
New York Agricultural Experiment Station.

GENEVA, N. Y.

MISCELLANEOUS NOTES ON INJURIOUS INSECTS II.

- I. THE PERIODICAL CICADA.
- II. THE PALMER WORM.
- III. WHITE GRUBS ATTACKING ASTER PLANTS.
- IV. PAPILIO ASTERIAS ATTACKING CELERY.

V. H. LOWE.



PUBLISHED BY THE STATION

T

BOARD OF CONTROL.

GOVERNOR BENJAMIN B. ODELL, JR., Albany.
STEPHEN H. HAMMOND, Geneva.
FREDERICK C. SCHRAUB, Lowville.
NICHOLAS HALLOCK, Queens.
LYMAN P. HAVILAND, Camden.
EDGAR G. DUSENBURY, Portville.
OSCAR H. HALE, North Stockholm.
MARTIN L. ALLEN, Fayette.
JENS JENSEN, Binghamton.
THOMAS B. WILSON, Halls Corners.

OFFICERS OF THE BOARD.

STEPHEN H. HAMMOND, WILLIAM O'HANLON,
President. Secretary and Treasurer.

EXECUTIVE COMMITTEE.

STEPHEN H. HAMMOND, LYMAN P. HAVILAND,
FREDERICK C. SCHRAUB, NICHOLAS HALLOCK,
THOMAS B. WILSON.

STATION STAFF.

WHITMAN H. JORDAN, Sc. D., *Director.*

GEORGE W. CHURCHILL, <i>Agriculturist and Superintendent of Labor.</i>	LORE A. ROGERS, B.S., <i>Assistant Bacteriologist.</i>
WILLIAM P. WHEELER, <i>First Assistant (Animal Industry).</i>	GEORGE A. SMITH, <i>Dairy Expert.</i>
FRED C. STEWART, M.S., <i>Botanist.</i>	FRANK H. HALL, B.S., <i>Editor and Librarian.</i>
HARRY J. EUSTACE, B.S., <i>Student Assistant in Botany.</i>	VICTOR H. LOWE, M.S., † F. ATWOOD SIRRINE, M.S., <i>Entomologists.</i>
LUCIUS L. VANSLYKE, Ph.D., <i>Chemist.</i>	PERCIVAL J. PARROTT, A.M., <i>Assistant Entomologist.</i>
CHRISTIAN G. JENTER, Ph.C.,	SPENCER A. BEACH, M.S., <i>Horticulturist.</i>
* WILLIAM H. ANDREWS, B.S.,	NATHANIEL O. BOOTH, B.AGR., <i>Assistant Horticulturist.</i>
¶ J. ARTHUR LECLERC, B.S.,	ORRIN M. TAYLOR, <i>Foreman in Horticulture.</i>
FREDERICK D. FULLER, B.S.,	FRANK E. NEWTON,
EDWIN B. HART, B.S.,	JENNIE TERWILLIGER, <i>Clerks and Stenographers.</i>
CHARLES W. MUDGE, B.S.,	ADIN H. HORTON, <i>Computer.</i>
ANDREW J. PATTEN, B.S., <i>Assistant Chemists.</i>	
HARRY A. HARDING, M.S., <i>Dairy Bacteriologist.</i>	

Address all correspondence, not to individual members of the staff, but to the NEW YORK AGRICULTURAL EXPERIMENT STATION, GENEVA, N. Y.
The Bulletins published by the Station will be sent free to any farmer applying for them.

* Connected with Fertilizer Control.

† At Second Judicial Department Branch Office, Riverhead, N. Y.

¶ Absent on leave.



LARVA OF *Papilio asterias* ON CELERY STALK.

MISCELLANEOUS NOTES ON INJURIOUS
INSECTS. II.

V. H. LOWE.

SUMMARY.

A brood of the periodical cicada is due to appear this spring. It is located in Niagara, Monroe, Kings, and Richmond counties in this State, and in 18 of the central, southern and eastern states and the District of Columbia. It is probably the largest of the 17-year broods. The adult females injure trees, shrubs and vines by puncturing the twigs and small branches in order to deposit eggs in the wood. The injury is not usually serious except when the insects occur in very large numbers. There seems to be no practical method of destroying the adults when occurring in sufficient numbers to do serious injury.

The palmer worm was very abundant in some of the apple orchards in Western New York during the spring of 1900. It has practically disappeared and is now found only occasionally. The insect has been noted as a species that appears suddenly in large numbers and disappears as quickly as it came, not to appear again for several years.

White grubs were found very destructive to aster plants grown in the field. The same field was in nursery trees the season before and while the grubs had not

injured the trees sufficiently to be noticed, they were there in sufficient numbers to cause serious injury to the asters. The only practical remedy found was to pull up the infested plants and destroy the grubs.

The celery caterpillar, *Papilio asterias*, is found in varying numbers every year. During the past two years it has been unusually abundant in Western New York causing injury, especially to celery in the seed bed. It is easily checked by spraying with paris green, where practical, or jarring the caterpillars to the ground and destroying them.

INTRODUCTION.

This bulletin is the second of a series dealing with miscellaneous notes on injurious insects, of which Bulletin No. 180 is the first. These notes aim to deal principally either with subjects that are considered of too little importance at the time to be the objects of extended investigation, but are of too much interest to be laid aside; or with topics upon which immediate information is desired. In some cases they may be preliminary to a more exhaustive discussion to appear in a later publication.

While, in the main, the notes are intended to be the result of our own observations, the demand for immediate information concerning species that have been but little studied here at the Station sometimes makes desirable a collection of data from other publications. In such cases the literature of the subject is drawn upon freely.

I. THE PERIODICAL CICADA.

Much interest is again being manifested in the periodical cicada or, as it is more often called, the seventeen-year locust, because of the expected appearance above ground during the spring of 1902 of one of the largest broods known in the United States. Considerable anxiety, especially on the part of fruit-growers, is also apparent as to the probability of injury to young trees and vines. As a result there is much demand within the State for information concerning this species. It may be added, however, that the peculiar interest with which this insect is viewed lies not alone in the fact that many are apprehensive of injury to their crops, nor even in its interesting habits above ground ; but one naturally considers it no small privilege to look upon a living, active creature that has just emerged from a comfortable sojourn of seventeen years under the sod.

The interesting habits of the cicadas, their appearance in great swarms, and the noisy way in which they proclaim their presence, early attracted attention. The species is a native of America, and probably the first known record of its appearance is found in Moreton's New England Memorial in which it is stated that a swarm appeared in Plymouth in the spring of 1633¹.

The periodical cicada was originally described by Linné, who gave it the scientific name *Cicada septendecim*, publishing the description² in 1758. It has been suggested³ that the popular but incorrect name "seventeen-year locust" probably originated with the early settlers who associated the swarms of cicadas with the devastating hordes of migratory locusts.

The unusual interest attached to this species has also resulted in its being made the subject of investigation from the time of the earliest entomologists until the present day. The difficulty of following a number of individuals through their long life underground, however, prevented a thorough knowledge of the insect's subterranean life until the comparatively recent investigations of the

¹Harris. Insects Injurious to Vegetation. Second Edition, p. 180.

²*Systema Naturae* (tenth edition).

³Hopkins, A. D. W. Va. Agr. Exp. Sta. Bul. 50, p. 5.

late Dr. C. V. Riley and those of C. L. Marlatt which resulted in throwing much light on its entire life history.⁴

LIFE HISTORY.

The life history of the periodical cicada does not differ materially from that of many other species of insects except for the long life under the ground. There are many others that are known to live nearly a year in the soil, and a few, such as the common white grub, the larva of the May beetle, are about three years in the ground before emerging; but no other insect known can equal the periodical cicada for longevity.

The egg.—The eggs are laid in the twigs and smaller branches of deciduous trees. They are placed well into the wood in double rows as described on a subsequent page. The egg is at first pearly white in color, but, as the shell is very thin and semi-transparent, turns darker, probably because of the color of the growing embryo. According to Marlatt⁵ Dr. Potter has stated that this change of color is noted at 15 days and after. In shape they are oblong, slightly curved and measure about 2 mm. ($\frac{1}{16}$ in.) in length (Plate I, Fig. 3). They increase in size somewhat, probably by the absorption of the juices of the surrounding plant tissue. The period of incubation varies, depending apparently upon weather conditions. The usual period is probably from six to seven weeks.⁶

The larva.—When the larva is fully matured within the egg and ready to emerge, the egg shell gives way in a line along its back permitting it to escape. The newly hatched larva is an awkward, somewhat spider-like creature measuring about 1.5 mm. ($\frac{1}{16}$ in.) in length. The body is slender and sparsely covered with minute hairs. The head, legs and antennæ are long in proportion. In color it is creamy-white, marked only by deep-red eye-spots and reddish claws. The most striking peculiarity of the insect, both in the larval and pupal stages, is the prominent lobsterlike front legs with which it digs its way into the ground. When the larva has gained its freedom it begins to move about actively but

⁴U. S. Dept. Agr., Div. of Ent., Bul. 14, n. s.

⁵Idem., p. 81.

⁶Marlatt. Idem., p. 80.

soon loosens its hold and drops to the ground. Owing to the lightness of its body it is not injured by the fall. After reaching the ground the first impulse of the young larva seems to be to get beneath the surface, for it soon seeks some opening by which to enter.⁷

One of the first to investigate successfully the life and habits of the larva was Dr. Riley who undertook to follow the life of the insect through until it emerged. His investigations were begun in Missouri in 1881 but were finally turned over to a Mr. Barlow who continued them until 1891. During these ten years the larvæ under observation had passed four stages and were ready to enter the first pupal stage. These and subsequent observations by Marlatt showed that the larvæ pass the first molt during the first year or year and a half, the second after an additional period of two years, the third after three or four years more and the fourth three or four years later.

During its life underground the larva grows to over nine times its length at the time of hatching. Its body becomes quite robust and somewhat wedge-shaped. The hairs scattered over the body become more numerous and coarser, while the front legs develop into formidable digging appendages.

Marlatt and others⁸ have found that while the larva undoubtedly remains in one place most of the time, it may move about to some extent. It lives within a cell of compact earth, which is usually formed so that one or two fine roots of the food plant run through the walls in easy access of the insect's beak. It may thus obtain nourishment by thrusting its beak into the tissue and sucking the sap.

The pupa.—The pupa resembles the larva in its advanced stage but the red eye-spots are wanting and the true eyes show more prominently. The rudimentary wings have also become quite prominent, while the front legs are much developed and are well fitted for digging. The habits of the pupa while it remains underground are practically the same as those of the larva. It passes two molts.

Location in the soil.—There has been much difference of opinion

⁷ Marlatt. U. S. Dept. Agr., Div. Ent., Bul. 14, n. s., p. 81.

⁸ Idem., pp. 91 and 93.

as to the depth in the soil to which the larvæ and pupæ are capable of going. Observations have shown that the usual depth is from one to one and a half feet. One instance has been recorded,⁹ however, where the pupæ came up in the bottom of a cellar. In another case they came up through a mass of cinders five feet thick. Other cases have been reported where they were found ten feet or more below the surface of the ground. Another instance was observed by the writer where the pupæ had evidently remained for some time at a much shallower depth. In this case they appeared in an old orchard. A large number of examinations showed that the average distance of the pupæ beneath the surface of the soil was about eight inches. A feature of considerable interest in connection with the life of the insect under ground is its ability to live in soil that has been under water for some time. At least two instances of this kind have been recorded. In one case the ground was annually flooded for several years, apparently without injuring the cicadas which were found from 12 to 18 inches below the surface.¹⁰

Habits of the pupæ above ground.—When ready to abandon the subterranean life the pupæ dig upward toward the surface of the ground. They always emerge in the spring, usually, in this climate, about the middle of May although the time probably varies somewhat with the season. The individuals in a given locality usually come out of the ground at about the same time, not more than three or four days elapsing between the appearance of the first and last individuals. Most of them come out during the night but occasionally stragglers appear during the early morning hours.

The pupa when it first appears above ground is soft bodied and creamy white in color. It may move about actively for a short time, probably a few hours, although often less, in search of a suitable support which it can climb and cling securely to. The skin hardens rapidly and after the insect has found a suitable place and is prepared for the change, splits down the back and the adult escapes, leaving behind the empty pupa skin, Plate I, Fig. 1. It is not uncommon to find these old pupa cases

⁹ Marlatt. U. S. Dept. Agr., Div. Ent., Bul. 14 n. s., p. 92.

¹⁰ Idem., p. 93.

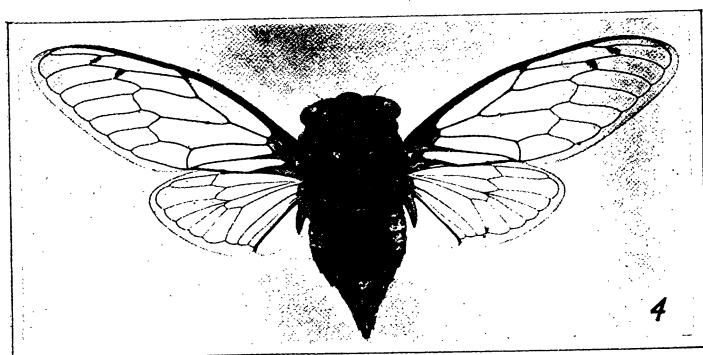
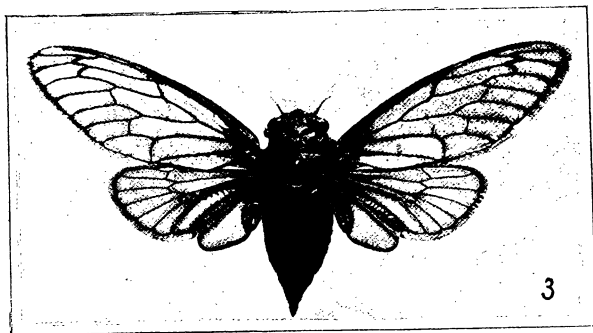


PLATE I.—PERIODICAL CICADAS AND PUPA CASES, DOG-DAY CICADA, AND LARVA OF *Papilio asterias*.

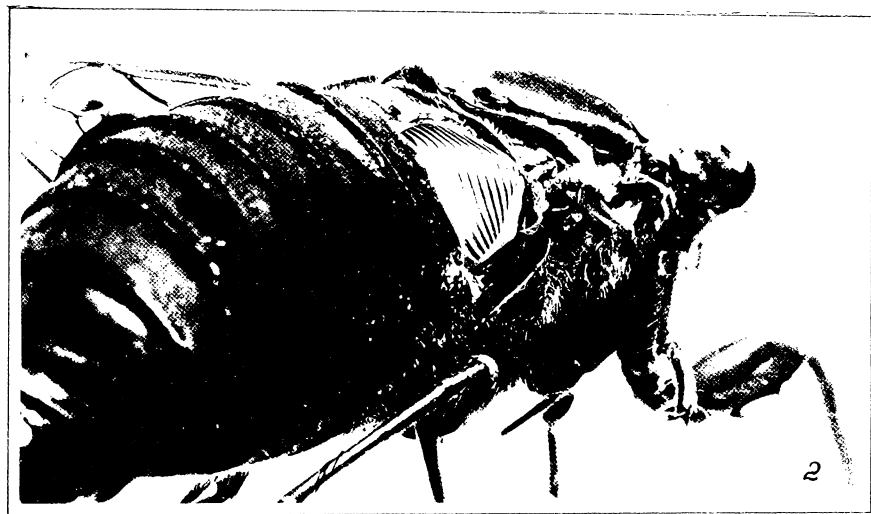
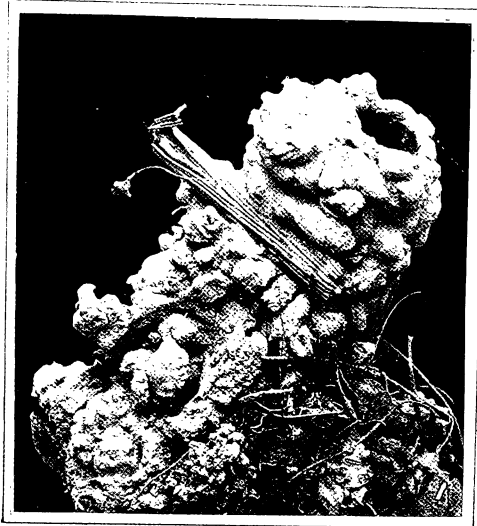
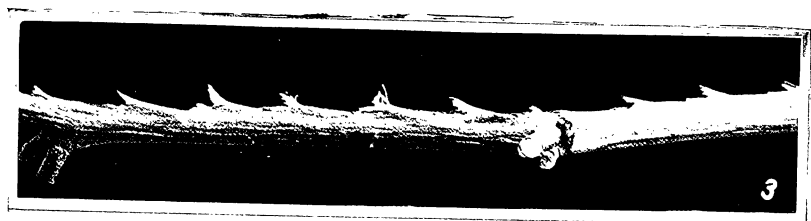


PLATE II.—SOME CHARACTERISTIC DETAILS OF PERIODICAL CICADA AND ITS WORK.



PLATE III.—ADULT PERIODICAL CICADAS.



PLATE IV.—FEMALE CICADA DEPOSITING EGGS.

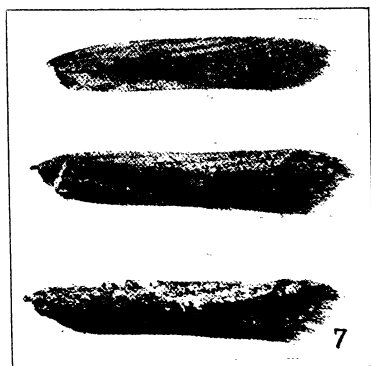
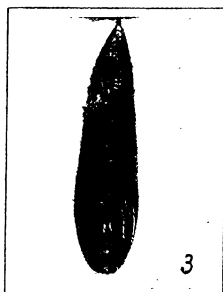
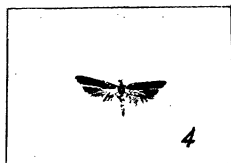
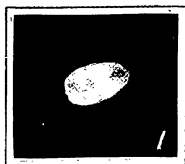


PLATE V.—SOME CHARACTERISTIC DETAILS OF THE PALMER WORM AND ITS WORK.



PLATE VI.—WORK OF PALMER WORM ON APPLES.



PLATE VII.—PALMER WORM IN PARTIALLY COMPLETED RETREAT.



PLATE VIII.—WHITE GRUBS FEEDING AT ROOT OF AN ASTER.

EXPLANATION OF PLATES.

PLATE I.—1, *Pupa-case of periodical cicada*; 2, *Cases from which adults failed to escape*; 3, *Adult periodical cicada*; 4, *Adult dog-day cicada*; 5, *Larva of Papilio asterias on celery*.

PLATE II.—1, *Hut or chimney of cicada*; 2, *Sound producing organ of male cicada*; 3 and 4, *Injury caused by egg-laying of cicada*.

(Figs. 2 and 4, enlarged.)

PLATE III.—*Adult periodical cicadas*.

PLATE IV.—*Female cicada depositing eggs*.

PLATE V.—*Palmer worm*: 1, *Egg*; 2, *Injury to young apples*; 3, *Pupa*; 4, *Moth*; 5, *Injured leaf, with attached pupæ*; 6, *Typical wing*; 7, *Wing variations*.

(Figs. 1, 3, 6 and 7, enlarged; 2, 4 and 5, natural size.)

PLATE VI.—*Work of palmer worm on apples*.

(Enlarged.)

PLATE VII.—*Palmer worm in partially completed retreat*.

(Enlarged.)

PLATE VIII.—*White grubs feeding at root of an aster*.

attached to the leaves or twigs several weeks after the adults have escaped. Some idea of the manner in which the adult escapes from the pupa skin is given by Fig. 2, where two adults are seen which only partially succeeded in freeing themselves. The upper one succeeded in freeing its head, thorax and both wings while the lower has but its head and thorax free.

Height to which the pupæ climb.—The pupæ usually do not climb far. The old skins from which the adults escaped will usually be found from a few inches to from five to ten feet above the ground. A comparatively small number may succeed in going much higher. In one instance the writer found the pupa cases nearly thirty feet above the ground attached to the limb of a tree and in a few cases several were found at about twenty feet.

Building huts.—Under some circumstances not yet well understood the pupæ build chimney-like huts on the surface of the ground just before abandoning the subterranean life. These huts may open at the top or be closed at the top and open at the sides. The hut is in reality a continuation above ground of the channel in the earth made by the pupa. Plate II, Fig. 1 shows a hut, natural size, that opens at the top. In some cases large numbers will be built and in others but very few. They are built on both high and low ground, as instances are recorded where they have been found in both localities. That a preference may sometimes be shown is not improbable. A case in point was observed by the writer at Union Springs during the spring of 1899 when the cicadas appeared in large numbers in that locality. The pupæ emerged in greatest numbers in a grove which was on both high ground and low swampy land. Although careful search was made the huts could be found only on the low wet land although as many or more cicadas had emerged from the higher ground.

The adult.—When it first emerges from the pupal skin the adult insect is soft bodied and creamy-white in color. But the integument soon hardens and as it does so turns jet black. The eyes and wing veins are coral red. The body of the female measures about one inch in length. The wings, which are membranous, form a roof over the body when at rest, projecting beyond it about half an inch. When expanded they measure about three inches from tip to tip. Plate III, which is from a photograph from life,

shows a number of cicadas natural size. At Fig. 3, Plate I, an adult female with wings spread is shown.

The adult cicadas are active, noisy creatures, flying about during the day and making the woods ring with their shrill song. Their flight is very short and hence, as they do not migrate in the immature stages, the species spreads very slowly.

Song of the periodical cicada.—The so-called song of the periodical cicada is produced by the males only. Each male has two song-producing instruments, one on either side of the basal segment of the abdomen, underneath and concealed by the wings. They are quite complex but each consists principally of a corrugated ear-like drum which, controlled by a powerful muscle, may be made to vibrate rapidly. Plate II, Fig. 2 is from a photograph showing one of the drums greatly enlarged. The song is usually produced in unison and is shrillest during the heat of the day. The warmer the sun the louder the song becomes. The locusts seem to be especially sensitive to sunlight and heat, as was well illustrated in the writer's experience at Union Springs, June 14, 1899. The day was windy with heavy fleecy clouds which frequently obscured the sun. While the sun was shining brightly, along the margin of the wood where the locusts were most numerous, they were very active, flying frequently into the air and making an almost deafening noise. As soon, however, as the sun was obscured by a cloud there was a decided lessening of activities and a lull in the song, which would almost cease if the sun was hidden very long. It is unusual for the cicadas to sing during the night, but instances have been recorded where the song has suddenly broken out long before daylight but to last for a few minutes only. The song has been analyzed by Dr. C. V. Riley and others and found to consist of three distinct notes.

Injury caused by the periodical cicada.—Contrary to the belief held by many, the adult cicadas eat little or nothing. If any nourishment is taken it is by the female only and it is doubtful if she, except in very rare instances, takes food. As previously stated the larvæ and pupæ feed underground on the sap from the roots of trees, shrubs and vines, but so little is required for their slow growth, that except in occasional instances where they

are unusually abundant, it is not probable that appreciable injury is done. The important injury is caused by the females in laying their eggs in the twigs. Frequently the twigs and smaller limbs are so weakened by the punctures of the female as to break off with the slightest wind. Large trees may withstand this injury without serious consequences, but small trees of a few years' growth are often seriously injured.

The extent to which young trees may be injured was well illustrated along the western shore of Seneca Lake during the spring of 1899. In one orchard in the vicinity of Earls, several young plum and cherry trees were badly broken as a result of the punctures of the females. Another case near Dresden was that of a small vineyard in which the cicadas appeared in large numbers. When seen by the writer, June 9, nearly all of the vines were badly broken and in most cases the new growth wilted. An examination showed that the cicadas had selected the growth of the previous year in which to deposit their eggs, thus causing the new growth to wilt and finally die. As a result of the attack this vineyard produced very little fruit that year. Old wounds caused by deposition of the eggs afford lodgment for other insects, especially the woolly aphis, thus resulting in a secondary injury which may be of a serious nature.

How the eggs are deposited.—The eggs are deposited in the twigs of both fruit and forest trees and of vines. In fact all kinds of trees are attacked except evergreens. At Plate IV, which is from a snap shot from life, a female is shown natural size in the act of depositing her eggs in the branch of a young apple tree. She is enabled to place her eggs within the twig by means of her sharp ovipositor. This is a very strong instrument of a tough horny substance. It is spear shaped and consists of three pieces, the support or back piece and two lateral blades which slide up and down upon it and which have saw-like teeth on the edges. When ready to deposit eggs the female slowly forces her ovipositor into the twig, splintering the wood and placing the eggs at a slight angle close together and in double rows. The two converging double rows are deposited at one time. It has been estimated that a single female will lay from 300 to 600 eggs. The external evidence that eggs have been deposited is made very plain by the

bits of splintered wood that project above the surface of the bark as shown at Plate II, Fig. 3. Fig. 4 is from a photomicrograph showing the twig much enlarged, cut open lengthwise exposing part of one row of eggs. The period of incubation usually varies from about six to seven weeks.

SUMMARY OF LIFE HISTORY.

The periodical cicada lives in the ground during most of its life. The seventeenth year in the north and the thirteenth year in the south pupæ appear above ground. The winged adults escape in a few hours. Their life is short, probably varying from about two to three weeks. Eggs are laid in the twigs of deciduous trees, shrubs and vines. They hatch in six or seven weeks. The young drop to the ground and work their way into the soil. They feed upon the sap from the roots, which they secure by inserting their beaks into the bark. They probably move but little, but live in a cell of earth just large enough to accommodate their bodies. The larval and nearly all the pupal life is passed in the ground. Slight injury may be caused by sucking the sap from the roots, but the principal injury results from depositing the eggs in the twigs.

BROODS.

Two distinct races.—Two distinct races of the periodical cicada are known, the seventeen and the thirteen-year races. The former is confined to northern temperatures and requires seventeen years to complete the life cycle, while the latter is confined to the south and requires but thirteen years.

Number of broods and distribution.—The number of broods was originally placed by Dr. Riley at twenty-two. Later investigations by Marlatt¹¹ resulted in his placing the number at thirty and renumbering all of the broods. The distribution is evidently confined to the United States east of the Rocky Mountains where the cicadas have been found in varying abundance in every state except Maine and New Hampshire.

An interesting table has been prepared by Marlatt giving the

¹¹U. S. Dept. Agr., Div. Ent., Bul. 18, n. s., p. 53.

old and proposed enumerations of the broods. Of this table Mr. Marlatt¹² says: "The following table, beginning with 1893, when the initial broods of both the seventeen-year and thirteen-year series appeared in conjunction, illustrates the new nomenclature suggested, and in parallel columns also are given the corresponding nomenclatures proposed by Professor Riley, by Walsh and Riley, by Fitch and the year records in Dr. Smith's register." The table is as follows:

NOMENCLATURE OF THE BROODS OF THE PERIODICAL CICADA.

Year	Broods of the 17-year race.					Broods of the 13-year race.				
	Proposed enumeration.	Riley numbers.	Walsh-Riley numbers.	Fitch numbers.	Smith register.	Proposed enumeration.	Riley numbers.	Walsh-Riley numbers.	Fitch numbers.	Smith register.
1893	I	XI	—	—	1842	XVIII	XVI	—	—	1854
1894	II	XII	VIII	1	1843	XIX	XVIII	XIII	3	1842-1855
1895	III	XIII	IX	—	1844	XX	II	—	—	1843
1896	IV	XIV	X	—	1845	XXI	IV	—	—	1844
1897	V	XV	XI	—	1846	XXII	VI	IV	—	1845
1898	VI	XVII	XII	7	1847	XXIII	VII	V	5	1846-1859
1899	VII	XIX	—	—	1848	XXIV	—	—	—	—
1900	VIII	XX	XIV	2-8	1849	XXV	—	—	—	—
1901	IX	XXI	XV	5	1850	XXVI	X	—	—	1849
1902	X	XXII	XVI	4	1851	XXVII	—	—	—	—
1903	XI	I	I	9	1852	XXVIII	—	—	—	—
1904	XII	—	II	—	1853	XXIX	—	—	—	—
1905	XIII	V	III	6	1854	XXX	—	—	—	—
1906	XIV	VIII	VI	3	1855	XVIII	XVI	—	—	1854
1907	XV	—	—	—	—	XIX	XVIII	XIII	3	1842-1855
1908	XVI	IX	VII	—	—	XX	II	—	—	1843
1909	XVII	—	—	—	—	XXI	IV	—	—	1844

OBSERVATIONS IN WESTERN NEW YORK ON THE BROOD
OF 1899.

Distribution.—To ascertain the distribution of this brood in the State a number of localities where the adults were abundant were visited. Reliable information was also received from other points and it was finally ascertained that the cicadas had appeared in the following localities: In *Monroe Co.*, on the northeast shore of Irondequoit Bay, and in the vicinity of Webster; *Livingston Co.*,

¹²U. S. Dept. Agr., Div. Ent., Bul. 18, n. s., p. 54.

Geneseo and Sonyea; *Ontario Co.*, Manchester, Victor, Padel-fords, Farmington, Bloomfield, East Bloomfield and Billsboro. Station; *Yates Co.*, Earls, May's Mills and Dresden and points between; *Cayuga Co.*, Union Springs and points extending about three miles north, three miles west and seven and one-half miles south; *Madison Co.*, Chittenango and vicinity; *Onondaga Co.*, Syracuse, Onondaga, and points south in the Onondaga Valley. Doubtless there are many other localities in the State where this brood appeared that are not mentioned here.

According to Marlatt¹³ this brood also occurs in Wyoming Co., and in Pennsylvania in Allegheny and Washington counties.

Date of first appearance.—The earliest date of the appearance of the adults of this brood which we have was June 1, when a few appeared near Victor, Ontario Co. But few emerged however, until June 4, when they appeared in swarms increasing in numbers during the following two or three days. On June 9, the females were depositing eggs. Egg laying was continued actively during the following week and was observed as late as June 19. June 20 they had almost entirely disappeared.

Localities in which the locusts were most abundant.—The swarms of locusts were confined largely to woodlands and old orchards. Here and there a few appeared in cultivated fields indicating that in previous years they had covered wider areas but had been reduced in numbers, probably by the cultivation of the soil. In the localities along Seneca and Cayuga lakes, especially the former, where the brood appeared, the local distribution was sharply marked. They were found very largely in the wooded gulleys along the lake and in the orchards bordering them. In a few instances they were also found in groves on high land.

Evidence that the brood is decreasing in numbers.—Evidence that the brood is decreasing is furnished by its history. A number of old residents state that the locusts were less abundant in 1899 than 17 years previous. In the vicinity of Earls and Dresden two old residents remembered them 34 years previous to 1899 and one 51 years previous to that date. During the memory of these men the cicadas have become greatly lessened in numbers. The two previous swarms had appeared over much wider areas, extending

¹³U. S. Dept. Agr., Div. Ent., Bul. 14, n. s., p. 32.

from the lake back to the top of the hills, while the only areas occupied by the last swarm were back from the lake and, as previously stated, confined largely to the gulleys.

OTHER EXPECTED BROODS.

History and distribution of 1902 brood.—The brood due to appear in 1902 (Brood X of Marlatt's enumeration, XXII of Riley's enumeration) is one of the largest, if not the largest, of the 17-year broods. In this State it is located in Niagara, Monroe, Kings and Richmond counties. The exact distribution in this State is probably not known. As it is of importance to ascertain its limits and especially the localities where the adults appear in greatest numbers, the writer will be especially glad to receive information from those who observe them this spring as to the time, numbers and localities in which they appear. This brood also occurs in the following states: Alabama, Delaware, District of Columbia, Georgia, Illinois, Indiana, Kentucky, Maryland, Massachusetts, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Vermont, Virginia, West Virginia and Wisconsin.

Other broods in New York State.—Brood XIV¹⁴ (VIII) due in 1906 is located at points on the eastern half of Long Island. Also throughout the District of Columbia, in Georgia, Illinois, Indiana, Kentucky, Maryland, Massachusetts, New Jersey, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Virginia and West Virginia. Brood II (XII) due in 1911 is located over a wide area in eastern and southeastern New York, extending the entire length of the Hudson River Valley and north into the Lake Champlain region, including the following counties: Albany, Dutchess, Greene, Queens, Suffolk, Richmond, Orange, Putnam, Rensselaer, Rockland, Saratoga, Ulster, Washington and Westchester. It also occurs in the following states: Connecticut, New Jersey, District of Columbia, Maryland, Virginia, North Carolina, Pennsylvania, Indiana and Michigan. Brood VI (XVII) which appeared in Richmond and Westchester counties in 1898 will be due again in 1915. It is known to occur also in

¹⁴Marlatt's enumeration; numbers in parenthesis Riley's enumeration.

Illinois, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Virginia, West Virginia and Wisconsin. Brood VIII (XX) is due in 1917. It is not positively known whether any portion of this brood is located in this State or not, but if so in the extreme western part of Chautauqua county only. It is located in Massachusetts, Ohio, Pennsylvania, West Virginia and possibly Illinois and South Carolina.

METHODS OF CONTROL.

Protection.—When occurring in large numbers, there seems to be no practical method of controlling the adults except over very small areas. Experiments with pyrethrum, kerosene emulsion and various acids have shown that all of these substances have some effect but are probably of little practical value. Small trees, shrubs and vines can be protected from the adults by covering them with sheeting or some similar material or with wire netting. This of course, would be practical only in the case of a few choice plants. As a means of reducing the numbers of a brood in any locality the pruning of branches in which eggs have been deposited if taken in time will prove effectual. The injured branches should be cut out soon after the eggs are deposited. As a further precaution against injury by the adults, young stock should not be planted during the two years previous to their appearance in those localities where the insect is known to occur.

*Natural enemies.*¹⁵—A number of parasites attack the periodical cicada including some interesting mite parasites of the eggs. A species of digger wasp is also known to attack the adults. A number of birds also feed upon them. Among birds the English sparrow is said to be their greatest enemy. Chickens will also feed upon them. In one case reported to the writer a hen was observed to devour fourteen in quick succession. Fox squirrels and ground squirrels have been observed feeding on them. In cases where the cicadas fell into the water blue cat fish, black bass and white suckers have been known to feed upon them. A fungus disease also attacks the adults.

¹⁵For an extended account of the natural enemies of the periodical cicada see U. S. Dep. Agr., Div. Ent., Bul. 14, n. s., pp. 95-107.

DOG-DAY CICADA.

A related species often mistaken for the periodical cicada.—A species which is often mistaken for the periodical cicada is known as the dog-day cicada or harvest fly, *Cicada tibicen* Linn. It requires but two years to develop; and as there are two broods the adults appear every year. This species is larger and the body is more wedge-shaped than the other. Its black and green color and the powdered appearance on the under side of the body also easily distinguish it from the smaller species. The song is a high sharp trill, most commonly heard about mid-day. Plate I, Fig. 4 shows a dog-day cicada with its wings spread.

II. THE PALMER WORM.

During the spring of 1900 many of the apple orchards of Western New York became over run with a small, active caterpillar popularly known as the palmer worm and scientifically as *Ypsolopus pometellus* Harr. It was most abundant in Erie, Niagara, Orleans, Genesee, Monroe, Ontario, Wayne, and Cayuga counties. The history of the insect shows that it has appeared in large numbers only after long periods of years, and that it usually disappears as suddenly as it comes. We were, therefore, much interested to know whether the insect would be true to its record and disappear this time as quickly as it came. Accordingly, we took pains to ascertain whether it had again appeared in numbers during the past season but were unable to locate an orchard in which it was abundant. As was to be expected, however, an occasional one could be found, and rarely a tree would contain quite a large number, showing that some agency or agencies, probably climatic, had prevented the development of a large percentage. Whether it will remain reduced in numbers for another long period of years remains to be seen.

Food plants and nature of injury.—It is probable that this species has a large variety of food plants. Fitch,¹⁶ recording an outbreak in 1853, considered the oak and the apple the most seriously injured, but adds that "all other trees and shrubs were more or less infested with the worms at this time." Of the fruit

¹⁶Noxious Insects of New York, p. 224.

trees the apple is evidently preferred although the caterpillars are known to feed upon the plum and cherry.¹⁷ The writer has observed them in a few instances feeding upon the pear.

When attacking fruit trees the caterpillars feed upon both leaves and fruit, skeletonizing the former and eating irregular holes in the latter. (Plate V, Figs. 5 and 2.) The injury to the fruit is quite characteristic. A shallow area is eaten out on one side and sometimes over a considerable portion of the fruit, from which one or more deep channels lead into the interior. Plate VI shows the characteristic injury to a young apple. The caterpillar is about to enter the channel. Favorite fruits for the caterpillars to work upon are those that hang so as to touch each other. In such cases the shallow area is often eaten out on both fruits and a deep channel made into each so that the caterpillar can pass from the interior of one directly into the interior of the other. In some cases very small apples may have nearly all the interior eaten away, the injury much resembling that of the green fruit worms. The result of such injury is to prevent the development of the fruit or cause it to become distorted.

DESCRIPTIONS AND NOTES ON LIFE HISTORY.

The egg.—The egg-laying habits of the females have remained a mystery. So far as we have been able to ascertain there is no record of where the eggs are laid and no description of the egg. With the hope of securing some of the eggs a large number of moths were kept in confinement. No eggs were secured except in two instances. The moths that laid these eggs were kept in small glass bottles with a single apple leaf that had been carefully examined before being placed in the bottle. After a few days two eggs were found on one leaf and one on another. They were stuck lightly to the surface and were easily jarred off. Two were placed on the upper and one on the under surface. None of the eggs hatched. In color they were pearly white, oblong-oval in shape, obtusely rounded at one end and tapering slightly toward the other. The shell was quite delicate and easily broken

¹⁷ Harris, T. W. As quoted by Slingerland in Cornell Univ. Agr. Exp. Sta. Bul. 187, p. 89.

except at the smaller end where it was thickened. They were about uniform in size and measured .36 mm. by .16 mm.

Failure to secure eggs from the other moths and the fact that these eggs did not hatch, indicate that the conditions under which they were secured were not normal. It is not improbable, however, that eggs are occasionally laid during the summer by the adults of the spring brood, as occasional young and full-grown larvæ were found by the writer late in August and on Sept. 19. Some of the young larvæ taken in September measured less than one-quarter inch, indicating that they had recently hatched. Adults were found on the former date but none on the latter. Although careful search was made but few larvæ were found, and these were scattered in several trees. The occurrence of the larvæ at this time of year means one of two things, either that they belong to a second brood or that there may be a great delay in the time of egg-laying among certain individuals that probably lay their eggs normally in the spring. The former seems to us the more probable as it would not be unnatural, while so long a delay in either egg laying or the development of the egg would seem to be extreme.

Although the life history of this insect is not yet well understood it seems probable from the time the larvæ appear and the fact that the adults have been kept alive until late in October,¹⁸ that the eggs are laid in the spring by the moths which have lived in some protected place during the winter.

The larva.—The larvæ or caterpillars appeared early in June. Individuals kept in our breeding cages were about three weeks in reaching maturity. They are very active when disturbed, violently jerking and wriggling the body and often dropping suddenly from the leaf or fruit and suspending themselves in the air in the same manner as the canker worms. On the leaves they make sheltered retreats for themselves by drawing over the edge of a leaf and fastening it by silken threads or by spinning a covering of silk over a depression in the leaf. At Plate VII a caterpillar is seen in a partially completed retreat. Not infrequently these retreats are abandoned without being completed. They also often draw two or three leaves together making a nest after

¹⁸Slingerland. Cornell Agr. Exp. Sta. Bul. 187, p. 95.

the manner of the larva of the bud moth. The soft parts of the leaves in the immediate vicinity of these hiding places are eaten, until finally it is necessary to seek food elsewhere, when new shelters are constructed. When alarmed the caterpillars will often seek one of their retreats if near to it. The following manuscript notes by Mr. P. J. Parrott, who studied the insect in the Huntress orchard at Manhattan, Kansas, are interesting in furnishing additional data on the habits of the larva.

"The amount of damage that this insect can do is remarkable. In some instances it will eat all of the leaf as far as it is feeding, while in the majority of cases it will consume the pulpy parts of the foliage, leaving in many cases nothing but the larger veins, ribs and stem of the leaf. The insect in the larval stage does not always feed exposed, but generally has more or less of its body protected by a case formed from an apple leaf or, in the commencement of the building of a new case, it hides in the bottom of an enfoldment of a leaf, protected by a silken roof of its own manufacture. The insect commences the folding of a leaf in any of the following ways : first,—when the upper surface of the leaves forms a concavity the larva will commence its work along the main rib. It lies parallel with the rib, and swings its head from side to side alternately, now frontwards and now backwards attaching each time to the sides of the leaf a fine thread till a coarse network of silken threads is formed ; second, on the lower surface when the lateral edges of the leaf are folded in towards that side ; third, when any part of the leaf is turned or inclined to turn on itself, the larva will seek such a hollow, and draw the edge of the leaf over itself after the manner of first and second cases ; fourth, when a leaf is in contact with another or overlaps within a short distance, the two are connected by the silken threads.

"As soon as it is hatched the larva commences to construct coverings after the manner described. Whatever the covering may be it leaves one or more apertures through which it may project a part of itself or sometimes entirely emerge to eat. When the covering or case is just formed the larvæ seem to prefer the parts of the leaf adjoining the case, but when this is devoured they commence to eat the pulpy parts of their case, and possibly do eat more or less of this from the very beginning,

but more so when they have devoured most of the leaf. When the greater part of a leaf is destroyed and nothing remains of their case but the veins and silken threads they abandon their case, crawling to some more removed spot, all the time moving hither and thither as if using some sense of discrimination till a suitable leaf is found. At other times they drop down with a web to leaves below; they may crawl to the end of a twig and eat into the terminal part; while in some instances, having eaten the greater part of the leaf, they will commence to work on the stem of the leaf, which in some cases they have severed, thus either precipitating themselves to the earth together with the leaf, whereon they commence to crawl for that or another tree; or, falling upon a branch below they then pass to other leaves.

"Larvæ at different parts of the day are to be found either outside of their cases, on the same or opposite side of the leaf, or just projecting out their heads from one side or the other of their cases within a short radius. The adults of these larvæ were kindly identified by Dr. C. H. Fernald."

The full grown larva measures about one-half inch in length. It is slender and tapering in shape. The color of the body varies from a flesh color to a sulphur-yellow tinged with green, or more decided greenish tints. The head and shield vary from light yellowish brown to dark brown. The legs and prolegs are yellowish to yellowish brown. The most prominent markings of the body are three broad dark lines extending the full length of the dorsum. The middle line may be divided longitudinally into two finer ones. This line is usually lighter than the others. The body is sparsely covered with fine hairs which arise from small black dots.

The pupa.—When about to pupate the larva attaches itself usually to a leaf, but not infrequently to the fruit or twig. (Plate V, Fig. 3 enlarged; Fig. 5 shows an injured leaf, natural size, with pupæ attached). Most of the pupæ found by the writer in the orchards were attached to the leaves. They measure about $\frac{1}{4}$ inch in length and are reddish brown to dark brown in color. The pupa stage probably lasts about 8 to 10 days as a rule, as a large number of individuals in confinement averaged about this number. Slingerland¹⁹ states that in their cages "Many pupæ

¹⁹Cornell Agr. Exp. Sta., Bul. 187, p. 94.

were found naked on the surface of the soil, and others in a slight silken web just beneath the surface of the soil." The majority of the pupæ are probably formed late in June.

The adult.—The adults appear during the last days in June or early in July. Most of those under our observation emerged during the first ten days of July. They are small active moths that fly toward dusk or at night, hiding during the day in any convenient retreat. They measure about three-eighth inch in length and about one-half inch from tip to tip of the expanded wings. They rest with the anterior part of the body well up. The color is slate or ash gray, often with a brownish tinge. The fore wings are marked with small dark spots. Four larger ones are readily distinguished near the middle and sometimes one near the base. A dark patch or broad line marks the tip which is also bordered with small black dots. These dots may extend along the anterior and posterior margins, either one or both. The posterior wings are dusky colored with a steel blue, or as Slingerland²⁰ has described it, an azure blue reflection. They are heavily fringed. (Plate V, Fig. 6 ; and Fig. 7, middle figure.) The joints of the antennæ are alternately dark and light. Plate V, Fig. 4, shows a moth natural size with wings expanded.

The variations in the markings of both larvæ and adults have resulted in the same species being described under different names.²¹ Fitch²² describes six varieties based on the markings of the wings. Three variations from the typical form (Plate V, Fig. 6) are shown at Fig. 7. The two lower wings do not seem to come under any of Fitch's varieties, but the lower one was supposed by him to belong to a distinct species. Slingerland²³ retains this as a variety.

From the published accounts of this species it appears that the life of the adult is not yet well understood. It seems probable, however, that the species hibernates in the adult stage. The fact that the adults have been kept alive in breeding cages until late

²⁰Cornell Agr. Exp. Sta., Bul. 187, p. 85.

²¹For synonymy of this species see Slingerland's list in Cornell Univ. Agr. Exp. Sta., Bul. 187, pp. 100-101.

²²Fitch. Noxious Insects of N. Y., 2d Report, p. 229.

²³Cornell Agr. Exp. Sta., Bul. 187., p. 85.

in October, see p. 18, and found active in the orchards late in August furnish evidence that strongly indicates that the adults live over winter.

SUMMARY OF LIFE HISTORY.

The caterpillars appear in June and feed upon both leaves and fruit. In about two weeks they are full grown. The chrysalis is naked and found in secluded places in the injured leaves or upon the bark or under rubbish, or in the grass under the trees. The adults appear in about ten days. It is probable that they hibernate making but one annual brood. Young larvæ found in September indicate a partial second brood. Little is known of the egg laying habits. It is a natural supposition that they are laid in the spring on the twigs or leaves.

METHODS OF CONTROL.

The sudden appearance and equally sudden disappearance of this insect have given practically no opportunity for experiment with remedies. But as the caterpillars feed openly on the leaf tissue, spraying with arsenical compounds would without doubt prove effectual. During the outbreak of this insect in 1900 it was very noticeable that the orchards that had been sprayed were comparatively free. One case especially, that came under the writer's observation, illustrated this. This orchard had not been sprayed that season, and was overrun with the insects. Two other orchards in the neighborhood that had not been sprayed were also infested while the sprayed orchards were in every case practically free.

III. WHITE GRUBS ATTACKING ASTER PLANTS.

The larvæ of the May beetle, *Lachnosterna fusca* Fröh., and allied species feed upon the roots of a large variety of plants. The adults or beetles feed upon the leaves of a variety of trees and shrubs. In Western New York nursery stock, especially young fruit trees, is often seriously injured. The grubs of the species above referred to are evidently the most numerous and consequently do the most damage. They feed upon the roots often eating the main root nearly off.

The field of asters that was injured by the grubs is located on the outskirts of Geneva. It contained about 20,000 plants of several varieties. The soil was principally sandy loam. The year previous a crop of nursery trees had been removed from the field. The aster plants began to show injury from the work of the beetles about the middle of July. The injured plants began to wilt suddenly and soon died. Examinations made during the latter part of July showed about ten per ct. of the plants injured. Later a few more plants were destroyed by the grubs, making the percentage of injured plants somewhat higher. The grubs were usually found feeding at the crown of the root and for a short distance above. Plate VIII shows two grubs, natural size, feeding. In every case the bark had been eaten off all the way around the stem and in many cases the stem was completely severed. From one to four grubs were found at each plant.

The grubs were all nearly full grown and hence were in their second year. If left undisturbed they would have emerged as beetles the year following. The eggs were laid in the ground during the spring of the year previous and the young grubs were evidently supplied with food by the roots of the nursery trees. The removal of the trees took this food away from them which meant that the crop that followed the next year would be sure to be injured by them.

No attempt was made to revive the injured aster plants, but as soon as one was observed to be wilting it was dug out and the grubs destroyed. By going over the field every day for about a week during the middle of July large numbers of the grubs were killed; probably most of them, as there was but comparatively little injury later. White grubs are difficult to check after a field has become infested. Prevention is by far the most satisfactory. If land is left in meadow for several years it is more apt to become seriously infested than if a short rotation of crops is practiced.

IV. *PAPILIO ASTERIAS* ATTACKING CELERY.

The larva of this species is popularly known as the celery caterpillar and in some localities the parsley caterpillar. It is known to feed upon a variety of plants of the family *Apiaceæ* (*Umbelliferæ*) among which are parsnip, parsley, dill, fennel, anise, caraway and carrot. In the celery growing sections the caterpillars sometimes become quite abundant. During the spring and summer of 1900 and 1901 they were quite numerous in the vicinity of Geneva. They were especially noticeable on young celery plants in the seed beds where they were sufficiently numerous to require attention every day.

The newly hatched caterpillars are nearly or quite black with a white band about the middle and one toward the posterior end of the body. By the time they have become full grown they have changed to a pea green color with a black band on each segment. In each of these bands are four orange-yellow spots, two on each side. The frontispiece is from a photograph, from life much enlarged, of one of these caterpillars nearly full grown. It was feeding on the celery stalk just before the picture was taken but was induced to stop for a moment by a gentle jar of the stalk when it assumed the attitude shown in the picture just long enough to be photographed. The same caterpillar is shown natural size at Plate I, Fig. 5.

The adult is one of the well known "swallow tail" butterflies. Both the males and females are black with sulphur-yellow and steel-blue markings. The former has two bands or rows of sulphur-yellow spots crossing the wings on the outer half between which are flecks or spots of blue. On the inner angles of the hind wings are eye spots nearly or quite surrounded by red. The female is less prominently marked with the sulphur-yellow spots but the blue spots are more prominent.

The insect lives over winter in the chrysalis stage. The adults appear in May or early June and soon begin to lay eggs on the leaves, usually on the under surface of the plants that are to furnish food for the caterpillars. They hatch in about ten days. The young caterpillars feed voraciously and increase in size rapidly. In about two weeks they are full grown and seek a sheltered place in which to form the chrysalis. Often the chry-

salis will be found on the under side of the leaf upon which the caterpillar has been feeding. The adults emerge in from ten days to two weeks. Eggs for the second brood are soon laid. The chrysalids of this brood remain until the following spring before the adults appear.

The caterpillars are seldom sufficiently numerous to cause serious injury, but if abundant they are usually held in check by jarring from the infested plants or handpicking. Spraying with paris green or other arsenical compounds, where practical, is an effectual method of destroying them. If paris green is to be applied, use one pound to each 150 gallons of water with the addition of enough freshly slaked lime to make the mixture somewhat milky in appearance.