

PSYCHE.

STUDIES FOR STUDENTS.

I.

THE ANATOMY OF THE LARVA OF THE GIANT CRANE FLY (*Holorusia rubiginosa*).

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PREFATORY NOTE.

It is the writer's intention to present under the title "Studies for Students" a series of short papers which shall offer to students an introduction to work in certain of those phases of insect study which are likely to be neglected by amateur entomologists, especially those who have not been members of collegiate classes in zoology or entomology.

There will be presented in each paper a small piece of work in the study of insect structure, development or physiology, in such a manner as to serve as a practical exercise or lesson which can either be directly repeated by the entomological student without other professional instruction, or can be used as an example and reference for the performance of similar work with some other species of insect. In the case of each of these papers (which will appear irregularly) the actual facts recorded will be new, i.e., the result of observations not heretofore recorded. Thus these papers may have a value to entomologists who are not specially interested in a "guide for self-instruction." The strictly technical directions to students will be enclosed in brackets.

It has long seemed to the writer that the almost exclusive attention of most amateur entomologists (and amateurs constitute the great majority of the total number of entomologists) to systematic work, the finding, preserving, identifying and describing of species, is a fact to be deplored. There is so much that is interesting and profitable to be studied in the structure, development and ecology of insects, that it is a pity that the systematic phase of insect study should monopolize such a large proportion of the work of the whole body of entomologists. It is with the thought that a few examples of the other phases of entomological work put into a sort of teaching manner may perhaps help some amateurs to make a beginning in other lines than the purely systematic one that these "Studies for Students" are written.

ANATOMY OF THE LARVA OF HOLORUSIA RUBIGINOSA.

The larvae of the Giant Crane-fly,*

*The immature stages of *Holorusia rubiginosa* have not hitherto been referred to in print. The life-history of this largest known Dipteron with a description of the immature stages will be made the subject of a brief paper in some future number of PSYCHE.

Holorusia rubiginosa, are found abundantly in a slime composed of decaying leaves and soil and water on the banks of Adalanta Creek near this University (Stanford). The larva is so large, full-grown specimens averaging about 2 to 2½ inches in length, and the character and disposition of its internal organs so readily and certainly made out in dissection, that it is chosen as subject for a short study of internal insect anatomy. As *Holorusia* does not occur elsewhere in the United States than on the Pacific Coast (as far as is known) students in other regions will have to use the larva of some other Tipulid species. Some rather large Tipulid is common in almost every locality, and the use of another species than the one whose structure is here described will make the work to some extent comparative in character and thus be even more instructive and interesting than if the same subject could be * used. The account of *Holorusia* will be found to answer as a guide to the dissection of any other Tipulid larva.

External Anatomy (Fig. A).

Technical note. Bring a number of the larvae of some large Tipulid species (found in vegetable slime, or about grass roots in pastures, etc.) alive into the laboratory. Note the various motions and the locomotion of the body. Kill

specimens by dropping into boiling water. After the specimen has straightened out and stiffened, requiring about a minute, (death is almost instantaneous) remove to 30% alcohol. After two or three hours remove to 50% alcohol, and after three hours into 70% alcohol. After twelve to twenty-four hours remove to 85% alcohol, in which keep the specimens.

[Verify the following statements if *Holorusia* is used; if another Tipulid is used compare conditions with those here described.] The body is composed of thirteen *segments*. Retracted into the first and second segments is the *head*, with strongly chitinized capsule. At the anterior end of the head, usually projecting slightly, are the short cylindrical unsegmented *antennae* and the strongly chitinized biting *mouthparts*. (The mouthparts can be better examined after the internal anatomy has been studied and the retracted head wholly exposed.)

The hindmost body segment bears terminally on a flat surface two large dark *spiracles* (breathing openings) surrounded by six backward projecting flexible lobes. On the ventral surface of this segment is the *anal opening* of the alimentary canal, on an elevation bearing four large and two smaller flexible processes. The segments of the hinder half of the body have each a median transverse construction; those of the anterior half are difficult to distinguish from one another, but it is assumed that each pair of the lateral

* I shall be glad to send to any one, two specimens of *Holorusia* larvae, properly killed for dissection, if the postage and actual cost of the wooden mailing bottles, amounting to about (?) cents, are paid by the applicant.

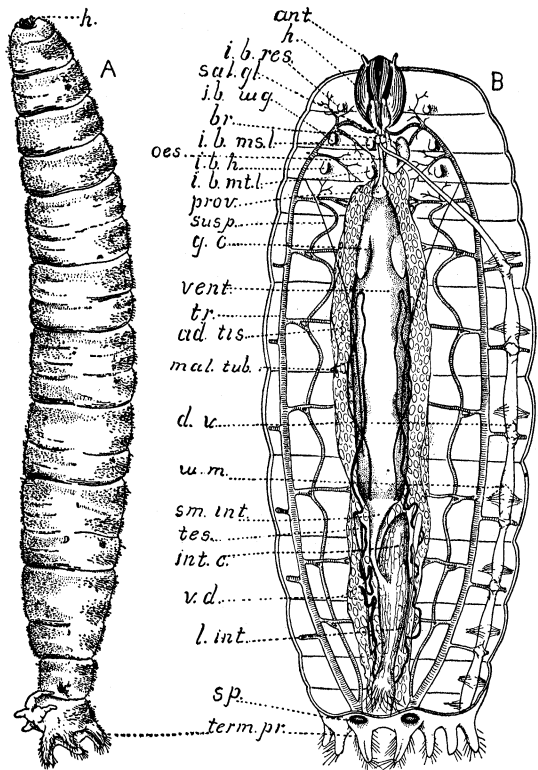
groups of *setae*, of which five pairs may be noted, represents a segment. The absence of all paired appendages back of the head is to be noted. [Make a drawing of the whole body of the larva from a lateral aspect.]

Internal Anatomy. (Fig. B.)

[*Technical note.* With fine scissors cut open the body along the median line of the dorsum, cutting through only the body wall. Put the specimen in a* dissecting dish, pin out the cut edges with ribbon pins, and cover with water.]

Alimentary canal and accessory parts. The alimentary canal extends through the middle of the body cavity, nearly wholly enclosed, in a thin perforated sheet of fat, *adipose tissue*. The canal consists, first of a slender tube, the *oesophagus*, embraced by the *circumoesophageal nerve commissures* and the *brain lobes*; second, of an abruptly dilated conical portion, the *proventriculus*; third, of a portion immediately behind this and not sharply marked off from it, the elongated *ventriculus*, bearing at its ante-

rior end four elongated pouches, the *gastric caeca*. In the sheet of adipose tissue surrounding the ventriculus several slender convoluted tubules may



HOLORUSIA RUBIGINOSA.

A, larva. B, dissection of larva, showing all organs except the muscles and ventral nerve chain. *h.*, head; *ant.*, antenna; *i. b. res.*, imaginal bud of pupal respiratory tube; *i. b. wg.*, imaginal bud of wing; *i. b. ms. l.*, imaginal bud of mesothoracic leg; *i. b. h.*, imaginal bud of balancer; *i. b. mt. l.*, imaginal bud of metathoracic leg (the imaginal buds of fore legs are concealed by head capsule); *sal. gl.*, salivary gland (the other salivary gland is removed); *br.*, brain; *oes.*, oesophagus; *prov.*, proventriculus; *susp.*, suspensorium; *g. c.*, gastric coecum; *vent.*, ventriculus; *tr.*, trachea; *ad. tis.*, adipose tissue; *mal. tub.*, Malpighian tubule; *d. v.*, dorsal vessel; *w. m.*, wing muscles of pericardium; *sm. int.*, small intestine; *tes.*, testis; *int. c.*, intestinal caecum; *v. d.*, vas deferens; *l. int.*, large intestine; *sp.*, spiracle; *term. pr.*, terminal processes.

*For a dissecting dish use a shallow tin dish, about 5 inches long, 3 inches wide and 1 inch deep, into which melted paraffine has been poured to a depth of $\frac{1}{2}$ inch and allowed to cool. On the smooth surface of the paraffine specimens may be pinned out with short pins and covered with water. Always dissect under water, as the water holds up the loosened parts.

be noted; these are the *Malpighian tubules*, the organs of excretion, four in number. They arise from the alimentary canal just back of the ventriculus at a part marked by a pale transverse line. Behind this line is a fourth part of the alimentary canal, the *small intestine*. It is of smaller caliber than the ventriculus and opens into the fifth division of the canal, the *large intestine*, near the anterior end of the latter. The large intestine is largest in front and tapers posteriorly to the very narrow rectal part. That portion of it in front of the point of entrance of the small intestine may be called the *intestinal caecum*.

The *salivary glands* lie one on each side of the oesophagus. Each is a U-shaped organ with the two arms greatly dilated, and the inner reaching a little farther forward than the outer. The *salivary duct* arises from the outer lobe; the two ducts anteriorly unite beneath the oesophagus, and the common duct thus formed opens into the mouth cavity. [Without removing the alimentary canal make a drawing of it as seen from one side; also make a drawing of the salivary glands and their ducts.]

[Remove a piece of salivary duct to a drop of water on a glass slide without a cover glass. Examine with low objective of compound microscope. Notice transverse lines. Press on two places of the duct with dissecting needles and pull gently apart a very short distance. Examine again under the microscope. The two parts will probably be connected by a spiral thread; this will be

seen to be what formed the transverse lines; it is really a spiral thickening of the walls.]

[Remove a small piece of fat to a drop of water on a glass slide. Examine with low power objective. Make a drawing showing the fenestrated structure, the definite outlines, as if the whole were enclosed in a delicate transparent case, and the small spherical bodies—the fat cells—within. Put on a cover glass and examine with the higher power objective.]

The respiratory organs. Lying along each side of the body is a main longitudinal *trachea* (air-tube). Each arises from one of the large posterior spiracles and in each of the third to the ninth segments forward gives off a large branch to the alimentary canal and a smaller one to the dorsal blood vessel (see below). [Make a drawing of the tracheal system, tracing the longitudinal vessels as far forward as possible.]

[Cut off a piece of one of the lateral tracheae and remove it to a drop of water on a glass slide under a cover glass. Examine it with the lower power of the compound microscope and notice the tubular appearance and transverse striations as in the salivary duct. The spiral nature of the thickening is not so easily shown as in the other case but it is characteristic of all insect tracheae.]

The reproductive organs. These consist in the male of two small white oval glands, the *testes*, lying one on each side of the large intestine imbedded in the muscles of the tenth segment, and of a

delicate duct, the *vas deferens*, running posteriorly from each to the ventral wall of the penultimate segment. The *ovaries* (of female specimens) are larger and more elongate than the testes and the *oviducts* (corresponding to the vasa deferentia) are more easily seen.

[Make a combined drawing showing the alimentary canal, salivary glands, tracheal trunks and reproductive organs in position in the body].

The nervous system. Remove the alimentary canal cutting the oesophagus across near the front end of the proventriculus. The *brain* is composed of two conspicuous white lobes united posteriorly lying above the oesophagus. The *sub-oesophageal ganglion* lies beneath and just below the oesophagus, and is connected with the anterior end of the brain lobes by the circum-oesophageal commissures. Back of the sub-oesophageal ganglion is a chain of four closely connected ganglia. The next ganglion is far removed from the fourth, lying in the sixth segment and is connected with the preceding and following ganglia by long slender commissures. Following the fifth ganglion are five others similar to it, each lying over the center of the sternal part of a segment. Each ganglion gives off four very conspicuous *nerve trunks*; one on each side arising from the middle of the ganglion going to the muscles of the body wall and another arising from the anterior end of the ganglion going to the viscera. The last ganglion, lying in the antepenultimate segment, in addition to the four

lateral trunks gives off from the posterior side two large divergent ones caudal to the two following segments. [Make a drawing of the nervous system.]

The muscular system. Along each side of the dorsal and the ventral median line of the body is a wide band of longitudinal *muscles*. The most conspicuous fibers reach from the exterior to the posterior border of each segment, but the others reach from either end to the middle, while others extend from the middle of one segment to the middle of the preceding or following segment, while still others are attached to various points of the body wall between the attachments of the sets already mentioned. Finally there is an innermost set of lateral transverse muscles in the anterior half of each segment. [Make a drawing showing the musculature of two successive segments.]

[Remove a bit of muscle to a glass slide and examine it with the compound microscope. Note the transverse striation].

The circulatory system. [Cut a second specimen open longitudinally along the median line of the venter, reserving the first specimen for some later work. Pin the cut edges out. Note again the general disposition of the body organs, so far examined. Examine again the reproductive organs; the specimen may be of the other sex from that previously studied. Remove the alimentary canal.] The *dorsal vessel* or heart is a slender, delicate membranous tube composed of a number of parts or chambers lying

along the median line of the back. [To see this well cut out the median dorsal strip of body wall carrying the heart and transfer it to a glass slide. Cover with water and examine first under the simple microscope and then under the low objective of the compound microscope.] It will be distinctly seen that toward the middle of each segment, from the last to the third inclusive, the tube becomes dilated and in most of these swellings except the last a pair of internal valves may be seen. From the anterior of these a straight anteriorly tapering tube, the *aorta*, extends forward into the head where it ends in branches. [Make a drawing of the heart and aorta.]

Attached to each dilatation of the heart are two fan-shaped groups, one on each side, of very delicate muscle fibers, called *wing muscles* from their shape. The convergent outer ends are attached to the body wall on the line of the median constriction in each segment. These muscles are easily seen under the compound microscope.

The imaginal buds of wings and legs.
[Returning to the first specimen (that opened along the dorsum) carefully remove the muscle fibres from the body wall of the three front (thoracic) segments of the body, not including the head. Be careful not to pick away certain small whitish bud-like bodies lying between the muscles and the body wall.] In specimens of sufficient age the *imaginal buds* of the wings and legs and of the external prothoracic respiratory

tubes of the pupa may be seen as small sac or bud-like bodies lying against and attached to the inner surface of the body wall of the thoracic segments. There are two pairs of these imaginal buds in each thoracic segment corresponding respectively to the prothoracic legs of the imago and prothoracic respiratory tubes of the pupa, the mesothoracic legs and wings of imago, and the metathoracic legs and halteres of the imago. The morphology and development of these imaginal buds will be the subject of the next paper in this series.

The head sclerites and mouthparts.
[After finishing the dissection of the internal organs remove the head entirely from the rest of the specimen and examine under the simple microscope]. Each of the short antennae arises from a small lobe on the plate covering the top of the head. This plate is long, tapering and decurved behind. Anteriorly along its sides it is united with the lateral plates, while the anterior margin is reentrant receiving the smaller end of the pear shaped *labrum* (upper lip). The distal part of this sclerite is membranous except for two lateral chitinizations. Posteriorly it is fused with the *epicranial plate*. The lateral plates are each oval, shell-shaped, having their anterior lower angles produced forward and united with each other. The single process thus formed projects forward and curves upward between the faces of the posterior jaws. The tips are provided with graduated

teeth. In the front of each large lateral plate is a narrow dorso-ventral sclerite carrying the jaws. These are two in number on each side. The anterior one (the *mandible*) is large, strong, toothed terminally, and provided on the

inner side with a large, softer, movable lobe. The posterior jaw (the *maxilla*) is less chitinous than the other; it is flat and provided at its outer angle with several papilla-like processes.

GYNANDROMORPHISM IN A NEW SPECIES OF HILARA.*

BY AXEL LEONARD MELANDER, AUSTIN, TEXAS.

While collecting insects in Western Wyoming during September, 1895, Dr. Wm. M. Wheeler chanced upon a very remarkable fly. This insect, *Dilophus tibialis* Loew, was taken among sweepings from the high grass along the borders of Hunter's Creek, at an altitude of about 8000 feet. The specimen was abnormal in the possession of an antennary appendage arising from the right fore coxa. Concerning this curious outgrowth Dr. Wheeler has already published a full account.†

With the same sweepings in which the *Dilophus* was taken were numbers of an undescribed species of *Hilara*, and among these was another abnormal specimen. As cases of malformation are rare, and especially so among insects, possibly on account of the number of ecdyses which these animals undergo, the occurrence of another teratological

fly in the same locality in which the *Dilophus* was taken is of some interest. The specimens collected were stored away until recently, when I undertook to study them in connection with the other species of *Hilara*.

Like most members of the genus *Hilara*, the new species exhibits striking sexual dimorphism, that is, apart from the peculiar hypopygial modifications, the first joint of the fore tarsi is greatly enlarged in the male, while of normal shape in the female. This character, which is well-nigh universal in the genus, is, like other secondary sexual characters, subject to considerable variation in form and size among the various species, and is therefore of taxonomic importance.

On sorting the Wyoming specimens with regard to the separation of the sexes, an individual was discovered which, so far as external characters are concerned, is neither a male nor a female. This specimen has the abdominal styles of the female, while at the

*(Contributions from the Zoological Laboratory of the University of Texas. No. 18).

† Archiv fuer Entwicklungsmechanik der Organismen. III. Band, 2 Heft, 1896.



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