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ORCHARD INJURY BY THE HICKORY TIGER-MOTH.

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CONTENTS.

INTRODUCTION.

The injurious stage of the hickory tiger-moth, *Halisidota caryae* Harris,[1] is a gregarious summer caterpillar (Pls. I, II) which, although a general feeder on deciduous trees and shrubs, causes occasional injury in orchards of pomaceous fruits and cultivated walnuts. While in this respect it is a minor pest, its injury, where it occurs, is severe and conspicuous and is the source of frequent inquiries to the Bureau of Entomology and to entomologists in the field. The writer's attention was frequently called to the work of this caterpillar while stationed at North East, Pa., during the seasons of 1914, 1915, and 1916, and there, incidental to the major projects then under investigation, the seasonal history and habits of this insect have been studied and the necessary remedial measures determined.[2]

HISTORY.

Injury by the hickory tiger-moth was first described by Harris in 1841 (1) in the earliest important work on economic entomology pub-

[1] Order Lepidoptera, family Arctiidae.

[2] The writer was assisted in 1915 by E. R. Selkregg and in 1916 by James K. Primm.

lished in America. Since then frequent reports of local outbreaks have been recorded in entomological literature. Complaints have been made to the Bureau of Entomology regularly since 1870, and specimens and records of injury have been received annually since 1904. Yet in spite of this constant occurrence there appear to be no records of very great destructiveness. The nearest approach to a general outbreak recorded occurred in 1907, when the bureau received numerous complaints from New England as well as scattered reports from other parts of the United States and from Canada. When Harris (1)[1] first described the adult, larva, and pupa as *Lophocampa caryae*, he gave in addition a brief account of the larval feeding and cocoon-making habits, and listed hickory, elm, and ash as food plants. Fitch (2) in 1855 gave a further account of larval habits and added butternut, sumach, and slippery elm to Harris's list of food plants; and during this same year the species was listed by Walker (3) and figured by Herrich-Schäffer (4). In 1882 it was listed by Grote (5). Few biological data were added until Beutenmüller (6) in 1890 listed 32 food plants of the hickory tiger-moth. The same year Dyar (7), in discussing head measurements of lepidopterous larvæ, recorded nine larva stages of *H. caryae*. Soule (8) in 1891 first described the egg and gave life-history records from egg to pupa, but recorded only seven larva stages. Packard (9) in 1893 also described the egg and larva stages and of the latter recorded only five. Eliot and Soule (11) in 1902 gave a popular account of the life history similar to the previous one by the junior author, and this later account is the most nearly complete record of its biology.

From 1905 to 1908, inclusive, the period when inquiries made to the Bureau of Entomology regarding this insect were most frequent, there were a number of brief references to it by economic entomologists in the northeastern United States. These references were brief and added little to the published records except to note its economic importance. Patch (12) mentions it as a late summer feeder, Felt (13 and 15) records it as of economic importance in New York, Sanderson (14 and 19) records it among apple insects of New Hampshire, Britton (16) refers to it as abundant in Connecticut, and Gibson (17) records an unusual outbreak for two years in several Canadian Provinces. Dr. L. O. Howard states that this species was unusually abundant in Greene County, N. Y., in September, 1917.

COMMON NAME.

This insect was called the hickory tussock moth by Harris (1), and until a comparatively recent time this name has been used. Comstock (10) called it the hickory tiger-moth. The latter name would

[1] Reference is made by number to "Literature cited," p. 13.

seem preferable, since the insect belongs to the family of tiger-moths (Arctiidae) and not to the family of tussock moths (Lymantriidae).

SYNONYMY.

Lophocampa caryae Harris, 1841.
Halesidota annulifacia Walker, 1855.
Phegoptera porphyrea Herrich-Schäffer, 1855.
Halisidota caryae (Harris) Grote, 1882.
Halisidota caryae (Harris) *Packard*, 1890.

DISTRIBUTION.

The hickory tiger-moth is distributed over the northeastern United States and the adjacent Canadian Provinces. According to records of the Bureau of Entomology and literature, its range extends from the Atlantic Ocean west to Missouri, Minnesota, and Saskatchewan, and from the Canadian Provinces bordering the United States south to North Carolina and southern Ohio. Records have been taken from the following States and Canadian Provinces: Maine, New Hampshire, Vermont, Massachusetts, Connecticut, New York, Pennsylvania, New Jersey, North Carolina, Ohio, Michigan, Illinois, Wisconsin, Missouri, Quebec, Ontario, Manitoba, and Saskatchewan. It is probably much more frequent in New England and the Middle States, however, since more than 75 per cent of the reports of destructiveness have come from this region.

DESCRIPTION OF STAGES.

EGG.

(Pl. II, fig. 4.)

The egg is nearly globular, flattened on the side of attachment, 0.75 mm. in diameter. The surface is glassy and in color it is a robin's-egg blue when first deposited. A brown ring appears on the upper surface about the second day, and in a few days the egg appears olive brown when viewed from above, although when viewed from the side it is greenish. In about two weeks, just before hatching, it becomes leaden blue. Infertile eggs do not change in color, but dry up in a few weeks. Eggs are deposited in a broad patch of 50 to 400 on the underside of the leaf. The writer has found one patch of 525 eggs.

LARVA.

(Pl. I, Pl. II, figs. 1, 2, 3.)

Full-grown larva.—Length, 32 to 38 mm. A striking grayish-white and black hairy caterpillar. It is covered with short spreading tufts of grayish white hairs, with a dorsal row of contiguous black tufts which appear like a velvety crest. These tufts occur on the first eight abdominal segments and a small one may be seen on the ninth. There also may be a pair of slender black pencils arising from the first abdominal segment, and another pair arising from the seventh. These pencils may be very long, may be inconspicuous, or absent altogether. The head and feet are black. The hair arising from the thoracic segments is longer than that of the rest of the body and when the

larva is at rest covers the head. The spreading side tufts give the larva a depressed appearance.

First instar (Pl. II, fig. 1).—Width of head, 0.46 to 0.50 mm; total length, 1.5 mm.; when full fed, 3 mm. The head is shining black and is much wider than the thorax of a newly hatched larva. The body is cylindrical, pale greenish white, and marked with black setiferous tubercles. Dorsally the tubercles appear as follows: On the first thoracic segment, a large dorsal plate and two very small tubercles on either side; second thoracic segment, one large compound tubercle on either side near the cephalic margin and a very small median tubercle near the caudal margin; third thoracic segment, 2 conspicuous tubercles on either side; first to eighth abdominal segments, 3 conspicuous tubercles on either side arranged in a triangle, two of them being near the cephalic and one near the caudal margin; ninth abdominal segment, 1 large compound tubercle on each side; tenth abdominal segment, 1 large plate covering most of the dorsal aspect of the segment. On all the thoracic segments and on third to ninth abdominal segments there are 3 small tubercles on each side; on abdominal segments 1 and 2 there are 4 on each side; and on abdominal segment 10 there is 1 one each side. All the lateral tubercles and lateral-dorsal tubercles bear 1 white seta. Black setæ are all dorsal, 4 arising from each thoracic segment, 1 from each of the 4 median abdominal tubercles, and 6 from the anal plate.

Second instar.—Width of head, 0.65 mm.; total length, 5 to 6 mm. when full fed. This instar differs chiefly from the preceding in the abundance of long whitish hairs which arise in considerable numbers from all the tubercles. The tubercles are larger and contrast strikingly with the color of the body.

Third instar.—Width of head from 1.12 to 1.16 mm.; total length, 10 mm. when full fed. More hairy than the preceding instar.

Fourth instar (Pl. II, fig. 2).—Width of head, 1.7 mm.; total length, 13 to 14 mm. The dorsal tubercles are nearly obscured by the hair arising from them.

Fifth instar.—Width of head, from 1.88 to 2.19 mm., average 2.1 mm.; total length, 18 to 19 mm. Tufts at sides of each body segment becoming conspicuous, and the black pencils may appear in this instar.

Sixth instar.—Width of head, from 2.91 to 3.09 mm., average 3.0 mm.; total length when full fed, 22 to 25 mm. The side tufts have become so conspicuous that they give the larva an almost flattened appearance. The black dorsal tufts are not yet touching and do not yet form a conspicuous crest.

Seventh instar (Pl. II, fig. 3).—Width of head, from 3.43 to 3.52 mm., average 3.46 mm.; total length, 27 to 32 mm. Practically the same as the preceding.

Eighth instar.—Width of head, from 4.10 to 4.30 mm., average 4.2 mm.; total length, 32 to 40 mm. This larva is very much like the preceding if it has yet to pass through another instar, or if this instar is the last it is like the mature larva previously described.

Ninth instar (Pl. I).—Width of head, from 4.7 to 4.9 mm., average 4.8 mm.; total length, 35 to 42 mm. This instar differs conspicuously from the immature forms because of the striking black crest.

COCOON.

(Pl. III, fig. 3.)

The cocoon is usually ellipsoidal, sometimes slightly flattened on one side, depending on the material which surrounds it. In length it averages 23 mm. and in width 15 mm. The larva mixes most of its gray hairs into the silk, making the cocoon very hairy. In color it is dirty gray.

PUPA.

(Pl. III, fig. 2.)

Length, 10 to 13 mm; width of thorax, 6 mm; width of abdomen, 7.5 mm. The abdomen is much stouter than the thorax and there is a slight constriction between them; the wingpads extend to the fifth abdominal segment; on the caudal end is a transverse row of spines recurved at the end. Color when newly transformed, yellowish, but soon becoming reddish brown; margins of segments and spiracles darker.

IMAGO.

(Pl. III, fig. 1.)

The following is Harris's original description of the moth (1):

* * * very light ochre-yellow in color; the fore-wings are long, rather narrow, and almost pointed, are thickly and finely sprinkled with little brown dots, and have two oblique brownish streaks passing backwards from the front edge, with three rows of white semitransparent spots parallel to the outer hind margin; the hind-wings are very thin, semitransparent, and without spots; and the shoulder covers are edged within with light brown. They expand from one inch and seven-eighths to two inches and a quarter or more. The wings are roofed when at rest, the antennæ are long, with a double narrow, feathery edging, in the males and a double row of short, slender teeth on the under-side, in the females; the feelers are longer than in the other Arctians, and not at all hairy; and the tongue is short but spirally curled.

FOOD PLANTS.

The hickory tiger-moth is usually recorded as a general feeder on the foliage of deciduous trees and shrubs. No less than 49 host plants from widely separated families have been listed by various observers. However, this wide range of food plants is confined to the nearly mature larva. The number of food plants upon which larvæ can develop from egg to pupa is much smaller and, as far as the writer has observed, is restricted to trees of the walnut and hickory family and to pomaceous fruits.

The writer has reared larvæ from egg to pupa on Japanese walnut, English walnut, black walnut, apple, and pear. In the field, colonies have been found frequently on all of the above and also on butternut, quince, and once on white hickory. In spite of its name walnut and not hickory seems to be its favorite food plant. An egg mass was found on a sour-cherry leaf, but a colony of larvæ were never found feeding on cherry in the field. Miss Soule (8) records finding an egg mass on a thorn leaf (*Crataegus* sp.).

The lots of larvæ which were fed on black walnut, Japanese walnut, English walnut, pear, and apple all reached the pupa stage and appeared normal. In the early larva instars the development was about the same. The later instars on Japanese walnut developed

somewhat faster than any of the others, and nearly all of them attained the ninth instar before pupation, although those hatching very late passed through only eight instars. Those reared on apple developed more slowly and passed through only eight stages, while the larvæ on pear passed through either eight or nine. The length of stages of larvæ feeding upon these plants will be given in detail in the discussion of seasonal history.

In confinement larvæ would feed on the foliage of many trees upon which they could not mature. Attempts to rear larvæ from hatching to pupation on sour cherry (Early Richmond variety), red oak, and slippery elm were unsuccessful. Those fed on oak and cherry passed through the early molts with regularity, but growth was slower than that of those reared on walnut and apple, and finally stopped altogether. A few larvæ that were started on oak and cherry at the beginning of the second stage reached the seventh, but were undersized and unhealthy in appearance. Elm was more distinctly unfavorable than either oak or cherry. Larvæ placed upon elm immediately after hatching failed to pass even the first molt, and those transferred from walnut as late as the fourth stage failed to pass the seventh.

Table I gives a list of the food plants recorded in entomological literature and in the records of the Bureau of Entomology with the authority for the previously published records. In this list nomenclature of the native species is according to Gray's Manual of Botany, seventh edition (1907), and the nomenclature for imported species is that of Bailey's Standard Cyclopedia of Horticulture.

TABLE I.—*A list of native and imported food plants of the hickory tiger-moth (Halisidota caryae).*

Acer saccharinum L. Silver maple. (Beutenmüller 1890.)
Acer pseudoplatanus L. Sycamore maple. (Beutenmüller 1890.)
Acer rubrum L. Red maple. (Beutenmüller 1890.)
Acer negundo L. Boxelder. (Beutenmüller 1890.)
Acer saccharum Marsh. Sugar maple. (Beutenmüller 1890.)
Aesculus glabra. Welld. Buckeye. (Beutenmüller 1890.)
Alnus rugosa (Du Roi). Alder. (Beutenmüller 1890.)
Betula a. var. *papyrifera* Marsh. Paper birch. (Beutenmüller 1890.)
Betula populifolia Marsh. Gray birch. (Beutenmüller 1890.)
Carpinus caroliniana Wall. Hornbeam. (Beutenmüller 1890.)
Carya sp. Hickory. (Harris 1841.)
Carya alba (L.) White hickory. (Beutenmüller 1890.)
Carya glabra (Mill.). (Beutenmüller 1890.)
Castanea dentata (Marsh). Chestnut. (Beutenmüller 1890.)
Celtis occidentalis L. Hackberry. (Beutenmüller 1890.)
Crataegus sp. Thorn. (Soule 1891.)
Cydonia oblonga Mill. Quince.[1]

[1] Confirmed by writer.

Fagus grandifolia Ehrh. Beech. (Beutenmüller 1890.)
Fraxinus sp. Ash. (Harris 1841.)
Hamamelis virginica L. Witch-hazel. (Beutenmüller 1890.)
Juglans cinerea L. Butternut.[1] (Fitch 1855.)
Juglans nigra L. Black walnut.[1] (Fitch 1855.)
Juglans regia L. English walnut.[1]
Juglans sieboldiana Maxim. Japanese walnut.[1]
Larix decidua Mill. Tamarack. (Fitch, according to Felt, 1905.)
Larix laricina (Du Roi). Larch. (Fitch, according to Felt, 1905.)
Ostrya virginiana (Mill.). Hop hornbeam.[1]
Prunus serotina Ehrh. Black cherry.[1] (Beutenmüller 1890.)
Prunus virginica L. Chokecherry. (Beutenmüller 1890.)
Prunus cerasus. Sour cherry. (Lintner 1891.)
Platanus occidentalis L. Sycamore. (Beutenmüller 1890.)
Platanus orientalis L. Sycamore. (Beutenmüller 1890.)
Pyrus communis L. Pear.[1] (Lintner 1891.)
Pyrus malus L. Apple.[1] (Beutenmüller 1890.)
Quercus alba L. White oak. (Beutenmüller 1890.)
Quercus palustris Muench. Pin oak. (Beutenmüller 1890.)
Quercus rubra L. Red oak. (Beutenmüller 1890.)
Rhus sp. Sumach. (Fitch 1855.)
Rosa sp.[1]
Rubus sp. Raspberry. (Eliot and Soule 1902.)
Tilia americana L. Basswood. Beutenmüller 1890.)
Tilia alba. White linden. (Beutenmüller 1890.)
Tilia europea. European linden. (Beutenmüller 1890.)
Salix sp. Willow. (Eliot and Soule 1902.)
Ulmus sp. Elm. (Harris 1841.)
Ulmus americana L. American elm. (Beutenmüller 1890.)
Ulmus campestris L. English elm. (Beutenmüller 1890.)
Ulmus fulva Michx. Slippery elm. (Fitch 1855.)

SEASONAL HISTORY.

EMERGENCE OF MOTHS.

There is one generation annually. The insect pupates in the fall, hibernates in the pupa stage, and the moths emerge in early summer. During the season of 1916 the earliest emergence from a lot of 36 cocoons was June 9 and the latest June 24, the majority emerging from June 12 to 15, inclusive. No adults were reared in either of the two previous seasons, but in 1914 larvæ were found in the field as early as June 18, indicating that moths must have emerged as early as June 1. In 1915 the larvæ appeared in the field about the same time as in 1916. The data relating to emergence of moths in 1916 are given in Table II.

[1] Confirmed by writer.

TABLE II.—*Time of emergence of adults of the hickory tiger-moth at North East, Pa., 1916.*

Date of emergence.	Total number of moths.	Number of males.	Number of females.	Date of emergence.	Total number of moths.	Number of males.	Number of females.
June 9	1	1	.....	June 16	1	.....	1
10	1	1	.....	19	1	.....	1
12	4	3	1	22	1	.....	1
13	8	7	1	24	1	.....	1
14	4	3	1				
15	3	2	1	Total	25	17	8

LENGTH OF EGG STAGE.

The length of the egg stage, based on records from 4 egg masses deposited in 1916, was 15 to 16 days. Two masses of eggs deposited June 15 hatched July 1; one mass deposited the same day hatched July 2; the fourth mass, deposited June 16, hatched July 3.

DURATION OF LARVAL FEEDING PERIOD.

The duration of the larval feeding period varies greatly. Miss Soule (8) records rearing one colony from egg to cocoon in 47 days, which passed through only 7 instars. During the season of 1915 larvæ reared by the writer on Japanese walnut required from 62 to 85 days from egg to cocoon, averaging 74.73 days. (See Table III.)

TABLE III.—*Duration of the larval feeding period, North East, Pa., 1915.*

Number of individuals.	Duration of larval feeding period.	Number of individuals.	Duration of larval feeding period.	Number of individuals.	Duration of larval feeding period.
	Days.		*Days.*		*Days.*
1	62	1	72	2	79
1	64	2	74	2	80
1	66	1	75	1	82
1	68	2	76	1	85
1	70	1	77		
1	71	3	78	22	[1] 74.73

[1] Average.

During the season of 1916 larvæ reared on the same food plant required 80 to 100 days, averaging 89.04 days. (See Table IV.)

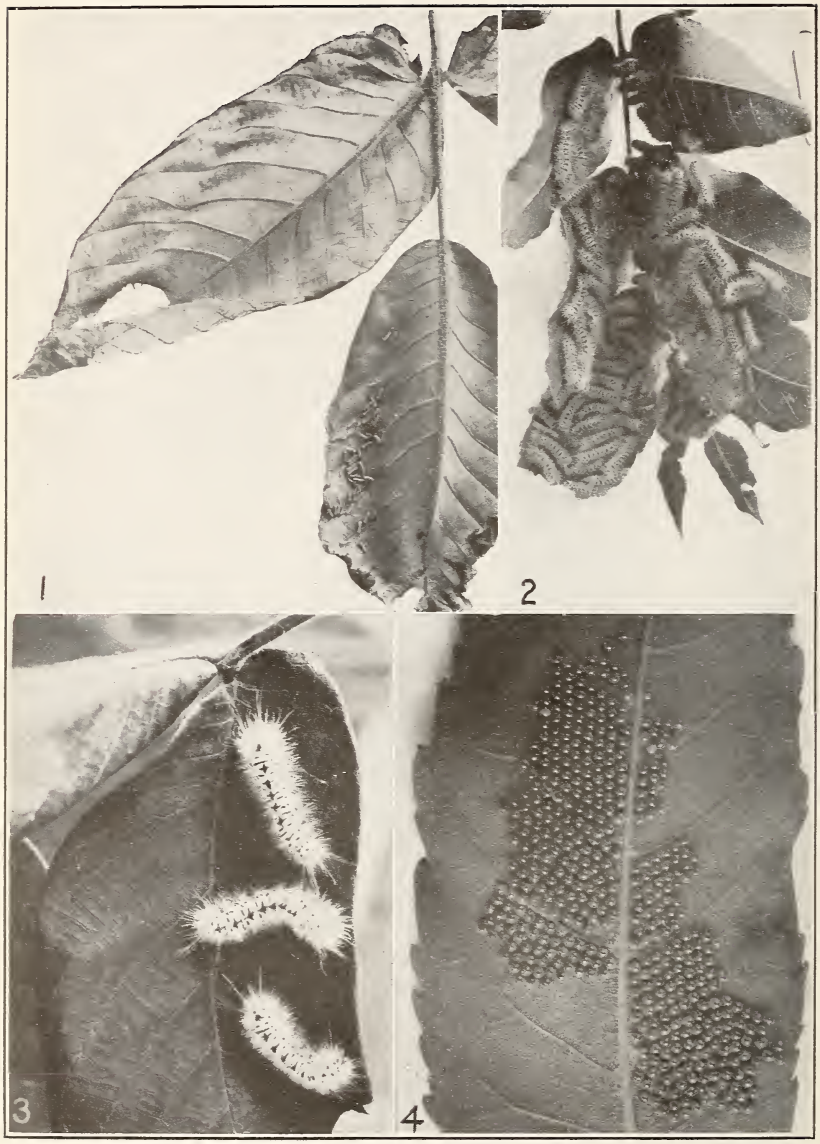
TABLE IV.—*Duration of the larval feeding period, North East, Pa., 1916.*

Number of larvæ.	Duration of larval feeding period.	Number of larvæ.	Duration of larval feeding period.	Number of larvæ.	Duration of larval feeding period.
	Days.		*Days.*		*Days.*
3	80	15	88	2	94
2	82	31	89	2	95
4	83	26	90	1	96
9	84	4	91	1	100
6	85	6	92		
21	86	8	93	145	[1] 89.04
4	87				

[1] Average.

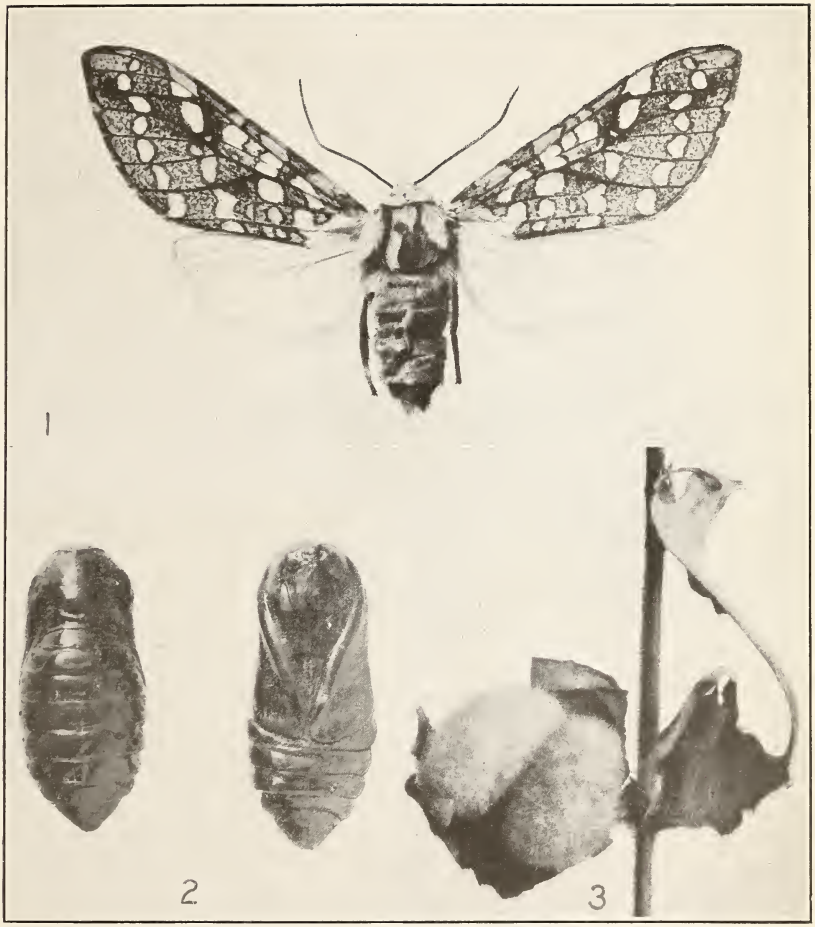
THE HICKORY TIGER-MOTH.

Larvæ on apple leaves, ninth instar. (Original.)



STAGES OF THE HICKORY TIGER-MOTH.

FIG. 1.—Larvæ, first instar. FIG. 2.—Fourth instar. FIG. 3.—Seventh instar. FIG. 4.—Eggs. (Original.)



THE HICKORY TIGER-MOTH AND STAGES.

FIG. 1.—Adult. FIG. 2.—Pupæ. FIG. 3.—Cocoons. (Original.)

The larvæ reared in 1915 passed through only 8 instars, but the majority of those reared in 1916 passed through 9 instars. This could not have affected greatly the time required for development, however, as the few larvæ which passed through only 8 stages in 1916 required an average of 88.71 days. In 1915 the larvæ were reared under natural conditions in bags on a tree, whereas in 1916 all lots but one were reared in battery jars. The one lot of 22 larvæ reared on the tree in 1916 required from 85 to 92 days from egg to cocoon, with an average of 87.18 days, very nearly the same as that of those reared in confinement.

No explanation is offered for the difference in time required for development of larvæ in the two seasons, but it should be stated that the season of 1915 was excessively rainy, whereas the 1916 season was excessively dry. It is probable that humidity affected the rate of development either directly or by its effect upon the food plant.

The duration of the larval feeding period varies somewhat when different food plants are used. The development of those reared on apple was similar to that on walnut, but a little slower, and the larvæ passed through only 8 stages. The shortest period required for development from egg to cocoon was 89 days and the longest was 96 days, with an average of 92.87 days.

Pear seemed a slightly more favorable food plant than apple. The development of the larvæ was more rapid, and although the majority passed through only 8 stages a few passed through 9 stages. Eighteen larvæ which passed through 8 stages required from 87 to 91 days, with an average of 88.77 days; 5 larvæ which passed through 9 stages required from 98 to 100 days, averaging 98.40 days.

The duration of the stages of larvæ reared on Japanese walnut during the season of 1916 was as follows:

First stage: Minimum 6 days, maximum 7 days, average 6.12 days; 232 larvæ reared.

Second stage: Minimum 4 days, maximum 7 days, average 4.78 days; 232 larvæ reared.

Third stage: Minimum 5 days, maximum 7 days, average 5.62 days; 232 larvæ reared.

Fourth stage: Minimum 6 days, maximum 7 days, average 6.02 days; 232 larvæ reared.

Fifth stage: Minimum 6 days, maximum 8 days, average 6.25 days; 232 larvæ reared.

Sixth stage: Minimum 6 days, maximum 13 days, average 8.52 days; 145 larvæ reared.

Seventh stage: Minimum 8 days, maximum 20 days, average 12.33 days; 145 larvæ reared.

Eighth stage (excluding larvæ that completed their feeding period in this stage): Minimum 13 days, maximum 25 days, average 18.03 days; 138 larvæ reared.

Eighth feeding stage (including only larvæ that spun cocoons at end of this instar): Minimum 19 days, maximum 29 days, average 23.29 days; 7 larvæ reared.

Ninth feeding stage (until spinning of cocoons): Minimum 13 days, maximum 26 days, average 20.95 days; 138 larvæ reared.

The period covered by the rearing records in 1915 began when the larvæ under observation hatched, on July 17, and continued until time of spinning cocoons, which extended from September 17 to October 10. In 1916 the earliest larvæ hatched June 30, and the first cocoon under observation was spun September 24 and the latest October 10.

DURATION OF PREPUPA PERIOD.

The larva period in the cocoon at North East, Pa., in 1916 averaged between 7 and 8 days. Of 19 larvæ which spun cocoons on September 24, 25, and 26, 10 pupated in 7 days and 9 in 8 days.

HABITS.

THE LARVA.

Larvæ from the same egg mass hatch almost simultaneously and upon hatching eat the greater part of the eggshells. They are gregarious in the early stages, and even in the later stages molt together. During the first four stages they feed gregariously, beginning to scatter in the latter part of the fourth. If during the first three stages a larva is separated from its fellows and is placed on a separate leaf or shoot, it will invariably find its way back to the others within a few hours. When one leaf or shoot is stripped the larvæ move in mass to another, often to another part of the tree.

After the fifth stage the larvæ scatter more or less and are solitary except about molting time. Often they migrate to trees quite a distance from the one on which the colony started. After the last molt the larvæ scatter widely.

The molting of the majority of larvæ from a given egg mass is almost simultaneous, and at this time the gregarious habit is most pronounced. Even after larvæ have scattered over a tree they come together to molt. A short time before molting a silken mat is spun upon which the larvæ rest for about a day before the early molts and sometimes for several days before later ones. This molting mat is spun upon a leaf or bunch of leaves, and sometimes before the later molts on the side of a branch or tree trunk. At each molting period there are often a few larvæ which fall behind and fail to molt with the rest. These invariably develop very slowly and usually do not mature.

Feeding injury is seldom conspicuous and usually unnoticed until the third or fourth instar is reached when the larvæ become very voracious. Larvæ in the first stage are surface feeders. Those on walnut and pear feed on the underside, eating nearly to the upper epidermis. Those on apple and quince feed on the surface. On these food plants the larvæ eat the leaf tissue as they go, while larvæ on cherry and oak leave patches of surface uneaten and also may feed on either upper or lower surface of the leaf. Larvæ in the second stage feeding on walnut and in the third stage on pomaceous fruits feed at the edge of the leaf, eating everything except the thicker leaf veins.

The cocoon is spun among leaves or in protected situations on the ground. If the infested trees are in the neighborhood of buildings cocoons may be found under boards, behind doors, or in similar situations.

THE PUPA.

The pupa hibernates on the ground. Moisture is probably necessary for successful hibernation, for from 36 cocoons wintered out of doors in a screen basket 25 moths emerged, whereas from 21 cocoons wintered in the insectary in a battery jar and protected from snow and rain, but exposed to the same temperature conditions, none emerged.

THE MOTH.

In emerging the moth usually breaks the pupal skin and then forces its way out of the end of the cocoon. If the cocoon is very loosely constructed the pupa may break out of it before eclosion, but this is not usual.

Copulation has been noted as early as the day of emergence and oviposition as early as 3 days thereafter. One moth continued ovipositing for 2 days, day and night, apparently without interruption, adding eggs to the same egg mass. Oviposition is performed deliberately. The moth's wings are folded back at rest at this time.

Moths oviposit readily in cages without being fed. They seem to prefer to oviposit on Japanese walnut leaves but will place eggs on cheesecloth or on the sides of the cage. The moths are very sluggish and can be handled easily in cages.

PARASITES.

This insect is remarkably free from parasitic enemies. None has been reared by the writer, and as far as he is aware only one species, *Pimpla pedalis* Cress (18), has been recorded.

ECONOMIC IMPORTANCE.

Injury by this insect is intensive and not extensive. It is due to the gregarious larvæ of the early stages which strip branches and sometimes small trees of their foliage. The injury to young trees in particular may be severe. After the gregarious habit is lost the larvæ scatter so widely that the injury done by them is inconspicuous.

Infestation by this insect so far as the writer has observed is not general even within an orchard. Several colonies of larvæ may be on one tree, but the writer has never seen a large tree completely stripped. Usually damage occurs in young orchards on which the codling-moth sprays have not been applied. The increasing importance of the cultivated walnut trees in the northeastern United States probably will cause this pest to become correspondingly more important.

CONTROL.

Spraying with arsenicals is the usual recommendation for the control of this pest. In orchards which have been thoroughly sprayed for the codling moth the writer has never noted an infestation. Nevertheless, the caterpillar soon becomes very hard to poison, and very large amounts are required to kill it in the later stages.

If control measures are not adopted until the larvæ are in evidence, they probably will not be applied until some of the larvæ are in the third or fourth instar. Spraying at this time is likely to produce discouraging results. Two trees infested with colonies of fourth-stage larvæ were sprayed with arsenate of lead July 31, 1915; on one the poison was applied at the rate of 3 pounds (paste) to 50 gallons and on the other 5 pounds (paste) to 50 gallons. None of the larvæ died until two days later on the tree sprayed with the larger amount of poison, and not until three days later on the tree sprayed with the smaller amount. On the tree sprayed with the smaller amount about 10 per cent of the larvæ survived. It was evident that unless they fed on poisoned leaves continuously for some time they were not affected at all. Unless the larvæ are confined on a sprayed tree they are very likely to migrate to another before eating enough to kill them.

In the gregarious stages colonies of these larvæ are easily collected and destroyed. When the infestation is scattered throughout an orchard this method is much the cheapest that can be employed and is entirely effective.

On young orchards which would not receive the spring spray applications for the codling moth, an application about the last of June of arsenate of lead (paste), 3 pounds to 50 gallons of liquid, would be of value in preventing injury by this pest.

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