	26	8	34	8	2 2/3	
40	2	Winesap	300	N	14	2	6	4½	2/3	Max. injury on W
		Nicotine sulphate-oil	300	S	8	1	9	2	1/3	Aver. infestation
		emulsion 9/28/33	300	E	15	0	15	5	0	4½%.
			300	W	18	4	22	6	1 1/3	
40	3	Winesap	300	N	21	7	28	7	2 1/3	Max. injury on N
		Nicotine sulphate-oil	300	S	15	0	15	7 2/3	2/3	6%.
		emulsion 9/28/33	300	E	21	2	23	5	0	
			300	W	12	1	13	4	1/3	
37	2	Winesap	300	N	105	6	111	35	2	Max. injury on E
		Oleic acid-oil	300	S	66	30	96	22	10	Aver. infesta-
		emulsion 10/7/33	300	E	162	36	198	54	12	tion 40½%.
			300	W	72	9	81	24	3	
37	3	Collins	300	N	177	36	213	59	12	Max. injury on N
		Oleic acid-oil	300	S	144	21	165	48	7	Aver. infesta-
		emulsion 10/7/33	300	W	147	60	207	49	5	tion 62%.
			300	E	153	16	169	51	20	

emulsion, because it acts as an ovicide and repellant as well as a contact insecticide.

Biological Control

Parasites. A number of parasites of *Ornix prunivorella* Chamb. were reared while carrying on the life history studies of this insect. At the time this study was made the infestation of *Ornix prunivorella* Chamb. was at its peak and the parasites were well established, enough so that it was difficult to obtain data and material for life history work(Plates XV, XVI, see pp. 66, 67). The species of this parasite is not known, but is very likely *Xenosternum ornigis* Mues. since this species was more plentiful than any other.

The general impression is that an insect which spends its larval life protected inside the leaf, from the time it hatches until it is ready to pupate, would not be parasitized readily by natural enemies. A majority of the parasites were external parasites of the larval stage. Observations were made on a few dried pupae in which there was a small hole and with a hollow interior. This would indicate that internal parasites attacked the larvae and emerged from the pupae.

Plate XV

Ornix prunivorella Chamb.

Parasite, hymenopterous external larval parasite.

July 14, 1933.

12 x.

Plate XV

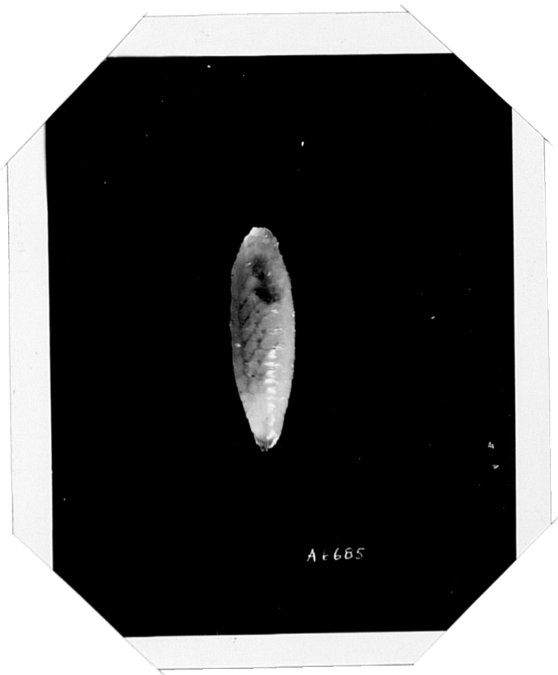

Plate XVI

Ornix prunivorella Chamb.

Parasite in cocoon.

July 14, 1933.

12 x.

Plate XVI

It appears that comparatively few of the tentiform leaf miners are able to successfully go through the winter. Early in the season infestation is scarce and it is not until midsummer and later, after the infestation has built up, that parasites become abundant. By this heavy parasitism late in the season, the number of over-wintering insects is reduced remarkably.

The collection of hymenopterous parasites was submitted on March 2, 1934, to Dr. Harold Morrison, Division of Insect Identification, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture. The following seven species of parasites were determined by Dr. A. B. Gahan, June 5, 1934:

Elasmus albicoxa Howard
Zagrammosoma multilineata (Ashm.)
Cirrospilus nigrovariegata Gir.
Sympeisis bimaculata Cwfd.
Catolaccus aeneoviridis (Gir.)
Horismenus fraternus (Fitch)
Tetrastichus caerulescens Ashm.

Dr. C. F. W. Muesebeck determined the following on March 14, 1934:

Apanteles tischeriae Vier.
Epirhyssalus new species.

In a paper published by Dr. C. F. W. Muesebeck in the Annals of the Entomological Society of America, June, 1935, "On the Genus Oncophanes Foerster, With Descriptions of Two New Related Genera", he described this new genus and species.

Doctor Muesebeck, placed this new species that was previously in the genus *Epirhyssalus* into the new genus *Xenosternum*, and described the new species, which is also the type species of the genus *Xenosternum*. The species is named *Xenosternum ornigis*.

Natural Control

Cultural Control. When this insect is abundant, it seems that orchard cultural methods will also have to be employed during the winter so as to decrease the number of emerging insects the following spring. This can be accomplished during the fall or winter, by disking or cultivating to destroy the pupae in cocoons attached to the fallen leaf or the larvae within the leaf mine, which may be in the fallen leaves. The same results would be obtained by burning the leaves, a method which is often used in the control of other insects as well as plant diseases.

DISCUSSION AND CONCLUSIONS

The unspotted tentiform leaf miner may infest from 90 to 95 per cent of the leaves of the apple tree with from one to ten mines or even more per leaf. The limiting factor of the number of mines per leaf appears to be the size of the leaf and the size of the insect mine. One can readily see that in this way a large percentage of the foliage on the tree is rendered inactive. In addition to this injury caused by the feeding of the insect is another injury brought about directly by the presence of these insect mines. This injury is spray burn caused by the spray materials entering the punctures or insect mines in the leaf and killing the leaf tissue around the mine. This injury kills approximately two to three times the area of the leaf tissue that is removed by the feeding of the insect and is located around the edge of the mine.

This spray injury was attributed to spray material entering the insect mines in the leaf, since the apple leaves that were not sprayed and were infested with the insect used in this study, both in the insectary and in the field, did not have this burn. The leaf tissue around the edge of the insect mines or where the larvae had been feeding was green and alive, instead of being burned or dead as in the case of leaf tissue around the insect mines of leaves that had been sprayed. A burning caused by the entrance of spray material, also caused the tissue to die around the edge of mechanical injuries.

In years past, this insect has been considered as one of minor economic importance, due probably to the following facts:

1. No insect injury is caused directly to the fruit.
2. Inferior quality of fruit is caused indirectly by damage to the foliage.
3. This insect is heavily parasitized and after a serious outbreak occurs and becomes harmful, it is usually checked by its natural enemies within a few years.

More consideration should be given this insect as being one of the harmful orchard pests, especially since stomach poison sprays are of no comparative value for the control of this insect. They caused more injury to the foliage than did the insect. As no one phase of control is satisfactory in itself, the following combinations should be resorted to:

1. Cultural practices such as fall plowing and burning of leaves.
2. Summer spraying with nicotine sulphate-oil emulsion.
3. Encourage whenever possible, the establishment of the parasites of this pest.

SUMMARY

1. A leaf mining insect infesting trees in the Kansas State College Experiment Station orchard at Manhattan, has been determined as *Ornix prunivorella* Chamb.
2. This insect had not been reported from Kansas before November 6, 1933 at which time, Dr. Annette F. Braun of the University of Cincinnati, made the identification.
3. This insect overwinters in both the larval and pupal stages. The life cycle is completed in 4 to 5 weeks during the summer.
4. Stomach poison sprays are of no comparative value in the control of the larval stage of this moth.
5. The larvae of this insect eat the inner leaf tissue and in this way make the mines. Spray materials enter the leaf at the point of injured leaf tissue and in this way, cause an injury known as spray injury.
6. The use of a nicotine sulphate-oil emulsion spray produced a 90 per cent control of this pest.
7. There have been reared and identified, 9 different

parasites from <u>Ornix prunivorella</u> Chamb., one of which is a new species and genus, it being the type species for the new genus.

8. The apple(<u>Pyrus malus</u>) is the favorite host plant of this injurious insect.

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