SOME LEPIDOPTEROUS LARVAE RESEMBLING THE EUROPEAN CORN BORER

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INTRODUCTION

The European corn borer (Pyrausta nubilalis Hübner) is unquestionably the most important potential insect enemy of the corn plant in the United States and Canada. Inasmuch as there are other lepidopterous larvae attacking corn which may be readily confused with the European corn borer, it seems desirable to give an account of these larvae, to point out the structural characters wherein they differ from one another, and briefly to discuss their habits and seasonal histories in order further to facilitate the identification of the European corn borer in the field, as has been done by Heinrich (13)* for the pink bollworm and lepidopterous larvae likely to be confused with it.

The larvae of two native species, Pyrausta ainsliei Heinrich and P. penitalis Grote, which also inhabit corn at certain seasons of the year, so closely resemble the larvae of Pyrausta nubilalis in color, size, and structure that their identification without final resort to the microscope will always remain uncertain. Immature larval stages of these three forms are especially difficult to separate. Other plants than corn attacked by the European corn borer are hosts of lepidopterous borers and surface feeders, some of which, although entirely unrelated to one another, resemble more or less closely the larvae of P. nubilalis. In order to draw a line, however, as to the forms to be included in this category, special consideration is given only to those larvae inhabiting the preferred food plants of the European corn borer. Field observations in connection with the species discussed were conducted in the Massachusetts area infested by the corn borer, unless otherwise indicated.

It was necessary in this work to make distinctions between food plants and shelter plants, as Ainslie and Cartwright (1, p. 837) also found necessary in their work on the biology of Pyrausta ainsliei in Tennessee. Generally, the naming of a particular plant as a host plant implies that the insect feeds upon it and derives its livelihood therefrom. This is not strictly true, however, for some lepidopterous larvae boring in weeds and other plants migrate at certain seasons of the year, particularly in the autumn, to other apparently more suitable plants in which they find desirable quarters for the winter (2). Usually the larvae possessing this migratory habit—those observed—are full grown in the fall and consequently require no further food in the spring for the continuance of their development. They have lived at the expense of small marrowed or pithy stems. When completely tunneled out, these stems are obviously frail and when subjected to the rigors of winter in the north are readily broken over, frequently exposing the burrows of the larvae within. Thus the larvae are feebly protected unless they migrate to more favorable situations or mine into the underground stems of the plants they infest, as do Gnorimoschema and Pterophorus in Solidago sempervirens L. Plants which afford only wintering or pupation quarters for an insect should be termed shelter plants. The term "host plant" is relative.

Eleven species are considered in the present paper. Descriptive matter in the text has been reduced to a minimum; the important differentiating structural characters, however, are pointed out and further emphasized by figures.

* Reference is made by number (italic) to "Literature cited," p. 792.

1 Received for publication Apr. 22, 1924; issued June, 1925. This study was projected by D. J. Caffrey, in charge of the European corn borer investigations, as an aid for field men. The writer materially benefited from his enthusiasm, suggestive criticisms, and general supervision of the work, and desires hereby to express his appreciation and thanks. It should also be stated that Carl Heinrich, of the Bureau of Entomology, read the manuscript, pointed out omissions, and suggested several important changes both in the text and in the figures.

2 Resigned Jan. 12, 1925.
FAMILY PYRALIDAE

SUBFAMILY PYRAUSTINAE

PYRAUSTA NUBILALIS HÜBNER


Botys lupulina Heinemann (nee Clerck), 1865, Die Schmett. Deutsch. und der Schweiz, 1, 2, 70.

Hapalia kasmirica Moore, 1888, New Ind. Lepidop. Ins., p. 222, pl. 7.


For complete information on the status, habits, life history, etc., see paper by Vinal and Caffrey (21).

The European corn borer (Pyrausta nubilalis Hübn.) was described by Hübner in 1796 as Pyralis nubilalis. The description consisted of a careful drawing of the male and a descriptive note added to the text of “Sechste Horde.” Hübner also described the female as silacealis in the same manner with a figure and a note, apparently not recognizing, owing to the complete difference in coloration of the two sexes, that this species was the female of his nubilalis. It seems that Clerck (3, Sect. I, pl. 9, fig. 4) in 1759 attempted to describe a species under the name Phalaena lupulina, but executed so poorly a figure that the majority of workers have disregarded it. Gueneé, although admitting that Clerck’s figure is poor, believed that lupulina should take precedence over Hübner’s nubilalis, since he was convinced that they were identical. He therefore assigned the name Botys lupulinalis to the species, giving Clerck credit for the authorship, and several succeeding writers have used the name lupulina of Clerck for Hübner’s species. A study of Clerck’s figure by later workers, however, has convinced them that Clerck’s lupulina is not identical with Hübner’s nubilalis. Since then the species has been described under a variety of names, but all recent catalogues on Lepidoptera maintain the name nubilalis Hübner. On account of priority, the generic name Botys erected by Latreille in 1802 has been supplanted by Schrank’s Pyrausta of 1801.

The full-grown larva of the European corn borer (description, 11, p. 174) (pl. 1, D) averages 0.81 of an inch in length, or 19.95 mm. (20, p. 27). The integument on the dorsal side of the larva is heavily granulated, the granulations extending to the pleura of the body segments. Laterad and ventrad the integument is a dirty white. The skin granules carry the pigmentation which varies from a pink, slate gray, or “smoky-fuscous” (11) to a light brown. Since each color may predominate over the other, various color combinations are present in living larvae which are obviously difficult to describe. The skin granules are most dense on the dorso-median plane and take the form of a distinct stripe which is more or less interrupted where the integument folds in on the dorsal side of the larva to delimit the body segments; notwithstanding this interruption, the stripe is plainly visible to the unaied eye as a dark, pigmented, longitudinal band. On the larva of Pyrausta ainsliei, a close relative of the larva of the European corn borer and almost identical with it structurally, this stripe or band is very insignificant (pl. 1, C), narrow, and difficult to establish as present. This difference has been found to be a safe field character for the separation of full-grown living larvae. This character can not be depended upon for use in separating material preserved in alcohol, as it is a well-known fact that even with the utmost care in preservation pigmented areas fade. The abdominal segments bear on the integument of the dorsum or in its creases and folds small rounded clear areas, some of which appear fused with each other, forming thereby somewhat irregular moniliform clear spaces. Miss Mosher endeavored to establish the constancy of these areas on the abdominal segments (18, p. 265) and used them in separating nubilalis from ainsliei. Heinrich has pointed out (11, p. 176) that this character is elusive and unreliable. It is possible to find in a small series of selected larvae some constancy as to the number and placement of these clear areas, but in a large series of larvae the character is at once seen to be inadequate and unreliable. As to the morphology of these areas Heinrich believes by analogy that they afford attachment for certain muscles and homologizes them with similar weakly chitinized areas in certain Phycitinae—notably Dioryctria and Pinipestis by way of example (11, p. 174, footnote). Microscopic sections through these areas

Journal of Agricultural Research
Vol. XXX, No. 8
Larvae Resembling the Corn Borer

Plate 1

DORSAL VIEW OF LARVAE

A.—Bidens borer, *Epiblema scudderiana*
B.—Nelumbo borer, *Pyrausta penalis*
C.—Polygonum borer, *P. ainsliei*
D.—European corn borer, *P. nubilalis*
E.—Parsnip webworm, *Depressaria heracliana*
F.—Greenhouse leaf-tyer, *Phlyctaenia rubigalis*
G.—Spindlesworm, *Achatodes zeae*
H.—Celery stalkworm, *Nomophila noctella*
fail to reveal that they afford attachment for body muscles, cutaneous or others. It is true that they are feebly chitinized, thinner in fact than other portions of the integument, but this is apparently due in large measure to the absence of the characteristic skin granules present elsewhere on the dor-
sum.

Heinrich uses the anterior epicranial setal group (11) and puncture to separate *nubilalis* from *ainsliei*. This unquestionably is a good character, and is, as a matter of fact, the only reliable character that can be used to separate the two species in all larval stages (see *P. ainsliei* below) (pl. 2, I and J).

**PYRAUSTA AINSLIEI HEINRICH**


*Pyrausta penalis* auct. (nee Grote).

After a careful comparison of the genitalia of the specimens of *Pyrausta penalis* Grote in the National Museum and after a further examination of Grote’s types of the same species in the American Museum of Natural History in New York, Heinrich was convinced that two species were involved and confused with each other under the specific name *penalis*. Accordingly, he separated this species and described it as *ainsliei* from specimens furnished him by George G. Ainslie of the Bureau of Entomology, Knoxville, Tenn.

In 1920 Flint and Malloch treated a lepidopterous larva occurring in smartweed as Lederer’s *obumbratalis* (8, p. 303-304). Heinrich (12, p. 57) established the identity of this species as *ainsliei*, admitting the possible synonymy but calling attention to the impossibility of fixing the actual identity of *obumbratalis* at the present time. To avoid confusion and possibly misapplication of a name, it is advisable at present to use *ainsliei* rather than *obumbratalis* as the designation for our smartweed borer.

The larvae of *Pyrausta ainsliei* have been found in all stages of development in eastern Massachusetts in the following plants: *Polygonum pensylvanicum* var. *laevigatum* Fernald, *P. lapathifolium* L., *P. persicaria* L. (smartweeds); *Xanthium* sp. (cockle-
bur); *Ambrosia artemisiaefolia* L. (rag-weed); *Eupatorium* sp.? (Joe-pye weed); *Apoecynum androsaemifolium* L. (spreading dogbane); *Typha latifolia* L. (cat-tail); *Chenopodium album* L. (lamb’s-quarters). Adults have been bred through from second instar larvae from all these plants with the exception of *Apoecynum* and *Chenopodium*. In these two cases very young larvae were taken from these plants in the field but failed to live in confinement. By subsequent visits to plants infested in the field, however, the writer was convinced that the species was developing therein. It should be stated in this connection that instances of larvae developing in plants other than *P. pensylvanicum* L., and *P. lapathifolium* L., were infrequent; so that it became apparent that the species greatly prefers the smartweed group of plants in which to breed.

In the late autumn larvae have been taken from the following shelter plants: *Rubus* sp.?, *Sambucus canadensis* L. *Zea mays* (corn), *Solidago canadensis* L., *Echinocloa crusgalli* L. Beau. (barnyard grass), *Bidens frondosa* L. (beggar-ticks); *Typha latifolia* L., *Apoecynum androsaemifolium* L. In November Vickery sent a lot of cotton plants collected at Wilmington, N. C., February 11, 1921, to the Arlington, Mass., laboratory, from which many larvae of *Pyrausta ainsliei* were cut. Cotton is probably a shelter plant.

Ainslie and Cartwright published some results obtained on the biology of *ainsliei* in which they list (1, p. 838) the following as reported natural food plants: *Polygonum pensylvanicum* (var. not given), *P. lapathifolium*, *P. persicaria*, *P. hydropiperoides*. They also reared the larvae in confinement.

**EXPLANATORY LEGEND FOR PLATE 2**

**LARVAL DETAILS**

A.—Setal map of *Pyrausta nubilalis*, prothoracic, mesothoracic, and third, eighth, and ninth abdominal segments of larva. (After Heinrich)

B.—Setal map of *Philcetania rubigalis*, prothoracic, mesothoracic, and third abdominal segments

C.—Setal map of *Diatraea zonella*, mesothoracic and ninth abdominal segments. (14, pl. 4)

D.—Setal map of *Depressaria heracliana*, prothoracic and eighth and ninth abdominal segments

E.—Setal map of *Lepostegia similalis*, third and ninth abdominal segments

F.—Setal map of *Nomophila noctuella*, prothoracic, mesothoracic, and third, eighth, and ninth abdominal segments

G.—*Epiblema scudderiana*: Setal map of prothorax

H.—*Heliothis obsolata*: Setal map of third abdominal segment

I.—*Pyrausta nubilalis*: Cephalic view, left half of head

J.—*P. ainsliei*: Cephalic view, left half of head capsule

K.—*P. nubilalis*: Crochets on plantum of pseudopodium

L.—*Epiblema scudderiana*: Crochets on plantum of pseudopodium

M.—*Heliothis obsolata*: Crochets on plantum of pseudopodium. (After Heinrich)
Larvae Resembling the Corn Borer

Plate 2

(For explanatory legend see p. 780)
on the leaves of Rumex crispus (curled dock) and Fagopyrum fagopyrum (buckwheat). These workers have found the larvae in the following plants, which they assume to be purely shelter plants: Zea mays (corn), Ambrosia trifida and A. artemisiaefolia (ragweeds) Xanthium communis, cocklebur) Solidago spp. (goldenrod), Aster spp. (aster), Pheleum pratense (timothy), Typha latifolia (cat-tail), Bidens bippinata and B. frondosa (beggar-ticks), Brassica arvensis (wild mustard) (recorded by Felt), Eupatorium sp.? (Joe-pye weed) (recorded by Chitten-den). Since both nubilalis and ainsliei possess this migratory habit, the former perhaps to a less degree, it will not be surprising if the larvae are taken in many plants and in other situations affording suitable quarters in which to pass the winter. Flint and Malloch (8, p. 293) published a substantial list of plants in which the larvae of ainsliei have been taken in the fall.

It is amazing that a species so abundant and so widely distributed as ainsliei should have remained undiscovered until so recent a time. It occurs abundantly wherever it has been reported as present, from Quebec, south through New England, New York, New Jersey, Pennsylvania, Maryland, Virginia, the Carolinas, and Tennessee, to Florida, west through Mississippi to Louisiana, and north through Kansas and Iowa to Michigan. It doubtless has a range even greater than we know of at present.

In Massachusetts the insect has a single brood (very often a partial second), in New York apparently one generation (Bartley and Hofer 6); in Northern Ohio apparently two generations (Poos 5); in Iowa two generations (20); in Tennessee two generations (1); and in Mississippi three generations (Allen 5). In New England the moths appeared in 1921 the first week in June, emergence continuing through July 10, on which date the last pupa was observed in the field. Larvae were full grown by September 1, although many immature were also present in the field. On September 12, 1921, the writer first observed the larvae in corn for the season and from this date until October 5 their numbers appeared to increase constantly in corn plantations and in other places of shelter. In confinement, pupae remained as such for an average period of 15.3 days.6 Egg masses hatched on the average in 6.5 days.

Small holes in the stalks of Polygonum and other plants with frass extruding and suspended somewhat beneath the openings indicate where the borers are at work in the plant. The tissue about the opening is usually slightly sunken and discolored. Since a large number of borers can be found at work in a single plant it is common to find the Polygonums on dumps and at ways-ide places in a state of utter collapse. On opening such infested plants one finds in place of the customary pith and fleshy medulla, a mass of castings, larvae, and larval exuviae. Prior to pupation, the larvae cut exits in the stalk for the convenience of the moths, covering these openings with tympana of silk. The larvae rarely mine through the septa of the nodes of Polygonum but confine their feeding almost exclusively to the internodes. The larvae are much less active than the larvae of Pyrausta nubilalis; in fact, they are comparatively sluggish. Corn borers, on the slightest disturbance or provocation, move out of their quarters; ainsliei larvae remain to be prodded out or summarily removed by hand.

Observations made by the writer in New England on the developing larvae do not completely coincide with those made by Ainslie and Cartwright in Tennessee (1, p. 840). The young larvae, for the most part, do not at once enter the stems of Polygonum, but invariably on emergence from the eggs they freely pit the midrib and feed on the epidermis of the under surface of the leaves which hold the egg masses. During the time the larvae are thus engaged the chitin of the mandibles fully hardens and the head capsule assumes its normal pigmentation. It is true that immediately following their escape from the eggs the young larvae remain assembled in gregarious fashion, but in the course of a day they disperse,

4 In this connection Ainslie and Cartwright also state (1, p. 838): "Leaves of all common weeds and plants were offered to the larvae, but in every case except the two mentioned above they were either refused or only slightly gnawed." This general statement implies that all common weeds and plants from various sections of the country were offered to the larvae. These investigators probably mean that the most common weeds and plants in the vicinity of Knoxville, Tenn., were utilized in experimentation.

5 Unpublished.

6 Wm. B. Turner, of the Sacramento Entomological Laboratory of Cereal and Forage Insect Investigations, was connected with the European Corn Borer Laboratory and directly associated with the work in 1920 and 1921. He secured the pupation records, devised cages, and contributed other important data to our knowledge of P. ainsliei. Mr. Turner died June 12, 1924.
entering the stems of the plant near where the eggs were deposited. As a result of larval feeding these small stems wilt. The larvae, therefore, leave these, migrating elsewhere to another section of the plant, and they may do so several times in the course of their development. Other pyraustine larvae have been observed to emerge from the stem in which they are feeding to pass through their first larval molt. This habit of migrating apparently works hardship on the species, for doubtless it accounts for the relatively high parasitism in larvae of *Pyrausta ainsliei*.

Egg masses were found to contain anywhere from 2 to 35 eggs. Ressler (20, p. 278) records having secured 50 in a single cluster. An average female probably lays 300 to 600 eggs. It is possible to distinguish very young larvae and egg masses of *Pyrausta ainsliei* about to hatch from those of *P. nubilalis* in the same condition wholly on a head capsule comparison. The head capsule of *nubilalis* showing through the transparent corium of the egg when the latter is about to hatch is always jet black; in *ainsliei* it is a light straw or pale tan color and only assumes its characteristic deep chestnut brown or black color 18 to 24 hours after emergence from the egg.

The following parasites have been reared from *Pyrausta ainsliei* larvae at the Arlington laboratory. This list has been furnished by Dettmar W. Jones: *Microbracon* n. sp.; *Panzeria* penitalis Coq.; *Ipoclistis* conquistor Say; *Bassus agilis* Cress.; *Glypta rufiscutellaris* Cress.; *Ephialtes aequalis* Prov.; *Exorista nigripalpis* Town.; *Rogas rileyi* Cress. *Microgaster epagoges* Gahan is probably a primary parasite of *ainsliei*. Ressler (20, p. 280) in Iowa records that he reared a braconid, belonging to the genus Aleoides, from this species. Ainslie and Cartwright reared a predator (1, p. 344) in *Callida decora* Fab. They suggest that doubtless larvae of *Chauliognathus pennsylvanicus* De Geer destroy some of the borers; "in two instances they have been found feeding upon the contents of the puparia [doubtless they mean pupae] in the stems."

The larvae are cylindrical, 18.5 mm., or 0.718 inch, in length when full grown (1, p. C). They do not vary in color so markedly as the larvae of *P. nubilalis*. The larvae are for the most part slate gray and plumbeous colored on the dorsum and a dirty white ventrad. The head capsule is usually a deep chestnut brown, yet specimens may be had with black head capsules. On hatching from the egg, however, the head capsules of the larvae are always pale.

From an examination of thousands of living specimens at the European Corn Borer Laboratory during 1920 and 1921 it has become evident that Carl Heinrich's (11) structural distinction between *Pyrausta ainsliei* and *P. nubilalis* larvae is the only positive one, so similar is the morphology of these larvae. It is a difficult character to establish with a hand lens, owing to the dark pigmentation of the head capsules. This fact, unfortunately, hampers its usefulness for field men. Nevertheless the distinction is always constant and can be used in every instar. Other characters have been tested and tables kept to establish their reliability, such as the shape of the anal plate, the disposition of the clear spaces on the integument, and the distance between certain tubercles on particular abdominal segments, but invariably these have had to be given up because of their inconstancy.

Heinrich's character bears on the arrangement of the setae and the position of the puncture in the anterior epicranial group (11, p. 178) (pl. 2, I, J).


Epicranial setae and puncture A1, A2, and A* lying in a straight line or with A* somewhat postero- lateral of A1, not postero-dorsad—*P. nubilalis*.

Owing to the fact that the head capsules of these larvae are somewhat globose in form it is probable that Heinrich in the latter instance, when he refers to A1, A2, and the puncture A* as lying in a straight line, actually means that their position is along an arc conforming to the declivity of the head.

**PYRAUSTA PENITALIS GROTE**

*Pyrausta penitalis* Grote, 1876, Canad. Ent. 8:98; Dyar, 1902, List N. Amer. Lepidop. No. 4893; Barnes and McDunnough, 1917, Check List Lepidop. Bor. Amer. No. 5129. *Pyrausta nelumbialis* Smith, 1890, Ent. Amer. 6:89.

In 1876 Grote described *Pyrausta penitalis* (the Nelumbo borer) from moths reared by Snow, of Lawrence, Kans. In 1890 J. B. Smith described the same species under the appropriate name of *nelumbialis*. He reared moths from larvae taken in the buds, flowers, seed capsules, and leaf and flower stems of the Egyptian lotus, collected at Bor- dentown, N. J.

During 1920 and 1921 the larvae of *Pyrausta penitalis* (pl. 1, B) were received at the European Corn Borer
The larvae have much the same habits as *P. nubilalis* and *P. ainsliei* in that they mine out the pith columns and feed on the medulla of the plants they infest, extruding frass from their burrows. Usually they spend more time in the open after hatching from the eggs than either of the above mentioned species, feeding on the leaf and flower buds, and the tender foliage. In confinement they have been observed to web together immature foliage and to feed therein for a considerable time prior to entering the stems of the plant. The larvae also appear to possess a greater silk-spinning ability than either *nubilalis* or *ainsliei*. When half grown, or before, they enter the plant and form definite burrows. While the larvae possess no particular body modifications for aquatic life they are capable of remaining in water for days. In lotus stems they have been submerged for a month without apparent injury. Larvae on the surface film of water attain the sides of the vessel in which they are confined by convulsing the abdominal segments from side to side. Observers have noted that the larvae of this species are not to be found in lotus plants in the autumn, but in hollow reeds or other places of shelter on shore (2). To remain in the old lotus or Nelumbo plants as they collapse and fall into the water in the autumn, remaining submerged over the winter, apparently would not make for the welfare of the species. It was noted at Riverton, N. J., in 1918, that old lotus plants practically all disintegrate during the winter.

Coquillett (4, p. 154) lists the following parasites of *Pyrausta penitalis*: *Exorista vulgaris* Fall.; *Hypostena variabilis* Coq.; *Panzeria penitalis* Coq.; *Phorocera comstocki* Will.

Full-grown larvae of this species are larger and more robust than either *Pyrausta nubilalis* or *P. ainsliei*. The pupae are also larger but the adults are smaller than the former, almost equaling in size the moths of the latter. The larvae measure 22.5 mm. or 0.87 inch in length, and are heavily pigmented. They usually are brownish-black on the dorsum and white ventrad. The head capsule is larger than in either of the above forms and has a mottled appearance, owing to the collection of the pigment in small regular areas, leaving the remainder of the chitin light colored. In *ainsliei* the pigmentation of the head is uniformly dark colored. However, in *nubilalis* specimens of the larvae can be found intermediate between *ainsliei* and *penitalis*; in such cases the pigment collects into irregular blotches. Heinrich sepa-
rates penitalis from nubilalis, as follows:

Epicranial puncture O* lying postero-dorsad of ocellus VI; mandible longer than broad; distal tooth concave—P. penitalis.

Epicranial puncture O* lying directly posterior to ocellus VI; mandible square, distal tooth pointed—P. nubilalis.

(Pl. 2, I, J.)

PHLYCTAENIA RUBIGALIS GUENÉE


Phlyctaenia rubigalis Guen. (the greenhouse leaf-tver) is apparently the most widespread and troublesome insect pest with which greenhouse operators have to contend. It is especially troublesome where chrysanthemums are exclusively grown. In New England practically every greenhouse examined in 1920–21 was severely infested by this insect. Although it is primarily a pest of chrysanthemums, it has also been found to attack rose, violet, snapdragon, and geranium. Davis (5, p. 100) found in Illinois that chrysanthemum and spearmint were particularly subject to attack. Infestations have also been found in celery, cabbage, beets, lettuce, cauliflower, and strawberry among garden crops. Many more plants, both ornamentals and vegetables, not mentioned here, doubtless are fed upon by the larvae of this species.

In 1921 the moths appeared in numbers in chrysanthemum houses the first week in May. From this time until the blooms and plants were cut in October and November the insect bred continuously. During the months of July, August, and September it was possible, on examination of greenhouse chrysanthemums, to find the insect in all stages of development—eggs, larvae, pupae, and moths. It was practically impossible to follow the broods in the field on account of the overlapping of generations.

After the blooms are marketed in October and November growers cut the old plants back severely, dumping or burning the tops out of doors. The old plants thus pruned soon give forth shoots which are used for the new crop of chrysanthemums the subseq-quent season. This dumping or burning of the tops reduces in a large measure the infestation, since practically all the developing larvae and pupae are removed from the house. Moreover, the moths flying in the houses have no further place for oviposition, and since it requires a week to 10 days for the old plants to produce shoots the majority of the insects die and the house is rid of the pest. In houses where a variety of ornamentals is grown the insect breeds continuously through the entire year; it is equally abundant in winter and summer. Davis (5) noted that the insect was rarely found in greenhouses during the winter months and attributed the fact to the cooler temperatures prevailing in houses in the winter. In the spring, greenhouses are apparently reinfested from moths emerging from the old chrysanthemum tops or litter out of doors, gaining entry through the ventilators. In midseason in 1921 it required 35 days under glass for the insect to complete its development from egg to adult. The larvae usually pupate in the webbed-up leaves.

The larvae (pl. 1, F) for the most part are surface feeders—a few instances have been noted in market gardens and from specimens received at the Arlington laboratory of the entry of the larvae into the stems of celery—feeding on the under surfaces of the leaves of chrysanthemum and also webbing the leaves together with strands of silk, forming thereby an irregular fabrication in which they live. They have also been observed to feed on the leaf buds in the axils of the expanded leaves and on the flower buds, which on opening produce large irregular blooms. When the larvae are numerous this latter type of feeding greatly discounts the market value of the blooms but has no serious effect on the vitality of the plant.

Full-grown larvae slightly resemble the European corn borer in a superficial way. The distribution of the setae on the body is almost identical in both species. Both are pyralids. The larvae measure when full grown 0.68 inch in length. They are pale sage-green in color and strongly translucent, so that portions of the tracheae, particularly about the spiracles, may be seen through the cuticula in living specimens. Average specimens bear a dark green stripe on the median dorsal plane and two white broader stripes halfway between the former and the pleura. The head capsule is pale yellow and mottled; the thoracic and anal shields are light yellow. The chitinized areas about the tubercles or
pinacula are pale (10, p. 112), indistinct, and sometimes wanting entirely. The chitinization of the pinacula forms the chief character whereby they can be readily separated from the larvae of the corn-borer group.

Two near relatives have been reared at the Arlington laboratory: *Phylactena tertialis* Guen. from elderberry, in which it breeds and overwinters as a larva, and *Phylactena terrealis* Tr. from carnations. The larva of the latter enters the stem of the carnation plant through the crown of terminal leaves. Its presence is readily detected by the wilting of this section of the plant which grows pinch off and unfortunately throw in the walks of their greenhouses. The larvae soon desert these pinched-off parts and return to the living plants to reinfest them. This wilting bears much resemblance to the wilting in certain plants resulting from the attack of the European corn borer, but the latter is not known at this time to infest carnation.

**DIATRAEA ZEACOLELLA DYAR**


Previous to Dyar's separation and description of *Diatraea zeacolella* (the larger cornstalk borer) in 1911 entomological writers on economic subjects referred to this insect as *Diatraea saccharalis* Fab., believing the species injuring corn identical with the one doing damage to sugar cane.

The larger cornstalk borer is primarily a southern insect. The records by various workers, especially Leiby (17, p. 10), show that it extends from Delaware to Florida, west to Louisiana, and possibly occurs in Kansas, Oklahoma, and Texas. It passes through two complete generations, one in the spring and early summer and the other in late summer and early fall. The overwintering larva pupates in the early spring.

The principal food plant of the insect is the corn plant. Other food plants have been recorded as: Gama grass, sorghum (sorgo), sugar cane (Howard), probably Johnson grass, and Guinea corn (Ainslie).

On hatching from the eggs the larvae feed on the epidermis of the leaves of corn (17, p. 28), finally working their way into the unopened whorl of corn leaves which unopened contain a rather uniformly sized series of holes running across the breadth of the leaf (19, p. 8). Another series of irregular perforations in the leaf may also be present when it fully expands, owing to the fact that the larvae feed within the bud in an irregular way, horizontally or upward, or downward. After feeding in either fashion for a time the larvae desert this part of the corn, migrating downward and reentering the plant generally between the first and second joints. Since the insect has two broods and the nature of the feeding for the two generations of larvae is closely parallel, much real injury is caused to growing corn, the growth of the plant being impaired and production being consequently diminished. The larvae apparently never attack the grain on the ear as do those of the European corn borer. “The larger cornstalk borer habitually passes the winter in the taproot of the corn plant, whereas *nubilalis* may be found at any point in the stalk and in the ear” (Caffrey).

Although the larger cornstalk borer possesses many structural characters common to the European corn borer, the two larvae differ quite radically in appearance. The larvae of *Diatraea zeacolella* are of two types, a summer and a winter form. The essential difference between the two types consists in the pigmentation of the pinacula. In the summer form they are crowned to black, well defined, in strong contrast to the white body and honey-yellow head. In the winter form these areas have all faded out, are pale, indistinct and seem to fuse with the whitishness of the body. The larvae average 24.9 mm., or almost an inch in length. They are, therefore, slightly longer than *nubilalis*, and more robust.

The supracoxal pinaculum on the mesothorax in *Diatraea* bears two setae, No. VI 2 (pl. 2, C); in *nubilalis* this same area is unisetose, seta VI (pl. 2, A) (15, pl. 4, fig. 1).

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2 Larval chaetotaxy is a difficult study. It is particularly difficult to trace setal homologies. The writer makes no pretense of being well informed on the subject. The Roman numerals employed in designating setae follow the system of Dyar, who did the pioneer work in America on this subject. Heinrich's papers have been freely consulted and studied. Fracker (10) has instituted a nomenclature of Greek letters, believing that by its utilization one can more readily grasp the homologies of setae. It seems that Fracker established his homologies by plotting one segment above the other. He failed, however, to take note of the fact that the hairs occur on definite body areas and that their changes in position are caused by modifications of the areas themselves. It has been pointed out clearly by Heinrich that when hairs are absent, as frequently happens on the ninth abdominal segment, it is necessary to trace the folds to determine what body areas have been reduced or crowded aside before one can decide what particular seta is missing. Fracker did not do this and, therefore, frequently has given the wrong designation to his seta. Fracker's system apparently would have been, in many ways, an improvement over the Roman method if he had correctly worked out the homologies between the segments.
Larvae Resembling the Corn Borer

NOMOPHILA NOCTUELLA DENIS AND SCHIFFERMÜLLER

Botyshelvolalis Maassen, 1890, Stübel's Reise, p. 170.

Nomophila noctuella (the celery stalk worm) has been known for a long time, yet notwithstanding its abundance and wide distribution, very few references to it occur in the literature on economic entomology. It is cosmopolitan, occurring in Europe, Algeria, Bengal and the eastern and western parts of the United States.

In 1893 Felt published a paper on this species (7) in which he records the fact that the larvae feed on certain grasses. He also states that Leach in "British Pyralids" records the larvae from Polygonum aviculare in Scotland.

The interest of the writer in Nomophila noctuella is due to its occurrence as a larva on celery in the market gardens in the vicinity of Arlington, Mass. It was found frequently associated with the larvae of Pyrausta nubilalis for which it has been mistaken.

Field observations in New England in 1920–21, supported by insectary rearings, indicate that there are two complete generations, the insect passing the winter as a larva in litter. Felt states that in New York there seem to be three broods a year. At Arlington moths emerged in 1921 during the last week in May, the larvae from which, forming the first generation, pupated and emerged over a 3-week period, from July 7 to July 22. The second-brood larvae, for the most part, were mature the third week in September and passed the winter as such. The pupal stage of the first brood was of 13.8 days duration in 1921.

The eggs, 0.37 mm. in diameter, are globular, slightly compressed at either pole, and sculptured. The sculpturing appears much like that on noctuid eggs—a series of radiating prominent ridges from the poles connected to each other by secondary transverse striae which increase in length in the region of the greatest diameter of the egg. The eggs are a dull white and slightly iridescent, this iridescence disappearing as incubation proceeds. At hatching time the eggs are brown, owing to the brown head capsule and thoracic shield of the larva within. The eggs are laid in groups varying from 4 to 48, but are in nowise attached to one another. They are usually to be found on the under sides of the leaves of the plant.

The larvae (pl. 1, II) were taken commonly from celery on the grooved side of the celery stalk, and also apparently preferred the blanched and semi-blanchled portions of the stalk. Only the outermost stems of the plant were observed to be infested. Since these are discarded when the celery is shipped to market it is doubtful whether the species does perceptible damage to celery. The larvae make irregular, shallow excavations on the stalk, usually covering the area with strands of silk, although instances were found where the feeding was carried on without any silken inclosure over the feeding area. They are surface feeders, never drilling into or tunneling the stalk as is so characteristic of the European corn borer. The larva on being prodded moves forward or backward with equal rapidity.

Full grown larvae measure 0.81 inch in length. They are a pale green or dirty white in color, depending apparently upon what they have been eating. The latter type is invariably found on celery. The head capsule and thoracic shield, as well as the large nearly quadrate areas about the tubercles on the median plane of the back, are chestnut brown. The larvae are distinguished from those of the cornborer group by the unusually long setae or hairs arising from the pinacula on the segments of the body; in Pyrausta nubilalis these setae are comparatively short and stiff. Seta III of the eighth abdominal segment is fully three times the length of the same seta in the European corn borer. Another difference readily noted is in the arrangement of the pinacula on the median plane of the back. These areas are close to those of the opposite half of the larva, and each posterior pair on the abdominal segments follows its antecedents in the same horizontal plane. In the Pyrausta larvae discussed, the posterior median pair of pinacula are lateroventral of horizontal lines drawn through the anterior pair; the four median pinacula on each abdominal segment if connected to one another by an imaginary line would describe a trapezoid on Pyrausta larvae, a parallelogram on those of Nomophila.

LOXOSTEGE SIMILALIS GUENÉE

Botis communis Grote, 1876, Canad. Ent. 8: 90.

The larva of Loxostege similalis (the garden webworm), is a foliage depredator, feeding exclusively in the open or in an irregular fabrication formed by webbing leaves together with silk. It is not a borer as is the European corn borer, yet it resembles the former in color and chitinization; there is no distinction between those of the dorsal and the pleural in color. The insect has been collected only from Mexico and South America. It is particularly damaging in California, Nebraska, Iowa, Missouri, New Mexico, Kansas, Oklahoma, and Texas. In the third last-named States second and third annual cuttings of alfalfa have been entirely destroyed in certain years.

The garden webworm, apparently incorrectly named since it injures to a large extent cereal and forage crops, feeds on and injures beets, sugar beets, potatoes, corn, cotton, wheat, alfalfa, and, doubtless, garden crops. Its natural food appears to be Amaranthus sp. (pigweed), and Chenopodium sp. (lamb's-quarters). Since the year 1909 the injury to alfalfa has steadily increased, becoming more serious and widespread.

A striking difference between this larva and those of the corn-borer group is the habit which the caterpillar of Loxostege has, when full grown, of descending from its food plant to the surface of the soil, where it forms a small silken cocoon in the litter and within this it pupates. The European corn borer, as a rule, pupates within its burrow and never forms a defined cocoon.

The larva is green-brown in color and three-fourths to seven-eighths of an inch in length. The pinacula on the dorsum are strongly chitinized, brown to black, and prominent; those on the pleura are pale and not so strongly chitinized. In Pyrausta larvae heretofore discussed the pinacula on the various parts of the body are uniform with respect to one another in color and chitinization; there is no distinction between those of the dorsal and those on the pleura in color. In nubilalis Seta IV + V on the ninth abdominal segment almost equals Seta III in size; in similalis IV + V is small and vestigial (pl. 2, A, E).

In the latitude of Kansas and Oklahoma the insect apparently passes through four generations, whereas in Texas it seems to breed continuously throughout the year, summer and winter.

FAMILY OLETHREUTIDAE

EPIBLEMA SCUDDERIANA CLEMENS


Epiplumea scudderiana (the Bidens borer) is common throughout eastern Massachusetts and doubtless occurs in equal numbers over the North Atlantic States. Specimens have been received at the European Corn Borer Laboratory from Maine, New Hampshire, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Ohio, and Michigan. With the exception of two records, one occurrence in lamb's-quarters (Chenopodium sp.) and one from burdock (Arctium sp.) the insect has been collected only from beggar-ticks (Bidens frondosa) and goldenrod (Solidago sp.).

Field observations indicate that the insect is single brooded in Massachusetts. In 1921 moths appeared the third week in June, the overwintering...
larae pupating the first week and throughout the month of June and early July. Young larvae were found as early as June 28 in Bidens plants. The majority of the larvae in the field were full grown the third week in September, 1921. The larvae remain over the winter in their food plants. The character of the injury to Bidens was, at any rate, first noticed in 1873 as the European corn borer and other pyralids by the characters enumerated under scudderiana. The character of the injury to Bidens (ragweed borer) has been taken only from Ambrosia artemisiifolia L. (ragweed) (14, p. 141). Apparently it is not common in eastern Massachusetts. It differs from the previous species of Epiblema in having the pinacula on the thorax and abdominal segments feebly pigmented; the setae are pale yellow; the thoracic and anal shields pale; the head light brown in lieu of black. It can be distinguished from the European corn borer and other pyralids by the characters enumerated under scudderiana.

**FAMILY OECOPHORIDAE**

**DEPRESSARIA HERACLIANA DE GEER**


Haemylis umbella Zett., 1840, Ins. Lapp., p. 999.

Depressaria ontariella Bethune, 1869, Canad. Ent. 2: 3.


Depressaria heracliana (the parsnip webworm) is a European species imported into this country probably in the late sixties of the last century. It was, at any rate, first noticed in 1873 as of economic importance, and has since distributed itself over the northern portions of the United States, west and south to the State of Mississippi and in Canada. It has been named the parsnip webworm from the habit which the larva possesses of webbing up the flower and seed heads of the parsnip. The insect breeds on wild carrot and probably on other umbelliferous plants. The larvae (pl. 1, E) of this species were observed in 1921 at Cliftondale, Mass. They were found living in masses and feeding on the flower heads of parsnip, which they had webbed together with strands of silk. In time this nestlike structure becomes dirty and foul from the collection of excreta. When the larvae were one-half to three-fourths grown, they were observed gradually to desert their feeding quarters externally and enter the parsnip stalk, although some remained in the original web and pupated therein. The majority, however, tunneled through the cortex and thin white medulla of the
plant, feeding in groups on the latter tissue, which lines the hollow stem. The larvae cover their entrances through which they pass into the stalk with tympana of silk. Later the moths rupture these structures as they emerge from the stalk. When full grown, the larva spins a pad of silk against the inside wall of the stem, in which one finds the cremaster of the pupa securely fastened, thus suspending the larval head downward. In 1921, under insectary conditions, the insect remained as a pupa 12.7 days. The moths appeared in mid-July and continued to emerge into August.

Full-grown larvae are slightly smaller than the larvae of Pyrausta nubilalis, to which they bear resemblance. The black head, thoracic shield, and pinacula of the body segment sharply contrast with the yellowish-white integument of the larva. The anal shield is lemon yellow. The dorsal surface is granulated, but the skin granulations are never as dense as in the larvae of Pyrausta. The prespiracular pinacula bear three setae, the chitinous rings of the spiracles are stout and black, the crochets on the planta of the pseudo-pods are in a completed circle, and the setal arrangement on the ninth abdominal segment differs from that of all the larvae previously discussed in this paper (pl. 2, D).

**FAMILY NOCTUIDAE**

*Heliothis obsOLETA FAB.*

* Heliothis obsOLETA Fab., Barnes and McDunnough, 1917, Check List Lepidop. Bor. Amer., No. 1090.

Although the larva of the corn earworm (*Heliothis obsOLETA Fab.*) primarily attacks the grain on the ear of field and sugar corn, it is also known to feed freely on the silk and sparingly on the foliage. The European corn borer attacks all parts of the plant. It habitually lives within burrows made in the stalk, in the midrib of the leaf, on the ear, and in the cob. The corn earworm never drills through the tough fibrous cortex of the corn plant or into the cob. When the insect attacks cotton, however, the larva bores into the boll, destroying the lint and the seeds. Both the corn borer and the earworm feed on the corn kernels, but the larva of the latter invariably enters at the tip end, whereas the corn borer enters the ear at every conceivable point, such as through the tip, through the side, and through the butt, and very frequently, indeed, it lives in the pith of the cob. Caffrey has noted that the breaking over of tassels in a cornfield does not necessarily preclude feeding in these parts by the corn borer, since he has found that the earworm is capable of occasionally doing the very same thing, particularly in late-developing sweet corn. The corn earworm is a most important destructive pest. Estimates have been made of an annual loss of from 2 to 5 per cent of the total corn crop produced in the United States, or of $30,000,000 to $50,000,000. The insect occurs throughout the United States and in many parts of the world.

In addition to the injury inflicted by the earworm to corn, it attacks several important crops such as tobacco and cotton. Tomatoes, beans, forage plants, and many others are periodically damaged. The caterpillars are large, robust forms belonging to the same family of insects as the cutworms. They are exceedingly variable in color, ranging from green to rose, brown to black, striped, spotted, or plain. Thus in a field one may collect larvae which by the layman or to the farmer would seem entirely different. When the larvae have completed their growth they fall or descend of their own accord to the soil, burrow 2 to 5 inches into it, and construct cells wherein they pupate. The corn borer never enters the soil to pupate but transforms in its burrow or in another place of seclusion to which it has migrated. In the Gulf States there are four broods of the earworm annually, along the Gulf coast there may be five or six, whereas in the northern States there are two, with possibly only one in the province of Ontario, Canada. In Massachusetts in 1921 the corn earworm was abundant and destructive.

The larvae are larger than those of the European corn borer, measuring when fully grown 1 1/4 to 1 1/2 inches in length. The dorsal pinacula are small, pale, or black, depending on whether the larva is light or dark colored; the supraspiracular pinacula on the pleura are always black or deep brown. The crochets on the prolegs are characteristic noctuid (pl. 2, M) in a meso-series. In the European corn borer, as pointed out elsewhere, the crochets are arranged in an incompletely circle with the opening outermost. The head capsule of the corn earworm is yellow-brown and mottled, whereas in the corn borer the head capsule is usually
black or a deep chestnut brown and is always black as the larva emerges from the egg. Just as the larvae of the corn borer group have only two setae, IV and V, on the prespiracular pinacula of the prothorax, so on this point the noctuids are structurally identical, but on the third, fourth, fifth, and sixth abdominal segments the setal distribution differs with respect to IV and V; IV is removed quite a distance from V and is directly caudad of the spiracle (pl. 2, H).

ACHATODES ZEAE HARRIS

Gortyna zeae Harris, 1841, Ins. Mass. Inj. Veg., p. 319
Achatodes zeae Harris, Dyar, 1902, List N. Amer. Lepidop., No. 2158; Barnes and McDunnough, 1917, Check List Lepidop. Bor. Amer., No. 2642.

Since Harris described Achatodes zeae (the spindleworm), and the injury to corn caused by its larva, infrequent references have been made to it in entomological literature. Forbes in his classical Twenty-third Report gives an account of it (9, p. 85) and characterizes it as the spindleworm, apparently from the fact that it has been found attacking corn in the so-called spindle stage of that plant.

The species is very abundant everywhere in Massachusetts in elderberry, but has only rarely been seen attacking corn. Dyar (6, p. 174) gives its distribution as the North Atlantic States. On May 28, 1921, eight young larvae were found in an equal number of sweet corn plants, but this corn was not advanced to the spindle stage. The corn was in proximity to a large growth of elderberry. The larvae found in the stalks were in well-defined burrows and were headed upward in these tunnels. The latter are very similar in appearance to those of the European corn borer, but in the above case the seasonal occurrence of Achatodes larvae did not synchronize with the latter. The plants were badly wilted as if from Papaipema attack.

The natural food plant of this species is elderberry in which the larvae have been found in large numbers. On May 17, 1921, it was possible to cut out, from new elderberry shoots springing from the soil, quantities of the larvae. On June 10 they were found in all stages of development. The first pupae were taken in the burrows June 16 and subsequently some were found which pupated in the soil, but pupation occurs largely in the burrows where the larvae developed. The pupae are large, reddish-brown and are supplied with two prominent processes on the cephalic end.

The larva (pl. 1, G) is striking in appearance. Head, thoracic and anal shields, and the pinacula are glossy black; the body of the larva is yellowish-white. On all the abdominal segments, with the exception of the ninth, the two anterior median pinacula are larger than those of the caudal pair; the anterior pair are circular in contour, the caudal pair elliptical. On the ninth abdominal segment the anterior set equals the posterior pair in size.

The larva of this species may be distinguished from other larvae treated in this paper by an examination of the anal shield. This is strongly chitinized, black, rugose, and bears on its caudal margin three pairs or a row of prominent and strongly produced spines.

KEY TO THE SEPARATION OF LARVAE TREATED HERETOFORE

1. Larvae without strongly produced spines on the anal shield... 2
2. Larvae with strongly produced spines on the anal shield... Achatodes zeae
3. Larvae with three setae on prespiracular shield... 3
4. Larvae with two setae on prespiracular shield... 4
5. Setae III and V on prespiracular shield small, indistinct, much smaller than Seta IV... Epiblema scudderiana
6. Setae III and V on prespiracular shield prominent, well defined, equal to Seta IV in size... Depressaria heracliana
7. Crochets on planta of pseudopods arranged in an incomplete circle or penellipse... 5
8. Crochets arranged otherwise; in mesoseries... Heliothis obsoleta
9. Seta III of the eighth abdominal segment normal sized; pinacula bearing Setae VII and VIII, respectively, on the eighth abdominal segment wanting, poorly defined or only lightly chitinized... 6
10. Seta III of the eighth abdominal segment abnormally long, terminating short of the caudal border of the ninth abdominal segment; pinacula bearing Setae VII and VIII, respectively, on the eighth abdominal segment well defined, strongly chitinized... Nomophila noctuella
11. Pinacula on body segments pale and indefinite (D. zeacolella, winter form)... 7
12. Pinacula on body segments strongly chitinized, well defined, and heavily pigmented... 8
7. Supraocular pinacula on the mesothorax furnished with one seta (Seta
No. VI). ........................................................................ Phlyctaenia rubigalis
Supraocular pinacula on mesothorax furnished with two setae (Seta
No. VI). ........................................................................ Diatraea zeaecolella

8. Seta IV and V on the subdorsal pinaculum of the ninth abdominal seg-
ment small and nearly obsolete, this pinaculum bearing one large
seta which is III. ..................................................... Loxostege similalis
Seta IV and V on the subdorsal pinaculum of the ninth abdominal seg-
ment large, almost equal in size to III. ................................. 9

9. (11, p. 178) “Epicranial setae and puncture A; A¢ and A* lying in a
straight line or with A* somewhat postero-lateral of A¢, not postero-
dorsad.” .......................................................................................... 10

“Epicranial setae and puncture A, A¢, and A* forming an obtuse angle
with A* postero-dorsad of A¢. ................................. P. ainslei

10. “Epicranial puncture O¢ lying postero-dorsad of Ocellus VI; mandible
longer than broad; distal tooth concaved” ................................. P. penitalis

“Epicranial puncture O¢ lying directly posterior to Ocellus VI; mandi-
ble square; distal tooth pointed” ........................................ P. nubitalis

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