

attracted to light as not very satisfactory, and spoke of the observations of various entomologists. Probably the most thorough investigation of this subject was made on cotton-field insects by a Mr. Mitchell, at Victoria, Texas. Mr. Mitchell captured 24,000 specimens at lights, and a determination of this material showed that about 15,000 of these were made up of injurious species, the remaining 8,000 being beneficial. Of these latter, there were 5,000 specimens of a single species of Carabid beetle. Prof. Riley's experience with light in an orchard went to prove that, contrary to what the manufacturer at Hazeltine claimed, the Codling Moth was not attracted by it. Mr. Ashmead believed that seventy-five per cent. of the insects attracted to lights were injurious. Mr. Sanderson and Mr. Busck considered the benefit of these traps as doubtful, but Mr. Busck thought a trap could be manufactured which would capture moths to the exclusion of beetles; he had used such a trap. Dr. Gill mentioned having observed a remarkable swarm or flight of insects to light in the Island of Trinidad. This flight lasted from twilight to very early morning, and was at its maximum at about 10 o'clock. Among the insects flying were many winged ants. Mr. Chapin said that enormous numbers of insects of all orders, and particularly mayflies, swarmed to the electric lights in Chicago when the arc lights were first established there. In reply to a question asked by Dr. Gill, Dr. Howard thought mosquitoes were not attracted to lights. In conclusion, he said he thought the whole trap-lantern scheme for destroying injurious insects more or less of a fraud.

—The first paper of the evening was by Mr. Sanderson, and was entitled :

NOTES UPON THE STRUCTURE AND CLASSIFICATION OF CHRYSOMELID LARVÆ.

By E. DWIGHT SANDERSON.

Few families of insects, and none among Coleoptera, contain more injurious species or do more damage than the Chrysomelidæ. The rapid spread and voracious appetite of the Colorado potato beetle have made it familiar to every farmer in the land, and many of its near relatives are fast pushing themselves into prominence. The flea beetles, grape and corn root-worms, and the cucumber and asparagus beetles, have caused the loss of millions to

American farmers, and the defoliation of our shade trees by such pests as the cottonwood and imported elm-leaf beetles cannot be valued from a dollars and cents standpoint. A few scarcely known beetles are one day feeding upon a common weed in some out of the way place; the next year we hear that they have ruined some crop of that locality, and in only a few years they have spread over a large area and become recognized as a serious pest. LeConte and Horn have well stated that the function of the family seems to be to hold the vegetable world in check by destroying its leaves; the trouble is that, from our standpoint, the beetles seem to have misinterpreted their duty, and to feel that the superfluous portion is that which man has planted.

Although, owing to their injurious character, more of the immature stages of the Chrysomelidæ have been described than of any other family of beetles, still the larger portion are unknown, and most of the descriptions are incomplete. Furthermore, no systematic study of the larvæ and pupæ has ever been made of the family as a whole, so that the general larval and pupal type of the family has never been described that they might be distinguished from those of other families, or that the different types and species among the seven hundred composing the family (in Boreal America) could be separated.

The work which I will briefly outline to-night was commenced as a thesis at Cornell University. Through the kindness of Dr. Howard and Mr. Schwarz, I have been allowed to study the large collection of larvæ in the National Museum during the past two years. These, with my own few collections and specimens from various parties, have given me quite a representative series. I have felt the need, however, of material from the tropics where this family is best developed, but all attempts to secure it have so far been in vain. The study of larvæ is certainly a new thing to most coleopterists. You will pardon me for quoting in this connection part of a letter from Mr. Martin Jacoby, than whom there is probably no better authority on the *Phytophaga*, as it brings out this point very strikingly. "I should have been very glad to be able to assist you in your study of the larvæ of the *Phytophaga*," he says, "but there is absolutely nobody here who ever attempted to collect or study the larvæ of beetles, and I know of nobody abroad. I have no doubt that there are such people, but I have never heard of them. I myself am quite ignorant of the early stages of the *Phytophaga*, but the more well-known ones have, of course, been described in different works."

When it is attempted to describe the larval type of the Chrysomelidæ we are at once confronted by two obstacles. On the one hand the larvæ of nearly allied families have not been sufficiently studied to make a definition of their characters possible, and on the other, types of the different groups of Chrysomelid larvæ are so distinct

that they have but little in common. In fact, as will be explained later, I am compelled to consider the Chrysomelidæ as a superfamily. There are several characters which I think will definitely separate any of its species from those of other families. The antennæ are of two or three segments; mandibles never elongate; prothorax never broader nor much longer than meta-thorax; with chitinized notum; thoracic legs always present (except in one or two genera of Hispidæ), short and stout (except in Cryptocephalidæ, which are case bearers), tarsal claw single; tergites of meso and meta-thorax and first seven abdominal segments never forming chitinized plates; ninth abdominal segment never longer than preceding segments (except in Cryptocephalidæ), tenth abdominal segment rudimentary, often bearing one or a pair of prolegs; no dorsal tubercles elongate and lateral tubercles elongate only in Cassididæ; a row of sub-spiracular, lateral tubercles always present; setæ stiff and bristly, never in long tufts.

The antennæ are typically composed of three segments, the two basal segments much flattened and the third conical or quadrate. Arising from the end of the second segment at the base of the third is an accessory digit, which sometimes becomes larger than the third segment. Indeed the latter is sometimes lost, and this digit appears to be the third segment. The third segment can always be distinguished from it, however, by its bearing one to several setæ at its tip. Round, ocelli-like sensoria are often found on the second segment. The ocelli are typically twelve in number, four caudad and two ventrad of each antenna. The two ventral are situated on the genæ, separated from the others by a suture, and it seems probable that originally there were a pair of ocelli on each of three head segments. The position of the ocelli is of considerable taxonomic value, but is a difficult character to determine, oftentimes necessitating boiling or bleaching the head. In two groups, the Donaciidæ and Eumolpini, the ocelli are entirely wanting. In most of the Gallerucini but a single ocellus occurs. This seems to be homologous with the caudo-ventral ocellus of the four caudad of the antennæ, as in certain species between the more typical Gallerucini and Chrysomelini all six ocelli are found, but this ocellus is very much larger than all the rest. The mandibles are typically five-dentate, though in one or two groups they are uniformly tridentate, and in a few genera entire. In some genera the number of teeth varies within these limits for the different species. In Diabrotica and several nearly allied genera, a curious tuft or brush of setæ occurs on the inner margin. The labra are quite variable in shape, but always bear four prominent, stout setæ. The setæ on the cephalic margin furnish good specific and often generic characters, though difficult to study, as they are easily broken off or misplaced. The maxillæ are of the usual type found in mandib-

ulate insects, though quite different in the different groups. In the Gallerucini the galea and lacinia are distinct, and both well developed, but in all others the lacinia is rudimentary, usually being represented by a small prominence bearing a large spine at the inner base of the galea. The setæ upon the palpi and stipes are very constant in position, as they are on the mentum and submentum. The labial palpi are small and of one or two segments, the palpiger being distinct only in the Cryptocephalidæ.

I have not, as yet, succeeded in satisfactorily homologizing the sclerites of the ventral part of the head. To the caudal margin of the submentum and the caudal margin of the occiput is attached a membrane which is continuous with the prosternum, *i. e.*, there is no suture between them. Beneath this membrane just caudad of the caudal margin of the submentum, attached at either side to the ventral margin of the epicranium and with the cardos of the maxillæ articulating upon its anterior margin at either side, is a rectangular, well chitinized sclerite, which seems to be similar to the gula of the adult beetles and yet also seems to bear exactly the same relation to the other sclerites as does the tentorium of the Orthoptera. That it is the same I am not prepared to say. Lying beneath the membrane to which the mentum is attached and connecting the epicranium, it seems to form the floor of the epicranial segment.

Before proceeding to describe the thorax and abdomen it may be well to explain the system of notation which I have used for describing the body tubercles and setæ. But first I wish to request that no one will ask me later on "What is a tubercle or seta," for I freely confess I don't know, though I have tried hard enough to find out. Tubercles, spines, setæ, and hairs or accessory setæ, shade into each other so gradually and their structure is so variable that I am at a loss to know how to define them and have not by any means secured a satisfactory knowledge of their morphology. That the tubercles and setæ of larvæ are of great taxonomic value has already been well shown in the case of Lepidopterous larvæ by Dr. Dyar and others. They have also been used considerably in the classification of Saw-fly larvæ. In the present study I have found them of the greatest value and interest. There seem to be a more or less definite number of setæ in the most generalized larvæ which are variously modified in number and position in those more specialized. When these setæ are surrounded by a thickened or pigmented area, or where they surmount a protuberance of the skin, I have called them tubercles. Often, however, the surface of the epidermis is uniform in texture, merely being divided into areas by folds. In such cases the usual setæ are sometimes distinct and easily recognized, but many times they are surrounded by a large number of small accessory setæ from which they are not distinguishable, as

in *Donacia* and *Criocera*. It would seem to me, therefore, that before the student of insect larvæ will be able to use the setæ and tubercles for the purposes of classification understandingly, it will be necessary to know more of their nature, history and origin. Whether the tubercles and setæ of lepidopterous, hymenopterous, and coleopterous larvæ are homologous in any way or whether they had a common origin, seems to me to be a question of importance. Dr. Packard's views as to the origin of the spines and tubercles, and his classification of them, in the *Notodontidæ* may or may not be correct for that family; it certainly has no bearing upon the similar structures found in the *Chrysomelidæ*.

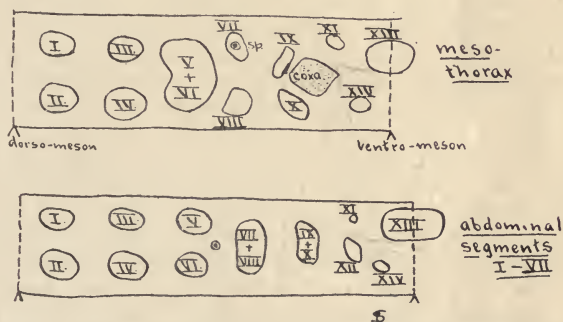


FIG. 1.—Diagram showing notation of tubercles of the most generalized *Chrysomelid* larvæ. (Represented as one-half of the larval skin is seen when mounted flat.)

The tubercles as numbered represent those of a purely hypothetical generalized type, and are not so to be found in any one species.

On either annulet of the meso and metathorax below the dorso-meson are two tubercles numbered I, II, III, IV; I and III being cephalic. Below these is a larger lateral tubercle extending across both annulets and outlining the forming wing discs which are immediately beneath, which I term V and VI. Below these are two tubercles, anterior and posterior, VII and VIII. The coxa of the leg articulates slightly with the caudal margin of tubercle IX and caudad of it is X. XI is cephalad of the coxa. XIII dextral and sinistral are usually grown together on the ventro-mesal line. Caudad of them are tubercles XIV, between the coxæ. The abdominal segments, I to VII, differ from the thoracic in that tubercles V and VI are separate, VII and VIII are united, as are IX and X, while tubercles XI to XIV are variously modified. The tubercles of abdominal segments eight and nine are always considerably grown together. On the pro-

thorax, tubercles I to VI are grown together and form the cervical shield; VII and VIII are sometimes distinct and sometimes grown together; IX and X are as on the other thoracic segments; XIII and XIV are usually grown together, forming a chitinized sternum which is cleft on the caudal margin. The tubercles are diagrammed as seen from the dorsal and ventral aspects, as most of the larvæ are naturally flattened. In studying them, when sufficient material was available, I have mounted the skins in Canada balsam.

The thoracic spiracle is always surrounded by or just above mesothoracic tubercle VII. The abdominal spiracles are situated either between or laterad of tubercles V and VI. Spiracles are always found on the first seven abdominal segments in the usual position. In the *Hispidæ* they are lacking on the eighth, but very large, round spiracles are found dorsally on the ninth segment. In *Donacia* the spiracles of the eighth segment are much enlarged, are close together near the dorso-meson, and their bases are prolonged into long sickle-shaped horns which aid in respiration.

In some larvæ the eighth abdominal spiracles are wanting. Just below the spiracles, at a variable distance from them, branch off from the trachea leading to the spiracle, two short tracheal appendages, which end blindly, merely forming small pockets or sacs. They are peculiar structures found in almost all of the larvæ examined, whose structure I fail to understand.

The legs are usually short and thick. In one genus of the *Hispidæ*, *Octotoma*, they are wanting. The segments seem to be homologous with those of the beetle. The coxal segment is much the largest, and is usually closely appressed to the body. On the outer side it is slightly articulated with a well chitinized tubercle which I have numbered IX, and which seems to be considerably like the trochantin described by Walton. The trochanter is triangular, and the femur and tibia are more or less rectangular in profile. The tarsus is short, sometimes hardly visible. It bears a single claw, and in the *Gallerucini* a well developed empodium or pulvillus. Such is a brief outline of the characters of the larvæ of the *Chrysomelidæ* in the broadest sense.

In their classification of the *Chrysomelidæ*, Leconte and Horn* divide it into eleven tribes, grouping them together as shown on the chart. The larval types of these different tribes are easily recognized, though their relationships appear somewhat different from those of the adults.

The larvæ of the *Donaciini* feed upon the roots of aquatic plants, are cylindrical, slightly arcuate, tapering slightly cephalad from the sixth or seventh abdominal segment, and sharply caudad;

(**Vide*, p. 336, LeConte and Horn, Classification of the Coleoptera.)

Ocelli are wanting, mandibles tridentate; maxillary palpi of three segments, galea and lacinia present but grown together and highly specialized, forming an organ for piercing the plant tissue; labial palpi of one segment; prolegs wanting; anus situated on the anterior margin of the eighth abdominal tergite; the spiracles of the eighth abdominal segment large, situated dorsally, and their bases developed into horns as already noted; tubercles wanting; setæ occurring in large areas between the folds of the skin.

Of the Sagrini, I have had no larvæ.

Of the Criocerini, I have had but three species of two genera, which genera seem to be poorly defined if judged by the larvæ. These species seem to be more nearly allied to the Chrysomelini, quite distinctly so, though a larger series might show a relationship to the Donaciini. They are cylindrical larvæ, tapering slightly from the middle toward either end; mandibles three to five dentate; ocelli six; maxillary palpi of three segments, lacinia wanting; labial palpi of one segment; anal prolegs present; ventral abdominal tubercular areas protruding ventrad and functioning as prolegs; anus in *Lema trilineata* and *Crioceris merdigera* on the anterior part of the ninth abdominal tergite, though normal in *C. asparagi*. These two species cover the body with excrement. They feed upon foliage.

In the Chrysomelini the larvæ of the genera *Chrysomela* and *Leptinotursa* have the abdomens strongly convex, while the remaining genera are more or less flattened and resemble the Gallerucini in their shape. Ocelli six; mandibles five-dentate; maxillary palpi of three segments, lacinia wanting; labial palpi of two segments; anal prolegs present; a large part of the larvæ having glandular tubercles.

The larvæ of the Eumolpini are nearly allied to those of the last tribe, are subterranean, feeding on the roots of plants, are short, thick, cylindrical, arcuate; ocelli wanting; mandibles tridentate or entire; maxillary palpi of three segments, lacinia wanting; labial palpi of one segment; anal prolegs present; tubercles sometimes faintly outlined, setæ strongly developed.

Different larvæ of the Gallerucini feed upon the foliage and bore into the roots and stems of plants. The most typical shape is that of the imported elm-leaf beetle, though the subterranean and boring larvæ, such as *Diabrotica*, become very elongate and cylindrical instead of flattened. The Gallerucini seem to be the most generalized larvæ. In a few genera six ocelli are present, in most they are reduced to a single ocellus, while often the ocelli are wanting; mandibles five-dentate; maxillary palpi of three segments, both galea and lacinia present; labial palpi of two segments; the usual pair of anal prolegs forming a single proleg; tubercles well developed, generalized, rarely glandular, sometimes with a metallic lustre; tarsi with a well-developed pulvillus.

Of the *Cryptocephalini*, I have had no specimens. The *Clyth-rini* and *Chlamydini* resemble each other, and I gather from descriptions also the *Cryptocephalidæ*, in being case bearers and having the abdomen bent sharply ventrad; ocelli six; mandibles tridentate; maxillary palpus of three segments, lacinia wanting; labial palpi of two segments, with palpiger distinct; legs elongate; prolegs wanting; tubercles wanting; ninth abdominal tergite longer than those cephalad. I have had but few of the larvæ of these three tribes, and but few have been described, but they seem to be most nearly related to those of the *Eumolpini*.

The larvæ of the *Hispini* are leaf miners, and resemble those of the *Cerambycidæ* more than most of the *Chrysomelidæ*. Each segment is marked dorsally and ventrally by a transverse depression, similar to those found in the larvæ of the *Cerambycidæ*, around which one may distinguish the usual setæ after considerable study. The caudal margin of the head is produced strongly caudad, to which projection are attached strong muscles also attached on the under side of the pronotum. Ocelli six; mandibles five-dentate; maxillary palpi of one or two segments, lacinia wanting; labial palpi of one segment, ligula reaching anterior of maxillæ, maxillæ and labium sometimes grown together; eighth abdominal spiracles situated dorsally on ninth tergite and much enlarged; prolegs wanting.

The larvæ of the *Cassidini* are probably the most interesting of all. They are flattened and elliptical in outline, bordered laterally with a row of long barbed spines (tubercles VII plus VIII on the abdomen, VI, VII and VIII on the thorax); arising from the ninth abdominal segment is a two-pronged organ whose prongs are really homologous with the lateral spines, known as the fæci-fork. When bent forwards the tip of this fork reaches the thorax or prothorax; it is usually covered with the cast skins of the larva and a mass of excrement, in which case the larva is almost entirely covered by it and appears on the leaf like a bird dropping. These larvæ have six ocelli; mandibles five dentate; maxillary palpi of two segments, lacinia wanting; labial palpi of two segments; prolegs wanting; head covered by the prothorax, mouth parts inferior.

Upon comparing the characters enumerated it is seen that the larvæ arrange themselves naturally into five main groups, with a classification somewhat as follows:

- With fæcifork.....Cassididæ.
- Without fæcifork.
 - Abdomen bent sharply ventrad, labial palpi of two segments, palpiger distinct, case-bearers.....Cryptocephalidæ
 - Cryptocephalini.
 - Clythrini.
 - Chlamydini.
 - Abdomen straight.
 - Caudal pair of abdominal spiracles on ninth segment, abdominal tergites and sternites with transverse depressions, body flattened, maxillary palpi of one or two segments.....Hispidæ.
 - Spiracles on first eight abdominal segments, no transverse depression (except fold between annulets).
 - Prolegs wanting, anus situated on anterior margin of eighth abdominal tergite, bases of eighth abdominal spiracles forming horns.....Donaciidæ.
 - With anal prolegs, anus not as above..Chrysomelidæ.
 - Lacinia present, anal prolegs single, claw with pulvillus.....Gallerucini.
 - Lacinia wanting, prolegs double.
 - Labial palpi of two segments, ocelli six.....Chrysomelini.
 - Labial palpi of one segment, ocelli wanting.....Eumolpini.
 - Labial palpi of one segment, ocelli six.....Criocerini.

These five larval types are very distinct. There is less similarity between some of them than between them and larvæ of other families. It seems probable therefore that they indicate a better classification of the Chrysomelidæ, ranking it as a superfamily, and dividing it into five distinct families. This is indeed almost the same classification as that of entomologists early in the last century.

It is obvious that from the many characters which the adult beetles have in common that entomologists have had good reason for considering the Chrysomelidæ as but one family and its various subdivisions merely as series. But as Dr. Weismann has well shown in his "Studies in the Theory of Descent," treating of lepidopterous larvæ, the generic and family relationships are most clearly to be discerned in that stage of insects in which these classes differ most in their habits. He there points out the incongruities between the larvæ of Lasiocampa, Clisiocampa, and allied genera, and most of the other genera then included in the Bombycidæ, and makes the query whether or not morphological differences do not exist in the adults so that these genera should form a distinct family. Further study of the moths has shown several distinctive characters, notably the wing venation, and the

Lasiocampidæ are now ranked as a family. He also shows that genera based on larval and imaginal characters more nearly coincide in their relation to each other than higher groups so founded. The following passage seems especially pertinent to the case in hand: "In families there is again an increase of irregularity. Although larval and imaginal families generally agree, there are so many exceptions that the groups would be smaller if they were based exclusively on the larval structure than if founded on the imagines (Nymphalidæ, Bombycidæ)." "If we turn to the groups of families we find a considerably increased incongruence; complete agreement is here again rather the exception; and it further happens in these cases that it is always the larvæ which, to a certain extent, remain at a lower grade, and which form well defined families, but these can seldom be associated into groups of a higher order, having a common character, as in the case of the imagines (Rhopolocera)." The numerous instances further cited by Dr. Weismann in different orders further confirm this view, whose truth must be apparent. Now the adults of all the Chrysomelina feed upon foliage externally, but the larvæ are much more variable in their habits, far more distinct in structure, and thus, as might be expected, show more clearly their relationships. As an example, LeConte and Horn have classed the two tribes, Hispini and Cassidini, as Cryptosomes upon their having "front inflexed, mouth inferior." If, as they state, the larvæ of both these tribes had the habit of covering themselves with excrement, their relationship would seem more clear, but such is not the case. The two larvæ are very dissimilar, the latter approaching the Erotylidæ and Coccinellidæ, while the former resemble those of the Cerambycidæ, between which there is certainly no very great similarity. This is the most striking instance in which the classification of the larvæ differs from that of the adults, though others are numerous. Inasmuch as the characters used to separate many groups of the Chrysomelina are confessedly unsatisfactory, it would seem that the relationships so clearly exhibited between the different groups of larvæ may be of considerable value in securing a natural classification, or, if that be not possible, at least add to our knowledge of the phylogeny of this large group of beetles.

This paper excited much interest, and was discussed by several of the members present. Dr. Gill said that one of the families should be called Cassididæ, instead of Cassidæ,* this being the proper family name derived from the genus Cassida; there was also a family of Gasteropod Molluscs called Cassidæ. He asked if the

* This correction has been made in the body of the article.—Publication Committee.