

NOTES ON LEPIDOPTEROUS BORERS FOUND IN PLANTS, WITH SPECIAL REFERENCE TO THE EUROPEAN CORN BORER

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The advent of the European corn borer, with its tremendous possibilities for injury if ever introduced into the great corn-growing states, has caused us to become much more concerned about the identity of the various caterpillars found feeding inside the parts of plants. The identity of the plant gives little help in this connection, since the corn borer has a very wide range of food plants and seems anxious to add to the list of those already known. Since lepidopterous larvæ vary considerably in their different stages as to colors and color patterns, and there are many with black or brown prothoracic shields and similar colors at the bases of the setæ, it is necessary to go farther than this in their identification. Easy keys are not available for the identification of such species and this paper is offered in the hope that it may aid field workers and others to be reasonably certain whether or not they have found the European corn borer. Of course the matter would be greatly simplified if we could include all the known species of borers in this country, but since material for such a study is now impossible to obtain, let us hope that our search for corn borers will bring to light, not only species hitherto described, but new life histories as well. It is appalling to think how little we know of the life histories, parasites, etc., of this single genus *Pyrausta*, whose one renegade member is costing us, not only great amounts of money but a great deal of time and anxiety as well.

CLASSIFICATION OF BORERS

Lepidopterous borers, in the main, belong to a few families. Nearly all of the species are provided with five pairs of prolegs, four abdominal and one anal, and these are armed with chitinous hooks or crochets. When these are absent the adfrontal area (Fig. 13, no. 29, *adf.*) and the median spine-like spinneret on the labium will distinguish them from larvæ of any other order. This paper does not include leaf-miners, borers in woody plants, or gall-making species.

The character found most reliable so far in the determination of lepidopterous larvæ is the arrangement of setæ on the various body segments. Some other characters have been used, and it seems quite possible that there are others available. In separating the families mentioned here, the arrangement of setæ on the prothorax and of the hooks on the prolegs are sufficient for the majority of cases. The

prothorax nearly always has a chitinized shield on the dorsum which, in most species, does not extend as far ventrad as the spiracle. This area of the thorax properly has six setæ on each side, two of these, one cephalic (seta I) and one caudal (seta II) are usually quite near the median line. The figures show the left side of the prothorax from the median line of the dorsum to that of the venter. Beside these dorsal setæ is a group found nearly always between the spiracle and the cephalic margin of the segment, but sometimes a little ventrad of the spiracle. Farther ventrad is a group, usually of two setæ, between the spiracular group and the coxa. Near the coxæ, usually between them and the median line of the venter, is one, or possibly two setæ, on each side.

The following families may be found in searching for corn borers:

- a Prolegs may be represented by swellings but hooks are never present; thoracic legs may or may not be present; setal arrangement never as in Fig. 11, no. 13. *Prodoxide*
- aa Prolegs, or at least crochets, nearly always present, if not, setal arrangement as in Fig. 11, no. 13. (See *Gelechiidæ*.)
- b A group of three setæ in front of the thoracic spiracle.
 - c Prolegs with one complete circle of large hooks and numerous irregular rows of very small ones (Fig. 11, no. 2) *Acrolophidæ*
 - cc Prolegs never with the small hooks as in Fig. 11, no. 2 and never with more than three rows.
 - d Hooks of prolegs arranged in two bands, one on each side of the proleg (Fig. 11, no. 6) *Ægeridæ*
 - dd Hooks of prolegs arranged in a complete circle (sometimes absent in *Gelechiidæ*).
 - e Of the four setæ nearest the median line on the dorsum of the ninth abdominal segment, the caudal two (setæ II) are closer together than on any other segment (Fig. 11, nos. 9, 10); body usually not tapering at the caudal end nor sharply constricted between segments. *Tortricidæ*
 - ee The four setæ on the dorsum not varying greatly in arrangement on the ninth abdominal segment; body usually tapering at the caudal end and often strongly constricted between segments { *Gelechiidæ*
Ecophoridæ
- bb With two setæ in front of, or occasionally slightly below, the thoracic spiracle; one of the setæ often very weak or small so that it is not easily located.
 - c Hooks of prolegs arranged in a complete circle or one nearly complete (Fig. 12, nos. 16, 17, 25), never with a single row on the mesal margin. . . *Pyralidæ*
 - cc Hooks of prolegs in a single row or band along the mesal margin (Fig. 14, nos. 37, 42) *Noctuidæ*

Prodoxidæ.—The larvæ of this family are found only in *Yuccas* and are only likely to be confused with those *Gelechiidæ* which lack prolegs. The setal and ocellar arrangement should be enough to distinguish them and no gelechiid borer has been described from *Yucca*.

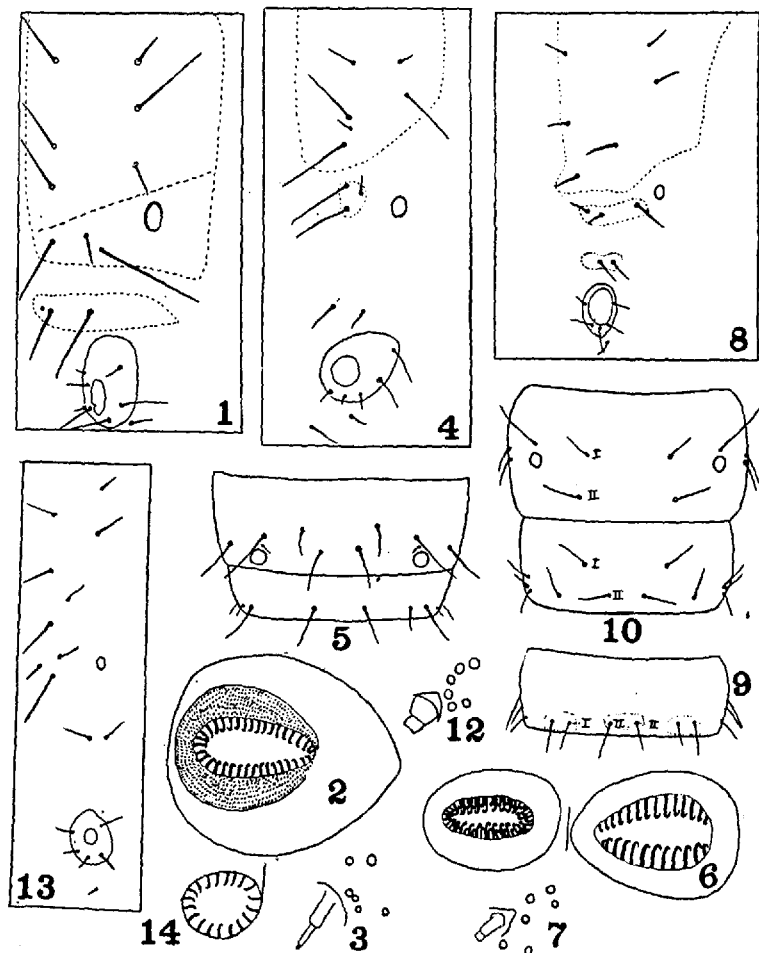


Fig. 11. 1, Acrolophidæ, *Acrolophus mortipennellus*, setal map of prothorax; 2, proleg of same; 3, ocellar arrangement; 4, Aegeriidae, *Melittia satyriniformis*, setal map of prothorax; 5, eighth and ninth abdominal segments; 6, proleg; 7, ocellar arrangement; 8, Tortricidæ, *Eucosma* sp.?, setal map of prothorax; 9, ninth abdominal segment; 10, *Cacæcia* sp., eighth and ninth abdominal segments; 11, proleg; 12, ocellar arrangement; 13, Gelechiidæ, *Melzneria lappella*, setal map of prothorax; 14, proleg of unnamed species.

Acrolophidæ.—These are not true borers but have been taken in the bases of corn stalks while searching for Crambids. These larvæ are often picked up in fields in the fall while they are searching for a place to hibernate. Of the three species listed in the twenty-third Illinois report, one is much more common than the others, *Acrolophus arcanellus* (*Pseudanaphora arcanella*) (Fig. 11, nos. 1-3). The prothoracic

shield is very heavily chitinized on all these species and extends ventrad to include the spiracular group of setæ. The ocellar arrangement is also distinctive.

Aegeriidae.—The only species of this family to be included here is *Melittia satyriniformis*, the squash-vine borer. The arrangement of hooks on the prolegs is distinctive (Fig. 11, no. 6) but figures of the prothorax, ocellar group and eight and ninth abdominal segments (Fig. 11, nos. 4, 5, 7) are given as a contrast to the Tortricidæ, to which this family is closely related.

Tortricidæ.—Several species of this family have been reported from various seeds and seed pods. The commonest genus found boring in stems is *Eucosma*, some members of which form galls. I have several species of this family which are as yet unidentified and figures of one of these from ragweed, which may be a species of *Eucosma*, are given. These (Fig. 11, nos. 8, 9) show the characteristic tortricid arrangement of setæ on the prothorax, also on the ninth abdominal segment. Another type of arrangement of the setæ on the ninth segment is shown in Fig. 11, no. 10. The ocellar arrangement (Fig. 11, no. 12) has been fairly constant in the species studied. The hooks on the prolegs are usually of two sizes but Fracker (Illinois Biological Monographs, Vol. 2, No. 1) states that in some Tortricids they are all of one size.

Gelechiidæ.—The majority of the larvæ of this family which live in plant stems form galls, and may be identified by Dr. Felt's excellent paper (N. Y. S. M. Bul. 200). The potato tuber moth, *Phthorimaea operculella*, is one which does not form galls, and an unidentified species of this genus has been taken many times in stems of giant ragweed and Silphium. *Metzneria lapella*, found in the fruits of burdock, and *Sitotroga cerealella*, the Angoumois grain moth, illustrate the type of gelechiid in which the prolegs are absent. The arrangement of setæ (Fig. 11, no. 13) will distinguish these larvæ from all others with the hooks of the prolegs arranged in a circle. Most of the boring species examined had hooks of one size (Fig. 11, no. 14) but many species in the family have them like the tortricids (Fig. 11, no. 11).

Ecophoridae.—The commonest member of this family is the parsnip webworm, *Depressaria heracliana*, which, after feeding in the flower heads and among the seeds of various Umbelliferae, and causing a characteristic webbing of the umbel, bores down into the stalk and pupates. The larvæ are true gelechiids, and were at one time included with them. Fracker remarks that "no satisfactory character has been found to separate them" and uses the arrangement of the ocelli which he finds unsatisfactory. The setal arrangement of *D. heracliana* is like that of the gelechiids (Fig. 11, no. 13) but it has proleg hooks of three sizes. It is yellow with black spots around the setæ, and the

abdominal segments show clear spaces much like *Pyrausta penitalis* (Fig. 13, no. 28, b).

Pyralidæ.—This family contains many injurious pests and among them several well-known borers. The larvæ are distinguished by the two setæ in front of the prothoracic spiracle, or slightly below it (Fig. 12, nos. 15, 18, 24) and the arrangement of hooks on the prolegs (Fig. 12, nos. 16, 21, 25) which are nearly always of three sizes, arranged in a complete circle, or in a broken circle, open at the lateral margin. In three of the subfamilies, Phycitinæ, Crambinæ and Pyraustinæ, are species with the boring habit. There is considerable individual variation in nearly all the species of this family making the classification exceedingly difficult. It will be impossible to make anything like a good classification, until a larger number of species have been reared. The following key will separate the principal genera.

- a Hooks of prolegs arranged in a complete circle and of three sizes (Fig. 12, no. 16)
 - b Adfrontal pieces reaching the vertical triangle (see Fig. 13, no. 29) which is very large; eight setæ present on each half of the ninth abdominal segment and not arranged in a straight line. *Elasmopalpus*
 - bb Adfrontal pieces not reaching the vertical triangle, which is of normal size; six setæ present on each half of the ninth abdominal segment, arranged in a straight line.
 - c Spiracular setæ always below the level of the thoracic spiracle (Fig. 12, no. 18); body never with skin sculpturing, as in Fig. 13, nos. 33, 34, but smooth, nor with a chitinized spot caudad of the spiracle on each proleg-bearing segment (see Fig. 13, no. 28, s. p.) body always with prominent black or brown spots around the setæ. *Diatraea*
 - cc Spiracular setæ seldom below the level of the thoracic spiracle (Fig. 12, no. 15), usually at least one of them in front of it, if both are below the level of the spiracle then there is a very distinct chitinized mark caudad of the spiracle on each proleg-bearing segment; skin often with sculpturing as in Fig. 14, no. 33. *Crambus*
- aa Hooks of prolegs not arranged in a complete circle (Fig. 13, nos. 21, 25)
 - b Setæ of prothorax and ocelli arranged as Fig. 13, nos. 20, 22; thorax distinctly narrowed towards the head, which is comparatively small. *Diaphania*
 - bb Setæ of prothorax and ocelli arranged as in Fig. 12, nos. 24, 26; thoracic segments of approximately the same width; head of normal size. . . . *Pyrausta*

Phycitinæ.—The only member of this family likely to be met is *Elasmopalpus lignosellus*, the lesser cornstalk-borer. It is easily distinguished by the character given in the key, also by the peculiar striped and banded appearance. One of the setæ on the lateral surface of the ninth abdominal segment is small and weak and should not be overlooked. *Etiella zinckenella*, reported as boring in beans in the west, belongs here, but is comparatively rare. Another borer in the stems of beans, *Monoptilota nubilella*, forms galls, and is not considered here.

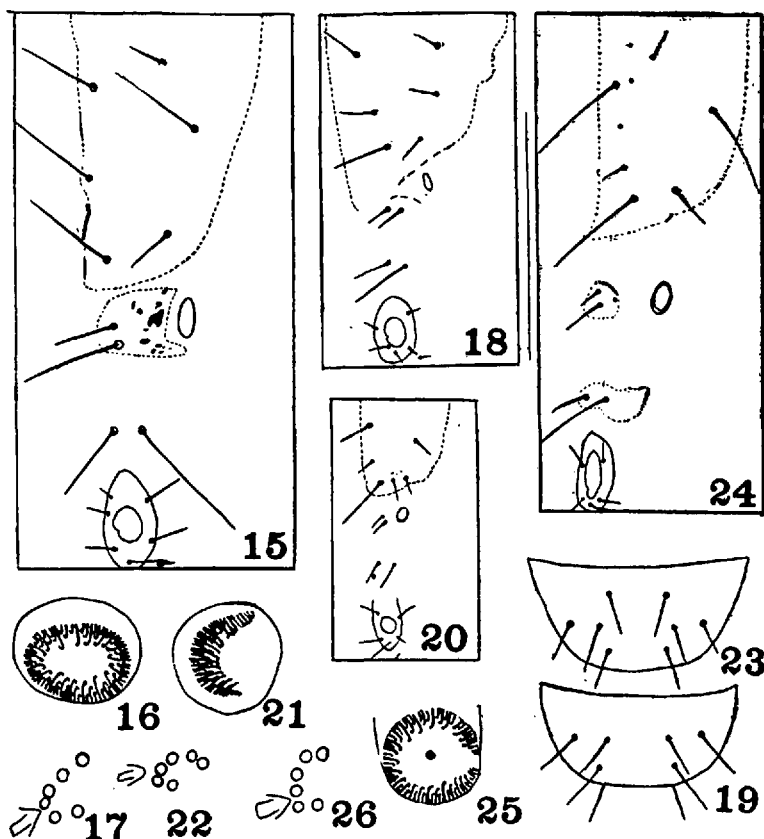


Fig. 12. 15, *Pyralidæ*, *Crambus* sp., setal map of prothorax; 16, proleg; 17, ocellar arrangement; 18, *Diatraea zeacolella*, setal map of prothorax; 19, tenth abdominal segment; 20, *Diaphania nitidalis*, setal map of prothorax; 21, proleg; 22, ocellar arrangement; 23, tenth abdominal segment; 24, *Pyrausta nubilalis*, setal map of prothorax; 25, proleg; 26, ocellar arrangement.

Crambinae.—Many members of this subfamily resemble certain *Pyraustinae* in many characters. The ocellar arrangement (Fig. 12, no. 26) and that of the setæ on the tenth abdominal segment (Fig. 12, no. 19) seem to be very constant characters, as well as those given in the key. Fracker states that some *Crambids* have the proleg hooks arranged in a broken circle like *Pyrausta* (Fig. 12, no. 25) but of two sizes instead of three. None of these have been found among the species under observation. In this subfamily the genus *Crambus* has a few species which are borers, and the genus *Diatraea* has two, the larger cornstalk-borer, *D. zeacolella*, and the sugar-cane moth borer *D. saccharalis cramboides*. Out of the large genus *Crambus* only four named species, *vulgivagellus*, *trisectus*, *leachellus*, and *hortuellus*,

were available and a considerable number of unnamed species. Each of these species could easily be separated from either of the species of *Diatraea* but genus characters are hard to find, owing to the great differences between some of the species, which seemed greater than those between certain of the species and *Diatraea*. In addition to the characters given in the key, there are certain cuticular markings, which may indicate sensory pores, that are always found in *Crambus* and never in *Diatraea*. On the chitinized area in front of the thoracic spiracle bearing the setæ, all *Crambus* species have certain markings, sometimes dark as in Fig. 12, no. 15, or at other times light, and somewhat transparent in appearance. Nearly all the species examined had the darkly chitinized spot caudad of the spiracle on the proleg-bearing segments much as those in *Pyrausta* (Fig. 13, nos. 27, 28, s. p.). On these same segments, and sometimes on others, a small circular or oval area was always found mesad of setæ I. Similar markings are also found in *Pyrausta* (Fig. 13, nos. 27, 28), but always dark-colored; while those in *Crambus* are generally pale.

Pyraustinae.—In addition to the characters given in the key this subfamily may be distinguished by the arrangement of setæ on the tenth abdominal segment (Fig. 12, no. 23), and the different arrangement of the ocelli (Fig. 12, no. 22, 26). Specimens of the genus *Phlyctænia*, which sometimes bores into stalks of celery, have not yet come to hand, so this genus is reluctantly omitted. *Diaphania nitidalis*, the pickle worm, and other species of the genus may easily be separated by means of the key and Fig. 12, nos. 20–22. Out of six species of *Pyrausta* examined, four of them namely—*nubilalis*, *penitalis*, *illibalis* and *futilis*—only two seem very closely related, *P. nubilalis*, the European corn borer, and *P. penitalis*, a borer in *Polygonum* and other weeds. Specimens from the Illinois State Natural History Survey labeled *P. nelumbialis*, now a synonym for *penitalis*, do not resemble other material of this species. They are considerably larger, fully one-third longer, with much finer skin sculpturing, the spiracles more than twice as large, and no trace of certain minute setæ found on both *penitalis* and *nubilalis*. This species varied from other species studied by the characteristic skin sculpturing shown in Fig. 13, nos. 33 and 34. This is considerably coarser in *penitalis*. The two species, *penitalis* and *nubilalis*, are so closely related that they are very difficult to separate. Since *penitalis* occurs in the region infested by the corn borer, and also infests corn, it is important to be able to separate them.

One of the easiest characters is the chitinized shield of the tenth abdominal segment, which is usually truncate along the anterior margin in *penitalis*, as in Fig. 13, no. 32, and with a rounded projection at the cephalo-lateral angle but this character is not reliable, since many

individuals show it with an emargination as in *nubilalis* (Fig. 13, no. 31) and less often with the sharper cephalo-lateral angle usually found in that species. The anterior dorsal setæ (setæ I) on the eight abdominal segments are, like most of the setæ, situated on dark tubercles which are often almost contiguous in *penitalis*, separated by a distance usually much less than the width of the tubercle, while the distance is usually much greater in *nubilalis*, but these vary somewhat. Another useful character, if its variations could be well described are the clear areas of the abdominal segments. These are shown contrasted in Fig. 13, nos. 27 and 28 and again in Fig. 13, nos. 31 and 32. These are always very distinct on each side of the median line on abdominal segments 2-8 in *penitalis*, each space oval, and nearly every space well bounded and separated from the next one, so as to give a row of them a distinctly moniliform appearance. Segments 3-7 usually show these rows of spaces divided into two sections, near the middle of the row, the space between varying in different segments (Fig. 13, no. 28). While these spaces may vary slightly as to number or degree of separation between individual spaces, there is a remarkable uniformity in all the segments. This is never true in *nubilalis*. After studying a large series of specimens, nothing approaching the regularity of *penitalis* was discovered. This species seldom shows anything but an irregular clear strip, but occasionally the spaces on one or two segments will seem to be quite distinct, but this arrangement will be different on other segments. The arrangement of spaces in *nubilalis* is shown in Fig. 13, no. 27 and they are seldom more distinct. When a skin is cleared and mounted the clear spaces in *penitalis* remain unchanged, while the nearest approach to this arrangement in *nubilalis* showed only a clear band, with no subdivision into individual spaces. There is a prominent furrow caudad of the anterior tubercles in *penitalis*, ending at the sensory pore. In *nubilalis* there are many more clear spaces in this location.

The setal arrangement on the head varies in the two species. The anterior setæ and punctures (*ant. 1, 2 ant. P*) have a very constant arrangement. In *penitalis* (Fig. 13, no. 30) they are not in line, the second seta being farther laterad than the first seta and the puncture. In *nubilalis* the setæ and puncture are nearly in line, with the puncture a little laterad. The adfrontal setæ and punctures offer some help in determination, their position in *penitalis* being fairly constant, with the second adfrontal always below seta *P* (Fig. 13, no. 30). The setæ in *nubilalis* are more variable in their arrangement, being sometimes much like *penitalis* with the second adfrontal opposite seta *P*, rarely below it. In many individuals they are as far dorsad as in Fig. 13, no. 29 which represents the extreme in that direction.

The skin sculpturing is of some help, being apparently very constant

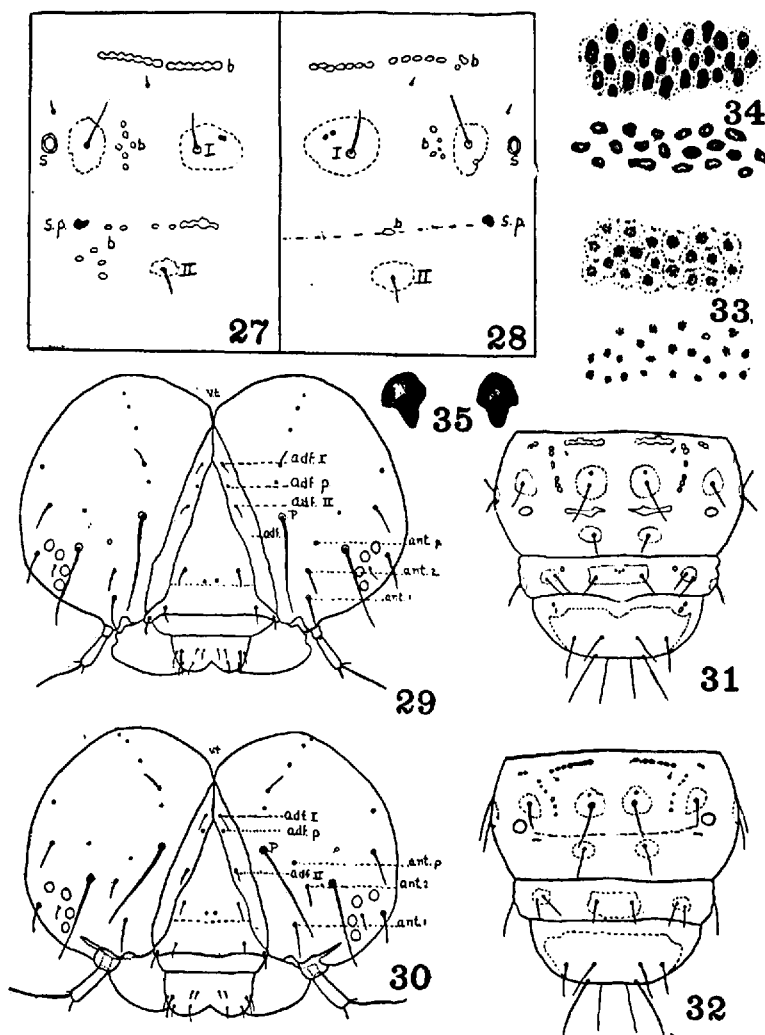


Fig. 13. Comparison of structures, *Pyrausta nubilalis* and *P. penitalis*. 27, *P. nubilalis*, left side, dorsum fourth abdominal segment, I, seta I; II seta II; b, clear spaces; s, spiracle; s. p., sensory pore?; 28, same segment, *P. penitalis*; 29, *P. nubilalis*, cephalic aspect of head, adf. adfrontal area; adf. I, adf. II, adfrontal setae; adf. p. adfrontal puncture; P, large seta of epicranium; ant. 1, ant. 2, anterior setae; ant. p., anterior puncture; v. t., vertical triangle; 30, *P. penitalis*, cephalic aspect of head; 31, *P. nubilalis*, abdominal segments, 8-10; 32, *P. penitalis*, same segments; 33, *P. nubilalis*, skin sculpturing, upper half from between setae of dorsum, fourth abdominal segment; lower, from below spiracle; 34, *P. penitalis*, skin sculpturing from same locations; 35, sensory pores? enlarged.

in *penitalis* as shown in Fig. 13, no. 34. In a very few instances the arrangement in *nubilalis* was found to approach that of *penitalis*, but the majority of cases showed the sculpturing as in Fig. 13, no. 32.

The sensory pores (Fig. 13, no. 35 s. p.) are usually more elongate in *nubilalis*, but vary in the two species.

The remaining species either had conspicuous black or brown spots around the bases of the setæ, as in *P. futilalis* and *P. illibalis*, or very pale yellowish ones. None of these had the chitinized marks (sensory pores) caudad of the spiracles on the proleg-bearing segments as in the previous group. *P. futilalis* has very large hooks on the prolegs and these extend around about two-thirds of the circumference. The labrum is more deeply notched than any of the others and the spiracles are decidedly oblong, edged with a prominent black chitinous ring. The full-grown larvæ average 25 mm. in length. *P. illibalis* is distinguished by the very small prolegs often with black tips. These bear very much smaller hooks than any of the others and when these are retracted the end of the proleg outside the hooks is seen to be covered with minute spines. The labrum is notched like *futilalis* but edged with a band of black. The spiracles are nearly circular with a narrow pale brown ring. The average length of a mature larva is 20 mm.

Noctuidæ.—There are quite a number of noctuid borers and all easily recognized by the characters given in the key. Several species of this family, such as *Arzama obliqua* and *Nonagria oblonga*, which normally bore in the stalks of the cat-tail, have been reported from corn. Other noctuid borers are the iris borer, *Macronoctua onusta*, certain species of *Hadena* reported from corn, *Chloridea virescens* which attacks tobacco, etc. Of all the species of noctuid borers, there were only available, *Papaipema nitela*, the common stalk borer, *P. furcata*, *P. nebris*, and *P. cataphracta*, *Heliothis obsoleta*, the corn ear worm and *Achatodes zeæ*, the spindle worm. These genera may be easily separated by the figures given of each. The stripes on *P. nitela*, the commonest borer, are not always very distinct, especially in the younger stages. The sixth seta on the shield (Fig. 14, no. 43 a) and the second spiracular (Fig. 14, no. 43 b) are usually very weak or wanting. This genus has been carefully studied by Mr. Henry Bird who has written descriptions of many species of larvæ. *H. obsoleta* often bores in stalks and the young stages look considerably like the European corn borer, and has been found in stalks infested by them. The skin sculpturing (Fig. 14, no. 39) is distinctive, no matter what the coloration. It consists of large spiny cuticular appendages, with alternating small spines, while minute ones fill up the spaces. *Achatodes zeæ* is always white with small black spots around the setæ, and the most easily recognized of all the noctuid borers. It is found in a variety of plants

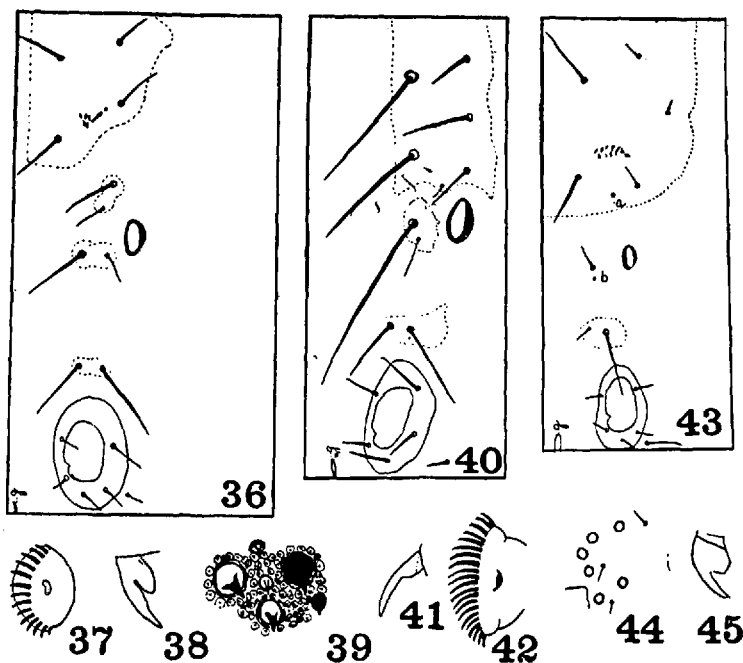


Fig. 14. 36, Noctuidæ, *Heliothis obsoleta*, setal map of prothorax; 37, proleg; 38, tarsal claw; 39, skin sculpture; 40, *Achatodes zeæ*, setal map of prothorax; 41, tarsal claw; 42, proleg; 43, *Papaipema nitela*, setal map of prothorax; 44, ocellar arrangement, typical of Noctuidæ; 45, tarsal claw.

and when mature averages 35 mm. The prothoracic gland is found in all of these noctuids, the slit where it is everted is represented in Fig. 14, nos. 36, 40, 43 g.

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