# The Canadian Entomologist.

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## POPULAR AND PRACTICAL ENTOMOLOGY.

### THE RELATION OF AGRONOMY TO ENTOMOLOGY: A PRACTICAL ILLUSTRATION.

BY JOHN J. DAVIS, WEST LAFAYETTE, INDIANA.

Numerous instances are on record where the occurrence of a noxious insect has resulted in recommendations which are not only effective in controlling the pest, but at the same time a benefit to agriculture. It is here sufficient to illustrate with such common examples as the northern corn root-worm (*Diabrotica longicornis*) and the corn root-aphis (*Aphis maidi-radicis*) which are controllable by proper rotations, and the alfalfa weevil (*Phytonomus posticus*) which is checked by the use of methods beneficial to the plant and disastrous to the insect. Recommendations for Hessian fly control may likewise be considered beneficial from the point of view of the agronomist, since it has been learned that the time of seeding to avoid the fly attack in the fall is coincident with the proper seeding date regardless of insect prevalence, and further that the supplementary recommendation, namely that of destroying the summer brood of fly by plowing under the stubble, is a good agronomic practice according to certain authorities, and especially in those sections where the fly is so frequently abundant.

In the past we have been largely dependent on two practices for the control of the common white grub (*Lachnosterna* spp.), namely that of pasturing hogs in infested fields and a rotation whereby corn, the most important field crop injured by grubs, is planted the year of grub abundance on ground which was continually cultivated during the flight of May-beetles the preceding spring. In other words, the control is practically a recommendation to plant corn on corn ground, that is, corn on ground likely to contain fewer grubs, in order to avoid injury. This can hardly be considered a remedy since it avoids rather than destroys the insect, and the practice of planting corn on corn ground is not good agronomic advice, nor indeed is it a good entomological practice in relation to such insects as the root aphis and root worm.

For several years past our records have shown very little or no injury to corn planted on ground which was in clover the preceding year, and not infrequently observant farmers have reported this condition. The past year observations which are more conclusive and which corroborate the above statment have been made. For instance, last fall at Cascade, Iowa, we collected grubs behind a plow which circled a field, two-thirds of which bore a crop of timothy and one-third a good stand of alsike clover. As the plow turned up the soil in the timothy area the grubs were very abundant but as soon as the clover sod was reached, scarcely a grub could be found. Further, at one corner of the clover area the clover had died out, apparently because the lime had washed away, and the small patch had grown up in smartweed, sorrel and the like, and here the grubs were again abundant as in the timothy end of the field. At Richland, Michigan, a farmer limed his field preparatory to sowing clover, but left one drill row unlimed to satisfy himself on the value of the lime. Last spring when the May-beetles were abundant at Richland there was an excellent stand of red clover over the entire field excepting the unlimed strip which grew up to grass and timothy. An examination this spring revealed 30 to 40 grubs to the square yard in the unlimed strip, that is, where the timothy was growing, while in the rest of the field where the clover had made a good growth only 1 or 2 grubs to the square yard were to be found, and in digging a trench from the clover into the timothy one knew as soon as the timothy strip was reached by an abundance of grubs. All of these facts give us conclusive evidence that May-beetles will not deposit their eggs in numbers in ground which has a stand of clover which covers the ground, probably because the clover mats over the surface and makes it difficult for the beetles to make an entrance.

The natural conclusion is to substitute clover for timothy in the rotation and to follow corn on clover ground, especially the year following an abundance of May-beetles. The growing of clover in place of timothy is a practice which has been recommended and advised by agronomists, but in most sections where the grubs are destructive the advice has not been followed. Farmers, as a rule, tell us they cannot grow clover in northern Illinois, southern Wisconsin and similar latitudes because of winter killing. On the contrary thoroughly competent authorities inform us that if the land is properly prepared for clover the danger of loss by winter killing is of little consequence, and that agriculture would be greatly improved in these sections if it were possible to secure a greater acreage of clover to replace the now large acreage of timothy. With the knowledge we now possess with regard to the importance of clover in the rotation as a means of preventing white grub injury it is not unlikely that it will have some influence in reducing the timothy and increasing the clover acreage in the white grub districts, and in this way in part compensates for the losses which have resulted within the past ten years.

A rotation which we have recommended in the past for the white grub territory of northern Illinois and southern Wisconsin and similar latitudes and which is approved by the agronomists is oats or barley, clover and corn. If oats or barley are on the ground the year of the May-beetle flight it will contain many grubs but since either will be followed by clover which is little injured by white grubs, no harmful results will follow. If the field bears a good stand of clover during May and June of the year May-beetles are abundant, few or no eggs will be laid in the ground and it can be safely followed by corn, while if the field is in corn the year the beetles are abundant, few eggs will be laid if the field is kept cultivated during the flight of the May-beetles,as it naturally should be,and further even should there be eggs laid in the corn ground as there occasionally are when the field is alongside a timber lot, the ground would be planted to oats or barley the following year according to the rotation suggested and these grains are little injured by grubs.

These few facts regarding the role of clover in the rotation to prevent white grub losses are brought together not only to emphasize the entomological importance of this crop, but also to show again the intimate relation between the study of soils and crops and field crop entomology,and the importance of a more intimate correlation of the two subjects.

# NEW SPECIES OF ODONATA FROM THE SOUTH-WESTERN UNITED STATES.

## Part I. Three New Argias.

BY CLARENCE HAMILTON KENNEDY, CORNELL UNIVERSITY, ITHACA, N.Y.

The following new species of Argia have been in the writer's hands for three years awaiting such time as he might have to describe them. The specimens from the Museum of Comparative Zoology labelled *solita* were called to my attention by Dr. Calvert. I wish to thank Dr. Calvert and Dr. Banks for the privilege of describing these. After I had taken *hinei* at Fillmore, Calif., I found that Dr. Hine had taken it in Arizona and his material was in Mr. Williamson's hands awaiting description. I wish to thank Mr. Williamson for the privilege of describing these.

### **Argia solita,** n. sp.

*Holotype.*—Male in the Museum of Comparative Zoology, Cambridge, Mass., with the pin labels; "Arizona, C. U. Lot 35;" and "A. solita." The Cornell catalogue shows that this was purchased from H. K. Morrison in 1883, when it was probably sent to Hagen for identification.

A study of the penes shows this to be a near relative of *Argia agrioides*. Among my material of *agrioides* from California are specimens from Chico which have unforked humeral stripes and which in drying have turned partially violet, so this may be a badly faded, pale variety of *agrioides*.

Length of abdomen 26 mm., length of hind wing 22 mm.

Colour: labium creamy; entire face and head otherwise violet, except rear of head which is pale (creamy?). Eyes?

Prothorax violet with a small black spot on the side. Mesothorax and metathorax violet, shading to creamy below with a mid-dorsal black stripe one-sixth as wide as either mesepisternum. Humeral stripe a hair line and a similar black line on second lateral suture. Legs and feet pale with a narrow, external black stripe on the femur. Wings hyaline, pterostigma mounting but one cell and brown in colour.

Abdomen violet. Segments 1 and 2 without distinct markings except a lateral spot at apex of seg. 1 and a narrow, black ring around apex of seg. 2. Segs. 3–6 each with a narrow, black apical ring and a lateral apical spot of irregular outline which is one-fourth as long as the segment. Seg. 7 with an interrupted, irregular stripe along the side, below the apical end of which is a small detached spot. No apical ring on seg. 7. Segs. 8–10 blue?—some irregular, obscure dark areas along lower side of seg. 8, which may represent a black lateral stripe in better preserved material.

Dorsal appendages short with a large ventral hook on the internal angle. Inferior appendage, bilobed, the lobes triangular and subequal; the posterior lobe directed caudad, the dorsal lobe directed dorsad, bearing on its apex an ill-defined spur directed dorsad. Inferior appendages as long as seg. 10 and twice the length of the superior appendages.

Female unknown.

**Argia alberta,** n. sp.

*Holotype.*—Male, collected by the writer in the Owen's Valley, at Laws, California, August, 1915, and now in the U. S. National Museum.

*Paratype.*—Female, collected by the writer in the Owen's Valley, at Laws, California, August 17, 1915, and now in the U. S. National Museum.

This species simulates *Argia sedula* in colour and appendages, but the penes show this to be more nearly related to the northern *violacea* group, while *sedula* is nearer *translata* and a large series of Mexican species.

I take pleasure in naming it after my father Albert Hamilton Kennedy.

Male, length of abdomen 22 mm., hind wing 18 mm.; female, abdomen 22 mm., hind wing 18 mm.;

*Male.*—Colour: Labrum pale blue, the remainder of the face and head blue with an olive or, in some dried material, a violet cast. Under surface of head yellowish gray with a small black spot on each side of the occipital foramen. Clypeus edged with black. A wide bar through the paired ocelli and a broad, black stripe behind each postocular area. Eyes dark blue, paler below.

Prothorax black dorsally with a bluish spot on each side. Mesothorax and metathorax dull blue (violet or brown in dried material) darker and duller on the dorsal surface and grayish on the sides. Mid-dorsal stripe occupying one-third of the area between the humeral sutures. Humeral stripe half as wide as the mid-dorsal, its upper third forked. A black line on second lateral suture 1 mm. wide.

Pterostigmata brown subtended by one cell. Legs pale with blue on base of femora, broadly marked with black on the dorsal and anterior surfaces of the femora and on the anterior and internal surfaces of the tibiæ. Tarsi black.

Abdomen with segs. 1–3 dull blue becoming duller or brownish on the lower sides. Seg. 1 with a baso-dorsal black spot. Seg. 2 with a narrow apical band and a lateral stripe black. Seg. 3 with the apical third ánd a lateral stripe black. Segs. 4–7 with the apical third and the dorsum black except a narrow basal band blue, the sides bluish or brownish. Segs. 8–10 pure, pale blue the lower edges more or less blotched with black.

Superior appendages twice as long as wide when viewed from above, slenderer in profile. A prominent, internal, apical hook directed ventrad. Inferior appendages bifid, the lower ramus round or bluntly triangular directed caudad, superior lobe directed dorsad and terminating in an acute point.

*Female.*—Colour as in the male but with the blue of the head and thorax paler. Eyes gray bluish above. Humeral stripe but half as wide as in the male, its branches linear. Legs marked as in male but the black on the femora reduced somewhat. Abdomen brown with a narrow apical band on segs. 2–6. Segs. 2–6 with an apical dorsal spot, a lateral stripe and an oblique spot on the lower apical angle of the side. Seg. 7 with dorsal half black except a narrow band across the base. Segs. 8–9 with dorsolateral stripe. Seg. 10 pale. In some females seg. 6 is coloured like 7.

Mesostigmal laminæ with nó special modifications.

A single male of this is in the Snow Collection from Colorado Springs, Colo., collected by E. S. Tucker. A male and female from Provo, Utah, are in the collection of Dr. Ris.

**Argia hinei,** n. sp.

*Holotype.*—Male, collected by the writer at Fillmore, Ventura Co., Calif., Aug. 7, 1915, and now in the collection of Mr. Williamson.

*Paratype.*—Female, collected by the writer at Fillmore, Ventura Co., Calif., Aug. 7, 1915, and now in the collection of Mr. Williamson.

Other material examined included thirteen males and a second female from Fillmore, Calif., and five males from Santa Barbara, Calif., all of which were of the dark typical coloration. A series of specimens from Arizona with less black were as follows: A male in Dr. Calvert's collection labelled "A. solita" by Hagen and which had been associated in the M. C. Z. collection with the type of *solita*. See figs. 17–22. Seven males and a female from the Huachuca Mts., Arizona, collected by Dr. Hine, July 28–29, 1907, and now in Mr. Williamson's collection. A single male from the Santa Rita Mts., Arizona, in the Snow Collection, Kansas University, collected by Dr. F. H. Snow, in June, at an elevation of 8,000 feet.

I take pleasure in naming this after Dr. Hine, a suggestion made by Mr. Williamson.

Male abdomen length 26–27 mm., hind wing 20 mm.; female abdomen 26 mm., hind wing 21 mm.

*Male.*—Colour: Labium and rear of head pale; labrum, face and top of head violet. A black bar through the ocelli; postocular areas edged posteriorly with black. Eyes violet in life.

Prothorax violet with a mid-dorsal stripe and a lateral stripe black.

Mesothorax and metathorax violet with mid-dorsal keel edged with pale; the mid-dorsal stripe slightly wider than either pale stripe bordering it. Humeral stripe one-third as wide as the mesepimeron, forked in its upper third. Second lateral suture narrowly black. Pterostigmata subtended by one cell, brown. Legs pale with a heavy black stripe on the upper and anterior surfaces of femur, and an internal black stripe on the tibia.

Abdomen with segs. 1–7 violet, segs 8–10 blue with the following black markings: a dorso-basal spot on seg. 1, narrow apical rings on segs. 2–7. Seg. 2 with a lateral stripe not reaching the apical edge. Segs. 3–5 with a spot covering apical fourth of the side, the pairs on segs. 4–6 confluent on the middorsal line. A small antero-lateral spot on seg. 6. Seg. 7 with the dorsal half black except a narrow basal band; and having a small latero-apical spot in the ventro-apical angle of the segment. Segs. 8 and 9 with more or less black on the lower sides.

Some males show antero-lateral spots on segs. 4–6.

The specimens from Arizona have less black on the head and thorax. In Dr. Calvert's specimen the humeral stripe shows no trace of a fork. In the male from the Santa Rita Mts. the humeral stripe is forked and almost as heavy as in the Fillmore and Santa Barbara specimens. The specimens from the Huachuca Mts. have humeral stripes from the narrow form in the Dr. Calvert male to those in which a fork is suggested by a more or less perfect branch, but in all cases narrow.

Appendages: superior appendage cupped on the ventral surface, with a tooth on the ental edge, which turns under the appendage thus being directed ectad; and a blunt, black subapical ventral tubercle. Inferior appendage bifid, the lower lobe rounded or triangular, the upper directed caudad and bearing a small tooth on its upper edge.

Female coloured brown with the black markings on the head and thorax as in the male. Eyes in life brownish violet. The abdomen with lateral stripes on segs. 2–9, those on segs. 7 and 8 more or less confluent with their mates along the mid-dorsal line. Segs. 2–8 with a latero-apical oblique spot on the lower apical angle of the side. Segs. 2–7 with a narrow apical ring.

The female mesostigmal laminæ have each a small posterior, free lobe.

## Explanation of Plate V.

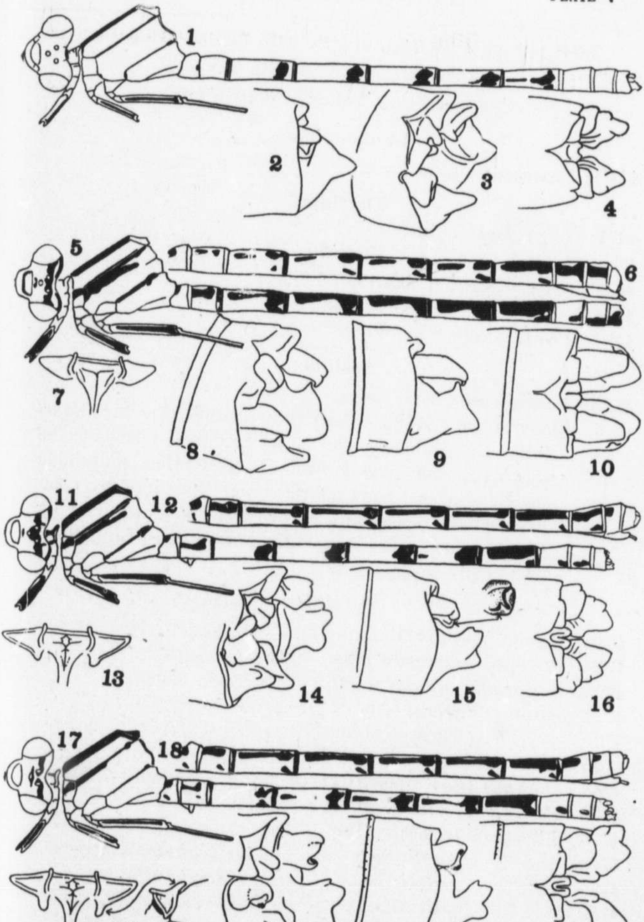
Figs. 1–4. Holotype of *Argia solita*. Fig. 1 colour pattern, figs. 2–4 appendages.

Figs. 5–10. Types of *Argia alberta*. Fig. 5 colour pattern of male, fig. 6 of abdomen of female; fig. 7 mesostigmal lamina of female. Figs. 8–10 male appendages.

Figs. 11–16. Types of *Argia hinei*. Fig. 11 colour pattern of male, fig. 12 of abdomen of female; fig. 13 mesostigmal lamina of female. Figs. 14–16 appendages of male.

Figs. 17–22. Pale *Argia hinei* from Arizona. Figs. 17, 20–22 the male labeled *solita* by Hagen and now in Dr. Calvert's coll.

Figs. 18–19. Female from the Huachuca Mts.




THREE NEW ARGIAS.

See p. 260.

# THE HEATH COLLECTION OF LEPIDOPTERA.

BY J. B. WALLIS, WINNIPEG, MAN.

(Continued from Vol. XLIX, page 229.)

## Limacodidæ.

4445 *Tortricidia testacea* Pack.

## Thyridæ.

4471 *Thyris lugubris* Bdv.

## Cossidæ.

4482 *Cossus* (*Acossus*) *centerensis* Lint.
4483 " " *populi* Walk.
4487 *Prionoxystus robiniæ* Peck.

## Sesiidæ.

4523 *Bembecia marginata* Harr.

Many of the "Micros" had been identified by Mr. Kearfott. Unfortunately the names had been taken off the specimens and placed behind series often containing several species. Some of these were identified by comparison with specimens in my collection, identified by Mr. Kearfott. The remainder were sent to Mr. Busck who kindly went over them.

## Pyralidæ.

4640 *Desmia funeralis* Hbn.
4703 *Evergestis straminalis* Hbn.
4709 *Nomophila noctuella* Schiff.
4714 *Loxostege chortalis* Grt.
4725 " *sticticalis* Linn.
4726 " *commixtalis* Wlk.
4748 *Diosemia plumbosignalis* Fern.
4769 *Peripasta cæculalis* Zell.
4770 *Phlyctænia ferrugalis* Hbn.
4773 " *itysalis* Wlk.
4779 " *terrealis* Tr.
4782 " *tertialis* Gn.
4789 *Pyrausta thestealis* Wlk.
4792 " *oxydalis* Gn. Probably.

4805 *Pyrausta fumalis* Gn.
4811 " *fumoferalis* Hulst.
4812 " *unifascialis* Pack.
4814 " *fodinalis* Led.
4816 " *perrubralis* Pack.
" *ochosalis* Dyar.
4824 " *generosa* G. & R.
4837 " *nicalis* Grt.
4842 " *funebris* Strom.
4858 *Nymphula icciusalis* Wlk.
4863 " *badiusalis* Wlk.
4866 " *maculalis* Clem.
4881 *Scoparia centuriella* Schiff.
4888 *Pyralis farinalis* Linn.
4895 *Herculia himonialis* Zell. This, according to Drs. Barnes & McDunnough is an abberation of *olinalis* Gn.
4913 *Schœnobius unipunctellus* Rob.
4916 " *tripunctellus* Rob.
4917 " *mellinellus* Clem.
4917b " *albicostellus* Fern.
4918 " *clemensellus* Rob.
4936 *Crambus pascuellus* Linn.
4939 " *unistriatellus* Pack.
4940 " *præfectellus* Zinck.
4953 " *perlellus* Scop. (*innotatellus* Wlk.)
4958 " *vulgivagellus* Clem.
4960 " *ruricolellus* Zell.
" *dorsipunctellus* Kearf.
4974 " *mutabilis* Clem.
4977 " *trisectus* Wlk.
4980 " *caliginosellus* Clem.
4982 " *luteolellus* Clem.
*Thaumotopsis fernaldellus* Kearf.
4995 *Argyria auratella* Clem.
5000 *Diatræa idalis* Fern.
5004 *Chilo comptulatalis* Hulst.
5079 *Mineola tricolorella* Grt.
5108 *Ambesa lætella* Grt.

5110 *Ambesa niviella* Hulst.
5127 *Meroptera pravella* Grt.
5150 *Salebria basilaris* Zell.
5155 " *purpurella* Hulst. (*Myrlœa delassalis* Hulst.)
5159 *Laodamia fusca* Haw.
5175 *Epischnia albiplagiatella* Pack.
5176 " *boisduvaliella* Gn.
5185 *Megasis atrella* Hulst.
5189 *Lipographis leoninella* Pack.
5232 *Hulstia undulatella* Clem.
5258 *Homœosoma uncanale* Hulst.
5270 *Moodna ostrinella* Clem.
5300 *Peoria approximella* Wlk.

## Pterophoridæ.

5326 *Platyptilia cosmodactyla* Hbn. In the collection as *punctidactyla* Haw., which is a synonym.
*Platyptilia pallidactyla* Haw.
5351 *Pterophorus homodactylus* Wlk.
5352 " *brucei* Fern.
5370 " *monodactylus* Linn.

## Tortricidæ.

5424 *Exartema fasciatanum* Clem.
5427 " *inornatanum* Clem.
5434 *Olethreutes* (*Argyroploce*) *nimbatana* Clem.
5436 " " *capreana* Hbn.
5437 " " *dimidiana* Sodoff.
5444 " " *hemidesma* Zell.
5452 " " *duplex* Wlsm.
5453 " " *nubilana* Clem.
5460 " " *constellatana* Zell.
5467 " " *instrutana* Clem.
5469 " " *campestrana* Zell.
5474 " " *bipartiana* Clem.
5489 *Eucosma morrisoni* Wlsm.
5493 " *ridingsana* Rob.
5496 " *circulana* Hbn.
5503 " *agricolana* Wlsm.

5528 *Eucosma culminana* Wlsm.
5532 " *juncticiliana* Wlsm.
" *confluana* Kearf. A form of *dorsisignatana* Clem.
" *heathiana* Kearf.
" *pallidicostana* Wals.
" *annetteana* Kearf.
" *imbrifiana* Dyar. Probably.
" *costastrigalana* Kearf.
" *bilineana* Kearf.
" *tenuiana* Wals.
" *awemeana* Kearf.
" *umbrastriana* Kearf.
5552 " *illotana* Wlsm.
5559 " *dorsisignatana* Clem.
5573 *Cydia radiatana* Wlsm.
" *dorsiatomana* Kearf.
" *pseudotsugana* Kearf.
" *triangulana* Kearf.
5633 *Epinotia fasciolana* Clem.
5654 *Ancylis mediofasciana* Tr.
5655 " *nubeculana* Clem.
5663 " *burgessiana* Zell.
5718 *Acleris subnivana* Wlk.
5722 " *nigrolinea* Rob. Probably.
5726 " *hastiana* Linn.
5740 " *cervinana* Fern.
5752 *Cenopis reticulatana* Clem.
5756 " *groteana* Fern.
*Sparganothis idæusalis* Wlk.
5765 *Sparganothis puritana* Rob.
5766 " *xanthoides* Wlk.
5767 " *irrorea* Rob.
" *vocaridorsana* Kearf.
5773 *Archips rosaceana* Harr.
5774 " *purpurana* Clem.
5777 " *cerasivorana* Fitch.
5796 " *persicana* Fitch.
5804 *Platynota sentana* Clem.

*Pandemis canadana* Kearf.
5811 *Tortrix alleniana* Fern.
5816 " *quercifoliana* Fitch.
5826 " *conflictana* Wlk.
5827 " *osseana* Scop.
" *clemensiana* Fern.
5829 " *argentana* Clerck.
5840 *Eulia triferana* Wlk.
5851 *Phalonia vitellinana* Zell.
5892 *Hysterosia inopiana* Haw.
" *cartwrightiana* Kearf.
" *merrickana* Kearf.

## Yponomeutidæ.

6033 *Harpipteryx canariella* Wlsm.
6034 " *dentiferella* Wlsm.
6035 " *frustella* Wlsm.

## Gelechiidæ.

6164 *Gnorimoschema gallæsolidaginis* Riley.
6226 *Gelechia lugubrella* Fab.
6254 " *ornatifimbriella* Clem.
6262 " *pseudoacaciella* Cham.
6335 *Trichotaphe flavocostella* Clem.
6344 " *setosella* Clem.

## Xyloricitidæ.

6380 *Stenoma algidella* Wlk.

## Œcophoridæ.

6402 *Depressaria arnicella* Wlsm. Probably.
6403 " *argillacea* Wlsm.
6404 " *sanguinella* Busck.
6409 " *novimundi* Wlsm.
6412 " *ciniflonella* Zell. Probably.
6421 " *canadensis* Busck. Probably.
" *juliella* Busck.
" (*Agnopteryx*) *flavicomella* Engel.
" " *walsinghamiella* Busck. According to the new list a synonym of *fernaldella* Wlsm.

6436 *Semioscopsis packardella* Clem.
6438 " *aurorella* Dyar.
6439 " *megamicrella* Dyar.
6440 " *inornata* Wlsm.
6443 *Ethmia fuscipedella* Wlsm.

### Elachistidæ.

*Mompha claudiella* Kearf.

### Tineidæ.

7024 *Tineola bisselliella* Hum. Probably.
7026 *Monopis biflavimaculella* Clem.
7030 " *monachella* Hbn.

### Hepialidæ.

7150 *Sthenopis argenteomaculatus* Harr. Probably.
7151 " *quadriguttatus* Grt. Probably. A study of our Manitoban forms of *Sthenopis* is desirable.

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## ECOLOGICAL NOTES ON THE SPRING CANKER WORM (*PALEACRITA VERNATA*, PECK).

BY B. P. YOUNG, CORNELL UNIVERSITY, ITHACA, N.Y.

During the past few years the elm trees of Lawrence, like those of many other Kansas municipalities have suffered materially from infestations by the spring canker worm, *Paleacrita vernata*, Peck. In fact, the large increase in numbers of this insect during the spring of 1916 seemed to foretell the impending danger of a worse devastation the next season and brought about a co-operative move on the part of the citizens to control the pest. Early in February, 1917, the city commissioners banded all elm trees, and other trees adjacent, as well as poles, with tar paper and tanglefoot, both in yards and on terraces in front. The cost of this work, combined with that of keeping the tanglefoot sticky during the season of emergence, was charged to the various taxpayers concerned.

Realizing the advantages of such conditions for an ecological study of the pest, the writer, while associated with the Department of Entomology of the University of Kansas, chose a district in which the trees had been completely defoliated the previous year and carried on the experiment outlined below.

The initial objects of the experiment were (1) the determination of the minimum temperature at which adults would emerge from the ground; (2) the average number of eggs laid by each female; (3) the incubation period; (4) the lowest temperature at which eggs would hatch, and (5) the percentage of sterility among eggs. Incidentally other interesting results were obtained.

On February 27th and on each of the twenty-five succeeding days which were warm enough to permit the emergence of adults from the ground, 100 female moths were collected from the trunks of a certain group of eight trees, either from the free portion below the bands or from the cotton beneath the bands. On two days, the 4th and 5th of March, the temperature became prohibitive to the emergence of the females, and on the 6th of the same month two separate increments were taken as a check upon each other, thus basing the results of the experiment upon the activities of 2,500 females.

Each increment of 100 females was taken to the insectary and placed immediately in a wide-mouthed, four-ounce bottle, containing a loose roll of cheesecloth. The mouth was then covered with the same material and the bottle kept under ordinary inside conditions of temperature, humidity, etc.

On each succeeding day, including the fourth, the eggs were scraped from the cheesecloth roll and weighed on a balance, accurate to milligrams. These eggs were then placed in separate vials, plugged with cotton, and placed outside a west window of the insectary office in a window box. All eggs deposited after the fourth day of confinement up to the time of death of all females were weighed together and placed in the fifth vial of a series of five.

In order to determine the average number of eggs to the milligram two large masses of eggs, especially free from foreign particles, were counted. Knowing the weight in milligrams and the total number of eggs in each, the desired average was readily computed. These two counts gave results so nearly identical that it was decided that the consideration of other masses was unnecessary, and an average of the results obtained in these two cases was used throughout the experiment.

Vials containing eggs were examined from day to day and

Milligrams of eggs deposited by 100 *Paleacrita vernata* ♀♀ during night of –

| Increments of 100 ♀♀ | II-27 | II-28 | III-1 | III-2 | III-3 | III-4 | III-5 | III-6 | III-7 | III-8 | III-9 | III-10 | III-11 | III-12 | III-13 | III-14 | III-15 | III-16 | III-17 | III-18 | III-19 | III-20 | III-21 | III-22 | III-23 | III-24 | III-25 | III-26 | III-27 | III-28 | Total-Mgs. | Days ♀♀ were kept |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 373 | 211 | 61 | 22 | 30 | | | | | | | | | | | | | | | | | | | | | | | | | | 697 | 12 |
| B | | 302 | 230 | 59 | 29 | 18 | | | | | | | | | | | | | | | | | | | | | | | | | 638 | 10 |
| C | | | 252 | 232 | 118 | 27 | 45 | | | | | | | | | | | | | | | | | | | | | | | | 674 | 9 |
| D | | | | 312 | 394 | 93 | 62 | 22 | | | | | | | | | | | | | | | | | | | | | | | 883 | 9 |
| E | | | | | 91 | 279 | 230 | 100 | 62 | | | | | | | | | | | | | | | | | | | | | | 762 | 10 |
| F | | | | | | | | 227 | 393 | 175 | 57 | 12 | | | | | | | | | | | | | | | | | | | 864 | 7 |
| G | | | | | | | | 230 | 382 | 143 | 50 | 26 | | | | | | | | | | | | | | | | | | | 833 | 7 |
| H | | | | | | | | | 189 | 425 | 104 | 42 | 55 | | | | | | | | | | | | | | | | | | 815 | 8 |
| I | | | | | | | | | | 214 | 372 | 152 | 53 | 65 | | | | | | | | | | | | | | | | | 856 | 10 |
| J | | | | | | | | | | | 273 | 235 | 43 | 22 | 42 | | | | | | | | | | | | | | | | 615 | 10 |
| K | | | | | | | | | | | | 260 | 198 | 74 | 70 | 81 | | | | | | | | | | | | | | | 683 | 9 |
| L | | | | | | | | | | | | | 110 | 477 | 148 | 43 | 38 | | | | | | | | | | | | | | 816 | 10 |
| M | | | | | | | | | | | | | | 189 | 263 | 58 | 22 | 33 | | | | | | | | | | | | | 565 | 9 |
| N | | | | | | | | | | | | | | | 365 | 232 | 24 | 22 | 39 | | | | | | | | | | | | 682 | 9 |
| O | | | | | | | | | | | | | | | | 330 | 272 | 80 | 40 | 33 | | | | | | | | | | | 755 | 8 |
| P | | | | | | | | | | | | | | | | | 158 | 141 | 183 | 63 | 70 | | | | | | | | | | 615 | 8 |
| Q | | | | | | | | | | | | | | | | | | 122 | 200 | 170 | 62 | 51 | | | | | | | | | 605 | 7 |
| R | | | | | | | | | | | | | | | | | | | 155 | 250 | 153 | 92 | 62 | | | | | | | | 712 | 9 |
| S | | | | | | | | | | | | | | | | | | | | 150 | 190 | 159 | 56 | 42 | | | | | | | 597 | 10 |
| T | | | | | | | | | | | | | | | | | | | | | 282 | 215 | 74 | 30 | 18 | | | | | | 619 | 9 |
| U | | | | | | | | | | | | | | | | | | | | | | 330 | 270 | 103 | 63 | 62 | | | | | 828 | 9 |
| V | | | | | | | | | | | | | | | | | | | | | | | 163 | 320 | 103 | 46 | 45 | | | | 677 | 8 |
| W | | | | | | | | | | | | | | | | | | | | | | | | 311 | 240 | 115 | 66 | 52 | | | 784 | 11 |
| X | | | | | | | | | | | | | | | | | | | | | | | | | 217 | 180 | 101 | 48 | 41 | | 587 | 12 |
| Y | | | | | | | | | | | | | | | | | | | | | | | | | | 218 | 188 | 42 | 50 | 21 | 519 | 11 |

Fig. 10—Data

Grand total of eggs deposited by 2500♀♀ – 17,681 mgs.
Average number of days ♀♀ were kept before all were dead – 9+.

were recorded as hatching when at least twenty-five larvæ had emerged. Oftentimes one or two larvæ would appear in a vial several days before the majority of the eggs were ready to hatch.

For the determination of the percentage of sterility in the eggs, those oviposited by ten different increments of 100 females were used, giving in all 50 vials of eggs. The number of eggs failing to hatch when compared with the total number of eggs in a vial gave the percentages of sterile and fertile eggs therein.

Furthermore, 25 females were taken from the sticky bands to see what effect the tanglefoot on the body of the insect would have upon the number of eggs deposited.

Observations upon the number of males and females emerging from a very limited area were ascertained by placing a light-tight box over this surface and counting those coming up within. By placing a shell vial in a cornucopia-shaped piece of cardboard in the side of the box the adults emerging would seek the light of the vial and could be counted from day to day. Unfortunately, the possibilities of this phase of the experiment presented themselves too late for the collection of sufficient data upon which to base definite conclusions. It would be interesting to learn whether the relative proportion of males to females differs materially during the season of emergence.

Average indoor temperatures were secured from a self-recording thermometer by averaging the twelve hourly readings during the day and night, respectively.

Outdoor mean day and night temperatures were computed from the daily readings taken by the physics department at 7 a.m., 2 p.m., and 7 p.m. The mean night temperature was assumed to be the average of the readings of the thermometer at 7 p.m. and 7 a.m. The mean day temperature, however, was not so easily obtained, but by giving the 2 p.m. reading double significance, as this was probably the highest daily temperature reading, and using this reading with those at 7 a.m. and 7 p.m. a fair average was secured. Thus, in order to compute the mean day temperature on March 25, '17, which showed the following readings: 7 a.m., 43°; 2 p.m., 69.5°; and 7 p.m., 64°, we would add 43,69.5, 69.5, and 64 and divide by four, getting 61.5°.

Fig. 10 is primarily a data sheet. Here the letters of the alphabet are used to designate the several increments of 100 females collected. The groups of figures extending diagonally across the plate represents milligrams of eggs deposited on successive nights from February 27th until March 24th, inclusive. The first four figures of each horizontal row indicate the deposits of a single increment during the first four nights in the insectary; the fifth, all after the fourth night until the entire increment of 100 females was dead. The last vertical column represents, in days, the length of time each increment was kept; the column next to this the total number of milligrams of eggs deposited by each increment. A grand total of the eggs deposited by the 2,500 females appears below as well as the average number of days the insects were kept before all were dead.

The number of eggs to the milligram was computed by counts made of the eggs deposited by increments *O* and *R* on the nights of March 14th and 18th, respectively, these masses being exceptionally free from foreign particles. The count on the former, weighing 330 milligrams was 3,851 or 11.67 eggs to the milligram; that on the latter, weighing 250 milligrams, was 2,930 or 11.72 eggs to the milligram. These results were considered close enough to warrant the adoption of 11.7 to be used as a multiplier in changing milligrams to number of eggs.

Table III shows the number of eggs considered in computing the incubation period for different parts of the season, together with the total number of eggs upon which was based the determination of the average number of days spent in the egg stage.

Table IV gives the data upon which the calculation of the average percentage of fertility of the eggs depends. In each case the letter in the first vertical column specifies the particular increment whose total number of eggs deposited during each successive night is designated and totalled; whose sterile eggs deposited during each successive night is recorded and totalled; and the computed percentage of sterile eggs for each night's deposit appears with its average. At the bottom of the table appear grand totals which show an almost identical percentage of sterility in the first two nights' deposits with an increase thereafter approximating a geometrical ratio.

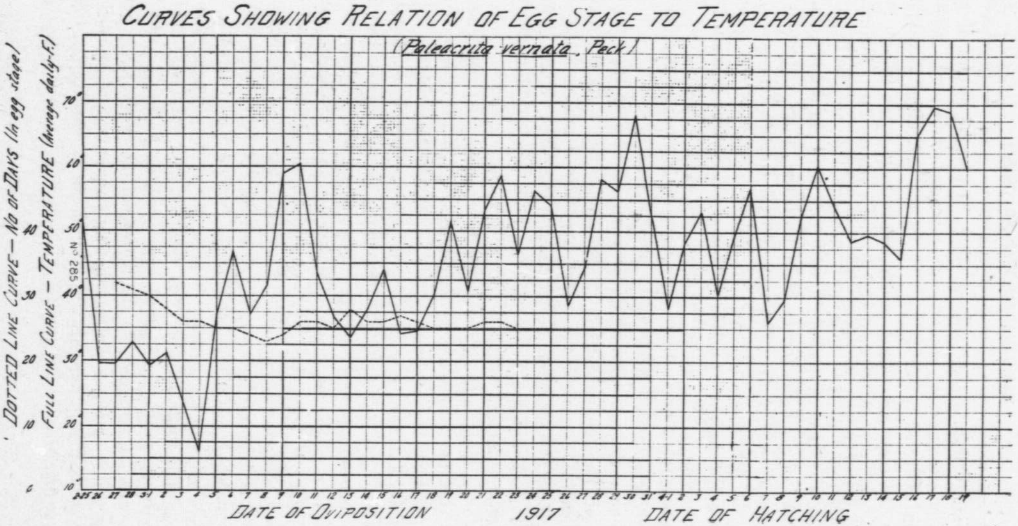
CURVES SHOWING RELATION OF EGG STAGE TO TEMPERATURE
(Paleacrita vernata, Peck)
DOTTED LINE CURVE — NO OF DAYS (In egg stage)
FULL LINE CURVE — TEMPERATURE (Average daily-F.)
DATE OF OVIPOSITION
1917
DATE OF HATCHING

Fig. 11

The relation of the duration of the egg stage to outdoor temperatures is shown graphically in Fig. 11. The full line temperature date curve was plotted by using the average daily outdoor temperatures as ordinates and the dates as abscissæ; the broken line egg-stage-date of oviposition curve, by using the incubation period as ordinates and dates of oviposition as abscissæ. On the same plate the parallel transverse lines represent the incubation periods of eggs laid at different times during the season; the left end indicating the date of oviposition and the right that of hatching.

Passing now to the consideration of results it seems best to discuss first the reasonably definite conclusions and later those which might be termed suggestive.

The females began to oviposit during the second night after emergence from the ground, if we assume that most of the moths collected each day emerged the evening of the preceding day. Or, in other words, they began to oviposit during the first night in captivity. The relative percentages of eggs laid during each day following collection are: 1st, 32.93%; 2nd, 38.4%; 3rd, 15.64%; 4th, 7%; during remaining period of life, 6.03%. It is interesting to note that 71.33% of all eggs deposited appeared during the first two nights after the moths were collected.

The average number of eggs deposited by each female under the conditions of the experiment was surprisingly low. The 17,681 milligrams of eggs deposited by 2,500 females means only an average of 82.7 eggs apiece, which when contrasted with figures running as high as 400 given by dissections as well as by standard texts, seems hard to account for. In all probability the females of this species, like those of many others among insects, normally fail to deposit all the eggs of which they are capable or possibly some sterile females die before leaving a single mass of eggs.

Turning to the figures on the percentage of sterility of eggs we find the following averages for all laid during the various nights in captivity: 1st, 10.8%; 2nd, 11.2%; 3rd, 22.4%; 4th, 46.7%; and thereafter, 82.8%, with a general average of 19.15% sterility. Therefore, if the average females lay 82.7 eggs and 19.15% of these are sterile we can say, disregarding all other casualty factors, that each emerging female will ordinarily start sixty-eight larvæ on their perilous life cycles.

The longest incubation period for any egg mass was found to be 32 days, the shortest 23, with an average of 26 days. Undoubtedly, as is to be expected, temperature plays an important role in the determination of this period, for eggs exposed to the sun, on account of a crack in the window box, under the identical conditions of others in other respects, hatched at least two or three days before those better protected from its rays.

The average number of days the females lived after being taken was about nine, although individuals varied widely in this respect.

Considering now some of the suggestive results we find good reasons for believing that the temperature prohibitive to the emergence of females is between 20 and 25° F. During the first four days of the experiment the average daily temperature remained steadily below freezing, about 30° F., and females were found in abundance, but during the fifth night the temperature dropped to 18° and as a result it was impossible to secure the moths either the next day or the following, which was preceded by a night even colder, but on the third day thereafter, following a decided rise in temperature during the previous day and night, plenty of moths were taken. The temperature of the fifth night was assumed to be that critical to the emergence of the females.

A study of Plate II shows no eggs hatching on April 1st, 4th, 7th, 8th and 15th at temperatures of 38, 40, 36, 39½ and 46 degrees respectively, but on the other hand on April 2nd, 5th, 12th, 13th and 14th they are shown to have hatched at temperatures as low as 48½, 50, 49, 49½ and 48½ degrees. Based upon the above figures an average daily temperature around 45° F. might be considered as that fatal to the hatching of eggs in the ordinary run of weather.

The count made upon the males and females emerging under a single light-tight box, 17 x 25½ inches in area, showed 34 males and 11 females, or approximately 75% of the whole number were of the winged sex.

On March 20th aside from the usual 100 normal females, 25 were taken from the tanglefoot bands, each having a certain amount of this sticky material on its abdomen. Comparing the 33 milligrams of eggs laid by the latter 25 females with 828 milligrams by the above-mentioned 100 females, we find that in case a moth is able to drag herself through the sticky band and go on up the tree she is not likely to deposit more than 16% as many eggs as she would otherwise have done under normal conditions. The conclusion to be drawn is that even those bands which do not keep the moths away from the lower branches are somewhat effective.

It was found by isolating individuals that eggs are not all deposited at one time but may be laid in at least four different masses. Almost always sterile eggs appeared bunched together, as if from one female and not a few here and there, mixed with fertile ones.

In conclusion, we might add one more suggestion gathered from the data on the fertility of eggs, Table IV. It would seem from the consideration of the uniformity which the grand total of the number of sterile eggs indicates for each succeeding night, when compared with the pronounced dropping off in the total number of eggs laid after the second night, that the sterile females retain their eggs as long as possible, while most of the fertile females oviposit during the first or second nights after emergence.

Results of similar experiments in other localities would be interesting for comparison.

TABLE I.

MEAN TEMPERATURES (FAHRENHEIT DEGREES).
INSECTARY OFFICE. 1917.

| Date | Day | Night | Date | Day | Night |
|---|---|---|---|---|---|
| February 27 | 82.0 | 80.0 | March 18 | 70.0 | 62.5 |
| " 28 | 79.0 | 80.0 | " 19 | 77.5 | 82.0 |
| March 1 | 81.0 | 76.0 | " 20 | 85.25 | 81.0 |
| " 2 | 77.0 | 78.0 | " 21 | 79.0 | 79.5 |
| " 3 | 80.5 | 76.67 | " 22 | 83.5 | 84.0 |
| " 4 | 64.0 | 71.0 | " 23 | 78.5 | 74.25 |
| " 5 | 72.0 | 76.0 | " 24 | 73.25 | 76.75 |
| " 6 | 83.0 | 69.5 | " 25 | 73.5 | 69.0 |
| " 7 | 73.5 | 75.5 | " 26 | 69.0 | 67.0 |
| " 8 | 82.0 | 83.0 | " 27 | 72.5 | 74.5 |
| " 9 | 84.5 | 83.5 | " 28 | 76.5 | 87.5 |
| " 10 | 81.0 | 86.5 | " 29 | 86.5 | 83.0 |
| " 11 | 70.5 | 62.0 | " 30 | 82.25 | 83.17 |
| " 12 | 75.0 | 77.0 | " 31 | 80.25 | 80.5 |
| " 13 | 75.0 | 73.33 | April 1 | 70.0 | 71.0 |
| " 14 | 80.33 | 81.33 | " 2 | 70.0 | 72.83 |
| " 15 | 81.5 | 87.5 | " 3 | 77.75 | 81.5 |
| " 16 | 74.0 | 70.0 | " 4 | 78.33 | 73.33 |
| " 17 | 76.33 | 74.0 | " 5 | 76.5 | 83.75 |

TABLE II.

OUTDOOR TEMPERATURES (FAHRENHEIT DEGREES).
1917.

| Date | 7 a.m. | 2 p.m. | 7 p.m. | Mean day | Mean night | Average daily |
|---|---|---|---|---|---|---|
| February 25 | 36.0 | 65.0 | 59.0 | 56.25 | 46.0 | 51.12 |
| " 26 | 33.0 | 37.0 | 29.5 | 34.0 | 25.25 | 29.62 |
| " 27 | 21.0 | 39.5 | 32.0 | 33.0 | 26.25 | 29.62 |
| " 28 | 20.5 | 44.0 | 36.5 | 36.25 | 29.25 | 32.75 |
| March 1 | 22.0 | 36.5 | 29.5 | 31 0 | 27.75 | 29.37 |
| " 2 | 26.0 | 39.0 | 31.5 | 34.0 | 28.5 | 31.25 |
| " 3 | 25.5 | 31.5 | 28.5 | 29 25 | 18.25 | 23.75 |
| " 4 | 9.0 | 22.0 | 19.0 | 18.0 | 14.5 | 16.25 |
| " 5 | 9.5 | 40.0 | 44.0 | 33.0 | 41.25 | 37.12 |
| " 6 | 38.5 | 56.5 | 51.5 | 50.75 | 42 75 | 46.75 |
| " 7 | 34.0 | 44.0 | 40.0 | 40.5 | 33.75 | 37.12 |
| " 8 | 27.5 | 53.0 | 47.5 | 45.25 | 37.75 | 41.5 |
| " 9 | 32.5 | 69.0 | 62.5 | 57.0 | 60.75 | 58.87 |
| " 10 | 59.0 | 73.5 | 70.0 | 69.0 | 51.75 | 60.37 |
| " 11 | 33.5 | 52.0 | 47.0 | 46.0 | 41.25 | 43.62 |
| " 12 | 35.5 | 40.5 | 37.0 | 38.5 | 35.0 | 36.75 |
| " 13 | 33.0 | 37.0 | 35.5 | 35.5 | 31.75 | 33.62 |
| " 14 | 28.0 | 44.5 | 41.0 | 39.5 | 35.0 | 37.75 |
| " 15 | 29.0 | 55.0 | 46.0 | 46.25 | 41.75 | 44.0 |
| " 16 | 37.5 | 38.0 | 34.0 | 37.0 | 31.5 | 34.25 |
| " 17 | 29.0 | 38.0 | 34.5 | 35.0 | 34.5 | 34.75 |
| " 18 | 34.5 | 43.0 | 41.0 | 40.5 | 40.25 | 40.37 |
| " 19 | 39.5 | 65.0 | 54.4 | 56.0 | 46.75 | 51.37 |
| " 20 | 39.0 | 46.5 | 43.0 | 43.75 | 37.5 | 40.62 |
| " 21 | 32.0 | 63.5 | 57.0 | 54.0 | 52.5 | 53.25 |
| " 22 | 48.0 | 77.5 | 66.0 | 67.25 | 50.5 | 58.69 |
| " 23 | 36.5 | 54.5 | 50.0 | 49.0 | 43.75 | 46.37 |
| " 24 | 37.5 | 66.5 | 61.5 | 60.5 | 52.25 | 56.37 |
| " 25 | 43.0 | 69.5 | 64.0 | 61.5 | 46.5 | 54.0 |
| " 26 | 39.0 | 46.0 | 42.5 | 43.5 | 33.75 | 38.62 |
| " 27 | 25.0 | 53.0 | 47.5 | 44.5 | 44.25 | 44.37 |
| " 28 | 41.0 | 73.0 | 64.5 | 63.0 | 53.25 | 58.12 |
| " 29 | 42.0 | 66.0 | 56.0 | 57.5 | 55.0 | 56.25 |
| " 30 | 54.0 | 79.5 | 75.5 | 72.0 | 64.0 | 68.0 |
| " 31 | 52.0 | 59.5 | 54.0 | 56.25 | 48.0 | 52.12 |
| April 1 | 42.0 | 40.5 | 39.0 | 40.5 | 35.75 | 38.12 |
| " 2 | 32.5 | 55.0 | 50.5 | 48.25 | 48.25 | 48.25 |
| " 3 | 46.0 | 58.5 | 57.5 | 55.12 | 51.25 | 53.19 |
| " 4 | 45.0 | 41.0 | 41.0 | 42.0 | 38.25 | 40.12 |
| " 5 | 35.5 | 55.0 | 53.0 | 49.62 | 49.25 | 49.44 |
| " 6 | 45.5 | 65.0 | 62.0 | 59.37 | 54.25 | 56.81 |
| " 7 | 46.5 | 39.0 | 32.5 | 39.25 | 32.75 | 36.0 |
| " 8 | 33.0 | 48.0 | 40.5 | 42.37 | 36.5 | 39.44 |
| " 9 | 32.5 | 60.5 | 57.5 | 52.75 | 52.25 | 52.5 |
| " 10 | 47.0 | 71.0 | 64.5 | 63.37 | 57.25 | 60.31 |
| " 11 | 50.0 | 65.0 | 58.0 | 59.5 | 48.75 | 54.12 |
| " 12 | 44.5 | 54.0 | 52.5 | 51.25 | 46.0 | 48.62 |
| " 13 | 39.5 | 59.5 | 51.0 | 52.37 | 47.0 | 49.69 |
| " 14 | 43.0 | 56.0 | 51.5 | 51.62 | 45.25 | 48.58 |
| " 15 | 39.0 | 45.0 | 44.0 | 43.25 | 48.5 | 45.87 |
| " 16 | 53.0 | 71.0 | 70.0 | 66.25 | 64.0 | 65.12 |
| " 17 | 58.0 | 77.0 | 73.5 | 71.37 | 68.0 | 69.69 |
| " 18 | 62.5 | 77.5 | 72.0 | 72.37 | 65.5 | 68.94 |
| " 19 | 59.0 | 70.0 | 65.0 | 66.0 | 53.5 | 59.75 |

TABLE III. INCUBATION PERIOD. (PALEACRITA VERNATA).

| Number of eggs considered | Oviposited | Hatched | Number of days in egg stage |
|---|---|---|---|
| 4,364 | II-27-'17 | III-31-'17 | 32 |
| 5,288 | II-28-'17 | III-31-'17 | 31 |
| 2,948 | III- 1-'17 | III-31-'17 | 30 |
| 3,650 | III- 2-'17 | III-30-'17 | 28 |
| 4,610 | III- 3-'17 | III-29-'17 | 26 |
| 3,264 | III- 4-'17 | III-30-'17 | 26 |
| 2,591 | III- 5-'17 | III-30-'17 | 25 |
| 6,507 | III- 6-'17 | III-31-'17 | 25 |
| 11,279 | III- 7-'17 | III-31-'17 | 24 |
| 4,973 | III- 8-'17 | III-31-'17 | 23 |
| 4,411 | III- 9-'17 | IV- 2-'17 | 24 |
| 7,570 | III-10-'17 | IV- 5-'17 | 26 |
| 2,820 | III-11-'17 | IV- 6-'17 | 26 |
| 6,447 | III-12-'17 | IV- 6-'17 | 25 |
| 7,348 | III-13-'17 | IV-10-'17 | 28 |
| 3,861 | III-14-'17 | IV- 9-'17 | 26 |
| 3,463 | III-15-'17 | IV-10-'17 | 26 |
| 3,077 | III-16-'17 | IV-12-'17 | 27 |
| 6,295 | III-17-'17 | IV-12-'17 | 26 |
| 4,914 | III-18-'17 | IV-12-'17 | 25 |
| 5,090 | III-19-'17 | IV-13-'17 | 25 |
| 8,237 | III-20-'17 | IV-14-'17 | 25 |
| 5,932 | III-21-'17 | IV-16-'17 | 26 |
| 7,383 | III-22-'17 | IV-17-'17 | 26 |
| 5,347 | III-23-'17 | IV-17-'17 | 25 |
| 6,002 | III-24-'17 | IV-18-'17 | 25 |
| 2,200 | III-25-'17 | IV-19-'17 | 25 |
| 139,871 | Total | Average | 26 |

TABLE IV. OVIPOSITED.

| Increments of 100 ♀ ♀ | Data | 1st night | 2nd night | 3rd night | 4th night | There-after | Totals |
|---|---|---|---|---|---|---|---|
| A | 1. Total number of eggs... | 4,364 | 2,469 | 714 | 257 | 351 | 8,155 |
| | 2. Number of sterile eggs.. | 480 | 494 | 251 | 117 | 310 | 1,652 |
| | 3. Pctge. of sterile eggs..... | 11 | 20 | 35.2 | 45.5 | 88.3 | 20.2 |
| D | 1. See same number above | 3,650 | 4,610 | 1,088 | 725 | 257 | 10,330 |
| | 2. " " | 341 | 707 | 256 | 204 | 132 | 1,640 |
| | 3. " " | 9.3 | 15.3 | 23.5 | 27.8 | 51.4 | 15.9 |
| E | 1. " " | 1,065 | 3,264 | 2,691 | 1,170 | 726 | 8,916 |
| | 2. " " | 222 | 303 | 431 | 605 | 537 | 2,098 |
| | 3. " " | 19.9 | 9.3 | 16.6 | 51.7 | 74 | 23.6 |
| F | 1. " " | 2,656 | 4,595 | 2,048 | 667 | 139 | 10,105 |
| | 2. " " | 140 | 374 | 507 | 347 | 108 | 1,476 |
| | 3. " " | 5.3 | 8.1 | 24.7 | 52 | 77.7 | 14.6 |
| I | 1. " " | 2,504 | 4,352 | 1,778 | 620 | 760 | 10,014 |
| | 2. " " | 179 | 576 | 347 | 251 | 581 | 1,934 |
| | 3. " " | 7.1 | 13.2 | 19.5 | 40.5 | 76.4 | 19.3 |
| L | 1. " " | 1,287 | 5,251 | 1,732 | 503 | 445 | 9,218 |
| | 2. " " | 135 | 476 | 298 | 189 | 402 | 1,500 |
| | 3. " " | 10.5 | 9.1 | 17.2 | 37.6 | 90.4 | 16.3 |
| M | 1. " " | 2,211 | 3,077 | 679 | 257 | 386 | 6,610 |
| | 2. " " | 906 | 394 | 205 | 167 | 350 | 2,022 |
| | 3. " " | 41 | 12.8 | 30.2 | 65 | 90.7 | 30.6 |
| U | 1. " " | 3,861 | 2,708 | 1,205 | 737 | 725 | 9,236 |
| | 2. " " | 280 | 293 | 361 | 434 | 682 | 2,050 |
| | 3. " " | 7.3 | 10.8 | 29.9 | 58.9 | 94.1 | 22.2 |
| W | 1. " " | 3,639 | 2,808 | 1,346 | 772 | 578 | 9,143 |
| | 2. " " | 215 | 171 | 311 | 407 | 540 | 1,644 |
| | 3. " " | 5.9 | 6.1 | 23.1 | 52.7 | 93.4 | 18 |
| Y | 1. " " | 2,551 | 2,200 | 491 | 585 | 252 | 6,079 |
| | 2. " " | 94 | 183 | 123 | 219 | 184 | 803 |
| | 3. " " | 3.7 | 8.3 | 25.1 | 37.4 | 73 | 13.2 |
| Grand total for 10 increments of 100 ♀ ♀ | 1. " " | 27,788 | 35,334 | 13,772 | 6,293 | 4,619 | 87,806 |
| | 2. " " | 2,992 | 3,971 | 3,090 | 2,940 | 3,826 | 16,819 |
| | 3. " " | 10.8 | 11.2 | 22.4 | 46.7 | 82.8 | 19.15 |

Total number of eggs deposited by 10 increments of 100 ♀ ♀ each.......87,806
Total number of sterile eggs.......16,819
Percentage of sterile eggs.......19.15
Percentage of fertile eggs.......81.85

# THE DORSAL PYGIDIAL GLANDS OF THE FEMALE COCKROACH, BLATTELLA GERMANICA.*

BY E. H. DUSHAM, ITHACA, N.Y.

While engaged in the study of the body wall of the cockroach, the writer's attention was attracted by peculiar and previously unnoted structures on the dorsal side of the 10th abdominal segment of the female. These are represented in Fig. 1. D. They consist of three groups of depressions in the cuticula at the very anterior portion of the segment, one large group at the centre, and a smaller group on each side of this. These depressions are of various sizes, the larger ones, however, being found in the middle group.

In fresh material, these structures are not visible from the dorsal side, being covered by the posterior part of the 9th segment. However, by stretching the intersegmental membrane between these two segments, the depressions are readily observed, especially in material which has been boiled in potash and stained with Eosin or Gentian Violet.

Under the oil immersion lens it will be seen that the smallest depressions are single, and contain a single pore at the centre (Fig. 2). The larger depressions on the other hand include numerous smaller depressions, the number ranging from two to twenty, according to the size of the depression. Each of these smaller depressions likewise has at its centre a single pore. Viewed from the surface it will be seen (Fig. 2) that the smaller depressions with their pores at the centre, appear as well defined areas, simulating somewhat the areas which characterize the surface of the cuticula in other regions of the body. In cross-section (Fig. 3) it will be seen that what appear as lines dividing the different areas when viewed from the dorsal surface, are in reality smaller ridges. It will also be noted that the pores extend through both layers of the cuticula.

The presence of pores in the cuticula indicated that glandular structures were present in that region. Accordingly cross and longitudinal sections were made through these parts, varying in

*Contribution from the Entomological Laboratory of Cornell University.

thickness from three to ten micra. Dietrich's, Bouins', and Fleming's (strong formula) Fluids were used for fixation. Best results were obtained with the last fluid, although Dietrich's Fluid gave excellent results. Sections were stained with Heidenhain's Iron Haematoxylin and Delafield's Haematoxylin with Eosin used as a counterstain. Better results were obtained with the former stain, especially after fixation with the Fleming's Fluid.

Cross and longitudinal sections through the region of the pores, showed that the hypodermis was very much thickened, and apparently consisted of several layers of cells (Figs. 4 and 5). The upper layer consisted of hypodermal cells with elongate, flattened, deeply stained nuclei, with axes parallel to the surface of the cuticula, and surrounded by but little cytoplasm. They resemble the normal hypodermal cells found in other regions of the body, but are not so regularly arranged nor contiguous, being scattered here and there between the upper ends of the cells of the lower layers.

Below these smaller cells, larger cells were present, sometimes appearing as a single layer, at other times presenting the appearance of two or more layers, due to the fact that they were crowded together so that their nuclei had been somewhat displaced. Longitudinal sections showed that these lower cells were not perpendicular to the surface of the cuticula, but slanted backwards at a considerable angle. They are somewhat columnar in shape, but vary much in this respect due to their being crowded together.

The minute structure of these cells is represented by figures 6 and 7. They possess large vesicular nuclei with distinct nuclear walls, prominent nucleoli, and deeply-stained chromatin granules. The cytoplasm of the individual cells is distinctly areolar in appearance. The most striking feature about these cells though is the presence in the cytoplasm of a rounded reservoir from which extends a delicate chitinous canal which opens at the surface by one of the pores previously described. The reservoir may be either laterad or somewhat beneath the nucleus, and the canal in many cases is quite sinuous, so that in sections, only portions of it show here and there. Surrounding the reservoir the cytoplasm is much more granular, the granules evidently being the secretion which collects in that region, and empties into the reservoir. From here the secretion is carried to the exterior through the minute canals, where it collects in the depressions in the cuticula.

What the nature of this secretion is, the writer did not determine. From the structure of the glands, and their resemblance to odoriferous glands of other insects, the writer is inclined to believe they perform a similar function in the case of the cockroach.

The writer wishes to express his thanks to Dr. W. A. Riley for his suggestions and advice in this work.

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## Explanation of Plate VI.

Fig. 1. Dorsal aspect of the 10 abdominal segment of the ♀ cockroach, showing location of the depressions in the cuticula. D, depressions; C, cerci.

Fig. 2. Appearance of depressions under oil immersion lens. P. pore.

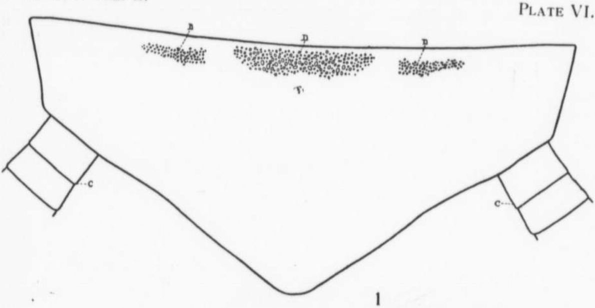
Fig. 3. Cross-section through a depression. Cu, cuticula; P, pore.

Fig. 4. Longitudinal section through the region of the pores. Cu, cuticula; Hyp., hypodermis; Gl., glands.

Fig. 5. Cross-section through the middle group of depressions. D., depression; N. Hyp., normal hypodermis; Gl., glands.

Fig. 6. Longitudinal section through the region of the pores (greatly enlarged). D., depression; Cu., cuticula; N. Hyp., normal hypodermis; Gl., glands.

Fig. 7. Glandular cell (greatly enlarged). Cu., cuticula; P., pore; C., canal; R., reservoir; B.M., basement membrane.

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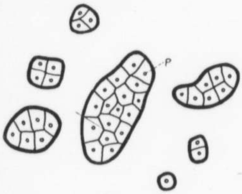


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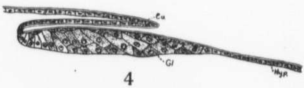


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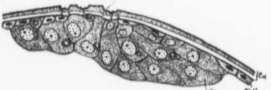


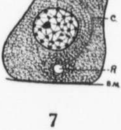


7

PYGIDIAL GLANDS OF BLATTELLA.

# AN ANNOTATED LIST OF THE CERAMBYCIDÆ OF CALIFORNIA.

BY RICHARD T. GARNETT, UNIVERSITY OF CALIFORNIA, BERKELEY, CAL.

(Continued from page 252.)

182. *Ipochus fasciatus* LeConte.
Taken in Southern California; common under bark of dead willow and oak. Found by Van Dyke hibernating. May 29.

183. *Monilema semipunctatum* LeConte.
Found near Cape San Lucas, Lower California.

184. *Monilema spoliatum* Horn.
Found in San Bernardino County. Taken by Wright at San Borga, Lower California.

185. *Monilema subrugosum* Bland.
Found at San José del Cabo, Lower California.

186. *Monohammus titillator* Fabricius.
Found in the middle and northern Sierras. Taken at Donner Lake by the author, July 1–12.

187. *Monohammus maculosus* Hald.
Found in the middle Sierras. Taken from pupal chambers in bark of *Pinus ponderosa* by author. July 6. (Donner Lake).

188. *Monohammus scutellatus* Say.
Found in the Sierras. Taken by the author at Donner Lake. July 7.

189. *Ptychodes trilineatus* Linné.
Taken at San José del Cabo, Lower California.

190. *Synaphoeta guexi* LeConte.
Found in the middle Sierras and Middle California. Bred from limbs of buckeye by Rivers and myself. Bred from chestnut at Los Angeles by Van Dyke (eastern chestnut). It is collected about willows in Southern California. It also breeds in poplar. Taken by author at Calistoga, Donner Lake, and Oro Grande. May 13–July 10.

191. *Acanthoderes peninsularis* Horn.
Found at San José del Cabo, Lower California.

192. *Lagochirus obsoletus* Thomson.
Found at Cape San Lucas, Lower California.

193. *Cœnopæus palmeri* LeConte.
Taken by Wright in San Bernardino County. Breeds in *Cactus opuntia*.

194. *Cœnopæus niger* Horn.
Found at El Chinche, Lower California.

195. *Leptostylus nebulosus* Horn.
Found in Washington and Nevada, and, therefore, must be present in the Sierras.

196. *Leptostylus biustus* LeConte.
Found at San José del Cabo, Lower California.

197. *Liopus crassulus* LeConte.
Bred by Schwartz from dead twigs of *Celtis texana*. Taken at Cape San Lucas, Lower California.

198. *Dectes spinosus* Say.
Breds in stems of *Ambrosia*, especially ragweed (*artemisiæfolia*), in which the larvæ hibernate. Found in Sierra San Lazaro, Lower California.

199. *Mecotetartus antennatus* Bates.
Found at Sierra El Chinche and Cape San Lucas, Lower California.

200. *Hyperplatys californicus* Casey.
Bred by Schwartz from dry twigs of *Populus monilifera* and *tremuloides* June 3. This is the western phase of *H. aspersus* Say.

201. *Hyperplatys aspersus* Say.
Found in California. Bred from apple twigs by F. X. Smith.

202. *Acanthocinus obliquus* LeConte.
Taken by Van Dyke breeding in yellow pine. Found in the Sierras from Mt. Shasta, south of Mt. Whitney. June 18.

203. *Acanthocinus spectabilis* LeConte.
Feeds on several coniferous trees, also breeds in pine stumps and logs, particularly that of yellow pine. Taken by the author from pupal chambers in the bark of yellow pine at Donner Lake. Found in the Sierras from Mt. Shasta to the San Bernardino Mts. July 1–21.

204. *Estola sordida* LeConte.
Found at San José del Cabo, Lower California.

205. *Peritapnia nudicornis* Bates.
Found in Sierra El Chinche, Lower California.

206. *Lypsimena californica* Horn.
Found by Van Dyke at Santa Monica, by Fall rarely at Pasadena, and by Fuchs in Yuba County.

207. *Pogonocherus crinitus* LeConte.
Bred from oak at Pasadena by Dr. Fenyes; bred from oak in Marin and Alameda Counties by Van Dyke. Found in Middle and Southern California. June 2–August 20.

208. *Pogonocherus concolor* Schaeffer.
Beaten by Pilate from *Fremontidendron*. Taken by Schaeffer in the middle Sierras.

209. *Pogonocherus oregonus* LeConte.
Found in the middle Sierras. Taken by Nunenmacher in Eldorado County; taken by Fall at Tahoe; thought by Van Dyke to breed in fir, probably also Douglas spruce. May 10–August 9.

210. *Pogonocherus californicus* Schaeffer.
Found in the middle Sierras; taken by Van Dyke in Placer County; taken by Blaisdell in Calaveras County; taken by Schaeffer in Tulare County. June 6.

211. *Pogonocherus volitans* LeConte.
Found at Cape San Lucas Lower California.

212. *Ataxia setulosa* Fall.
Found in Lower California.

213. *Saperda hornii* Joutel.
Taken at Los Angeles, Northern California, and the Sierras. Taken from willow by Van Dyke and Rivers.

214. *Saperda populnea* Linné.
Found in Northern California and as far south as Los Angeles. Feeds on poplar. Taken by author by beating poison oak bushes at Felton, Santa Cruz County. July 1-4.
var. *tulari* Felt & Joutel.
Taken in Merced and Tulare Counties.

215. *Mecas inornata* Say.
Breeds in the stems of the false sunflower and in *Helianthus tuberosus*.

216. *Oberea schaumii* LeConte.

Found in various parts of California, more common in the Sierras; breeds in willow and cottonwood, taken by Van Dyke in the Sierras, breeding in live twigs of the latter.

217. *Tetraopes elegans* Horn.

Taken at San José del Cabo, Lower California.

218. *Tetraopes femoratus* LeConte.

Taken in Sierras. May 11–June 17. Very common at times on milkweed.

var. *mancus* LeConte.

Common in Southern California on milkweed.

var. *basalis* LeConte.

Common throughout the Sierras on milkweed.

var. *oregonensis* LeConte.

Found in northern Sierras on milkweed.

219. *Lianema tenuicornis* Fall.

Found at El Taste, Lower California.

220. *Idœmea fulleri* Horn.

Reported from the southern part of the State. *I. californica* is, however, the one most probably seen in this State.

221. *Idœmea californica* Fall.

Beaten by Fall from live oak at Pasadena in June; others taken by Fall at light; several taken by Van Dyke on the sea shore at Santa Monica.

222. *Styloxus lucanus* LeConte.

Found in Lower California.

223. *Methia æstiva* Fall.

Found around electric lights at Pasadena.

224. *Dysphaga debilis* Horn.

Found at San José del Cabo, Lower California.

ADDITIONS TO LIST.

225. *Mallodon molarium* Bates.

Found at San José del Cabo, Lower California.

226. *Acyphoderes delicatus* Horn.

Found at El Taste, Lower California.

There are four species in the list which were given separate numbers which may be either synonyms or varieties (84–85, 131, 156, 199). Therefore, there are 178 unquestioned species confined to California, 10 present both in California and Lower California, and 43 confined to Lower California.

# THE PROBABLE ANCESTORS OF INSECTS AND MYRIOPODS.*

BY G. C. CRAMPTON, PH.D., AMHERST, MASS.

In view of the fact that such Crustacea as *Bathynella*, *Apseudes*, etc., so obviously fulfil the conditions one would naturally look for in those forms which are supposed to have departed as little as any from the ancestral condition of insects, it is indeed surprising that they have been passed over in silence (although they have been known to science for many years) despite all of the speculation concerning the nature of the ancestors of insects, and the various forms which have been put forward as the probable ancestral types. A comparative morphological study of the forms in question, however, has convinced me that they represent quite closely some of the types from which insects have sprung, and I would, therefore, maintain that the Anomostraca (e. g. *Anaspides*, *Koonunga*, *Bathynella*, etc.) and the Isopoda-Amphipoda group (e. g. *Apseudes*, *Ligia*, *Gammarus*, etc.) contain certain forms very like some of the ancestors of both insects and "myriopods" (*sensu lato*).

It should be clearly understood that neither the first insects, nor their immediate ancestors, were of any one single type; but from the very first, the ancestral insects differed greatly among themselves—although the degree of variation may not have been as great as that between the different representatives of present-day Apterygota. Some of the ancestral insects were doubtless quite like the Protura, while others may have borne a stronger resemblance to the campodeoid or other types of apterygotan insects; but the Protura have departed as little as any known insects from the primitive condition of the hexapodan group as a whole, although they have not retained certain primitive features preserved in other representatives of the apterygotan group.

The developmental tendencies which were to result in the production of a proturan type of insect with long slender body, composed of approximately twenty-one segments (allowing six for the head region, three for the thorax and twelve for the abdomen),

*Contribution from the Entomological Laboratory of the Massachusetts Agricultural College, Amherst, Mass.

bearing three pairs of "stumpy" legs in the abdominal region with reduced terminal appendages, etc., etc., are "foreshadowed," so to speak, in the *Bathynella* type of Crustacea, in which the body is also long and slender, and appears to be composed of approximately twenty-one segments. In *Bathynella* also, there is a marked tendency toward the reduction (or shortening) of the terminal appendages, and the last five segments of the body have lost their limbs completely, while the hindmost legs exhibit a marked tendency to become shortened and reduced—a condition which, if carried a little further, would result in the production of a creature in many respects quite similar to a proturan insect.

On the other hand, the "Isopoda-Amphipoda" group of Crustacea (including the Tanaidacea) exhibit many developmental tendencies which find opportunity for expression in certain other Apterygota. Thus the multiarticulate terminal appendages of such forms as *Apseudes* are suggestive of the many-segmented, paired cerci of such Apterygota as *Lepisma*, *Machilis*, etc., and the nature of the limbs, head, mouth-parts, and other structures in the Isopod-Amphipod group, is strongly suggestive of the condition found in certain Apterygota, even in regard to the minuter details. If we admit the possibility of the ancestors of insects differing markedly among themselves (as there is every reason to suppose was the case) it is, therefore, quite probable that some of them resembled the anomostracan type of Crustacea, while others probably resembled the isopod or amphipod type of crustacean.

It is quite probable that the ancestral "myriopods" were similar in many respects to the members of the "Symphyla-Pauropoda" group, and it would be a comparatively simple matter to derive these types from crustacean forms allied to *Bathynella* or other Anomostraca. If we assume that both the apterygotan type of insect and the Symphylo-Pauropodan type of "myriopod" were derived from crustacean forms allied to those mentioned above, it is evident that the myriopodan type in question has followed a course of development very close to that of the lower apterygotan insects; and in certain respects these "Myriopoda" have departed less from the ancestral condition than the most primitive representatives of the Apterygota have, so that a study of the "Myriopoda" in question is fully as important for a phylogenetic study of insectan evolution, as that of the above-mentioned Crustacea.

Any attempt to derive winged insects from forms unlike the apterygotan type of insect is wholly unwarranted, to my mind, since the lowest winged insects, such as the ephemerids, Plecoptera, etc., are anatomically strikingly similar to such Apterygota as the Lepismids, etc., which in turn are connected by intermediate forms with the lowest Apterygota such as the Protura: and no one who has carefully examined the Protura could doubt that in them we have the most primitive known representatives of the insectan group; so that the recent attempts to derive winged insects directly from a trilobite type of arthropod (without reference to the Apterygota) are extremely "far fetched," to say the least, and even the weight of Handlirsch's authority as a palæontologist is insufficient to convince a skeptical morphologist, when the evidence of anatomy is directly against Handlirsch's assumption—although many recent writers who have not taken the trouble to investigate the merits of the case, have unhesitatingly accepted Handlirsch's astonishing proposal that winged insects are to be derived directly from a trilobite type of arthropod without reference to the Apterygota, and regardless of the facts indicated by a comparative anatomical and embryological study of apterygotan and pterygotan insects.

Even if one were to grant, for the sake of argument, that the anatomically and embryologically far more primitive Apterygota are not so near the ancestral type of insect as the Pterygota are, we would not be justified in assuming that the Pterygota are to be derived from a trilobitan type of arthropod, since, as I hope to bring out in a more detailed discussion of the question, the Trilobita are more closely related to the Merostomata than to any other arthropods (save perhaps the Apodidæ), and serve to connect the Apodidæ with the Merostomata in a line of development leading *away from* that of insects and *toward* the *arachnid* line of evolution, instead of the trilobites standing more nearly in the direct line of descent of the insectan type of arthropod. Insects may perhaps also be derived from arthropods similar to the Apodidæ, or the Branchiopoda, but their line of development leads through such forms as the Leptostraca (and their relatives), to the Cumacea, Tanaidacea, and Anomostraca; while the line of development of the arachnids leads from the Branchiopoda, or Apodidæ, through the trilobites to the Merostomata, Eurypterida, etc., as can be readily seen by comparing such fossil merostomes as *Bunodes lunula* and other antenna-bearing Merostomata, with the Trilobita.

I would, therefore, maintain the following points: 1. That the trilobites do not stand in the direct line of descent of insects, but rather in a side branch leading off from the Branchiopoda and Apodidæ to the Merostomata, Eurypterida, and other arachnoid forms. 2. That the line of development of insects leads from the branchiopod (and apodid) type of arthropod, through such forms as the Leptostraca and their relatives, to the Anomostraca, Tenaidacea, and other crustacean forms which have preserved many features characteristic of the ancestors of insects and "myriopods". 3. That the members of the Symphyla-Pauropoda group are in many respects quite similar to certain of the ancestors of the "myriopods" in general, and that the members of the Symphyla-Pauropoda group are likewise very similar to certain ancestral insects, whose line of development is quite closely paralleled by that of the "myriopods" in question. 4. That the Apterygota in general have departed the least from the ancestral condition of insects as a whole, and the Protura are as primitive as any known Apterygota. 5. That apterygotan forms such as the Lepismids, etc., are very like the ancestors of winged insects and are structurally very closely related to the ephemerids and Plecoptera, which, with the fossil Palæodictyoptera, are the most primitive representatives of the pterygotan group. The details of the discussion of the evolution of insects, together with the grouping of the orders into super-orders containing the forms which are anatomically the most closely related, will be taken up more at length in a later paper dealing with the latter phase of the subject.

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**Mailed August 24th, 1918.**