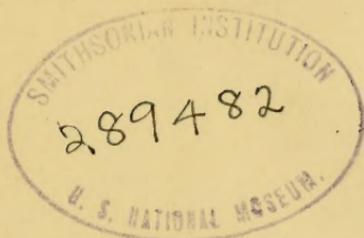


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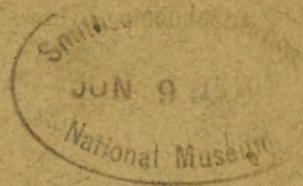
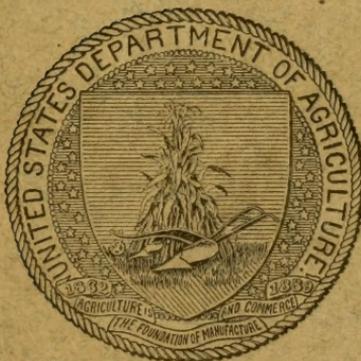
THE ANATOMY OF THE HONEY BEE.

BY

R. E. SNODGRASS,

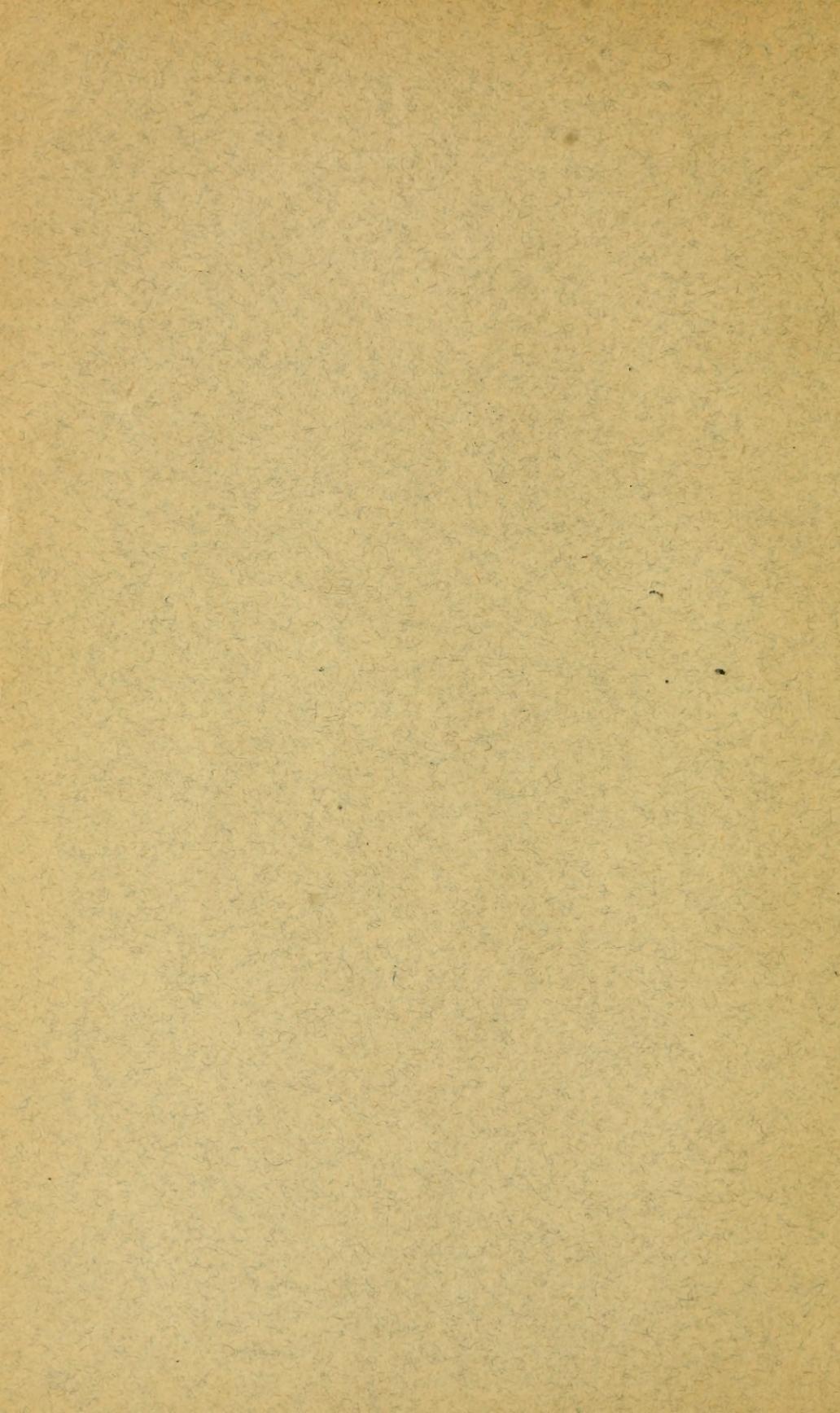
Agent and Expert.

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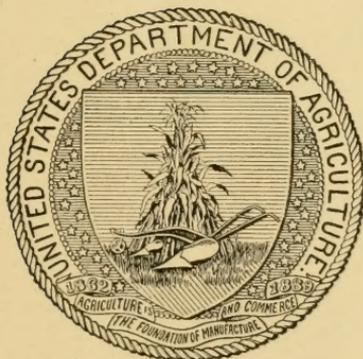
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., October 19, 1909.

SIR: I have the honor to transmit herewith a manuscript entitled "The Anatomy of the Honey Bee," by Mr. R. E. Snodgrass, agent and expert, of this Bureau. It embodies the results of detailed studies made by Mr. Snodgrass and should prove of value as bringing to the bee keeper reliable information concerning an insect of such great economic importance, and also as furnishing a sound basis in devising new and improved practical manipulations. I recommend its publication as Technical Series, No. 18, of the Bureau of Entomology.

Respectfully,

L. O. HOWARD,
Entomologist and Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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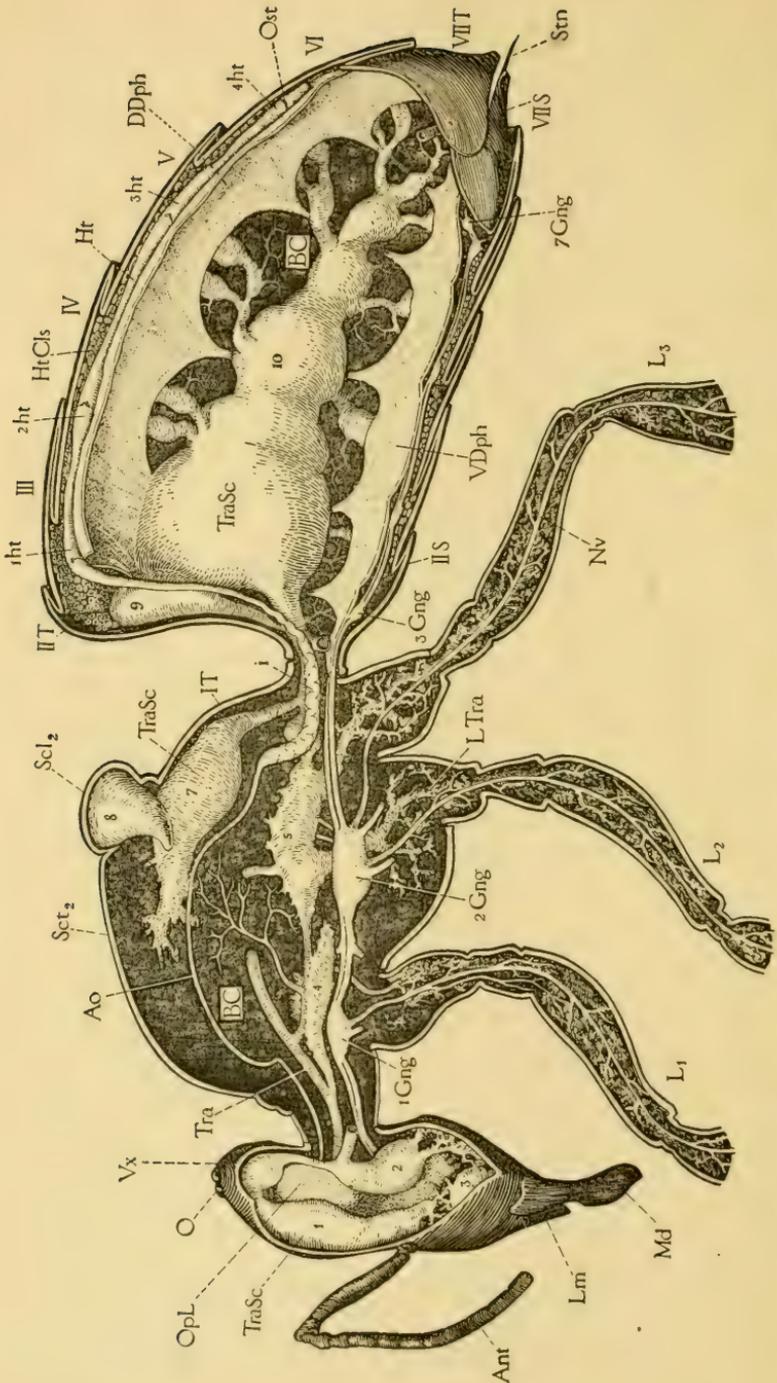


FIG. 1.—Longitudinal, median, vertical section of entire body of worker, showing nervous system (OpL-7Gng), tracheal system (TraSc, I-10), dorsal and ventral diaphragms of abdomen (DDph and VDph), and dorsal vessel consisting of heart (Ht) and aorta (Ao).

THE ANATOMY OF THE HONEY BEE.

I. INTRODUCTION.

The anatomy of the honey bee has been for years a subject of much interest to those engaged in bee keeping both for pleasure and for profit. This interest is due not only to a laudable curiosity to know more of the bee, but to the necessity of such information in order to understand fully what takes place in the colony. All practical manipulations of bees must depend on an understanding of the behavior and physiology of bees under normal and abnormal circumstances, and those bee keepers who have advanced bee keeping most by devising better manipulations are those, in general, who know most of bee activity. In turn, a knowledge of bee activity must rest largely on a knowledge of the structure of the adult bee.

Studies on the anatomy of the bee have not been lacking, for many good workers have taken up this subject for investigation. The popular demand for such information, however, has induced untrained men to write on the subject, and most accounts of bee anatomy contain numerous errors. This is probably to a greater extent true of the anatomy of the bee than of that of any other insect. Frequently the illustrations used by men not trained in anatomical work are more artistic than those usually found in papers on insect anatomy, and they consequently bear the superficial marks of careful work, but too often it is found that the details are inaccurate. It has therefore seemed the right time for a new presentation of this subject based on careful work.

The drawings given in the present paper are original, with the exception of figures 12, 54, and 55, and have been prepared with a thorough realization of the need of more accurate illustrations of the organs of the bee, especially of the internal organs. Mistakes will possibly be found, but the reader may be assured that all the parts drawn were seen. Most of the dissections, moreover, were verified by Dr. E. F. Phillips and Dr. J. A. Nelson, of this Bureau, before the drawings were made from them. An explanation of the abbreviations and lettering is given on pages 139-147.

It is hoped that the work will furnish the interested bee keeper with better information on the anatomy of the bee than has heretofore been offered to him, that it may provide a foundation for more detailed work in anatomy and histology, and, finally, that it will be

of service to future students of the embryology and physiology of the bee. With this last object in view the writer has tried to sum up under each heading the little that is at present known of insect physiology in order to bring out more clearly what needs to be done in this subject.

II. GENERAL EXTERNAL STRUCTURE OF INSECTS.

When we think of an animal, whether a bee, fish, or dog, we unconsciously assume that it possesses organs which perform the same vital functions that we are acquainted with in ourselves. We know, for example, that an insect eats and that it dies when starved; we realize therefore that it eats to maintain life, and we assume that this involves the possession of organs of digestion. We know that most insects see, smell, and perform coordinated actions, and we recognize, therefore, that they must have a nervous system. Their movements indicate to us that they possess muscles. These assumptions, moreover, are entirely correct, for it seems that nature has only one way of producing and maintaining living beings. No matter how dissimilar two animals may be in shape or even in fundamental constitution, their life processes, nevertheless, are essentially identical. Corresponding organs may not be the same in appearance or action but they accomplish the same ends. The jaws may work up and down or they may work sidewise, but in either case they tear, crush, or chew the food before it is swallowed. The stomach may be of very different shape in two animals, but in each it changes the raw food into a soluble and an assimilable condition. The blood may be red or colorless, contained in tubes or not, but it always serves to distribute the prepared food which diffuses into it from the alimentary canal. The situation of the central nervous system and the arrangement of its parts may be absolutely unlike in two organisms, but it regulates the functions of the organs and coordinates the actions of the muscles just the same.

Hence, in studying the honey bee we shall find, as we naturally expect to find, that it possesses mouth organs for taking up raw food, an alimentary canal to digest it, salivary glands to furnish a digestive liquid, a contractile heart to keep the blood in circulation, a respiratory system to furnish fresh oxygen and carry off waste gases, excretory organs for eliminating waste substances from the blood, a nervous system to regulate and control all the other parts, and, finally, organs to produce the reproductive elements from which new individuals are formed to take the places of those that die.

The study of anatomy or the structure of the organs themselves is inseparably connected with a study of physiology or the life functions of the animal. While physiology is a most interesting and important subject, and, indeed, in one sense might be said to be

the object of all anatomical research, yet the mere study of the structure of the organs alone, their wonderful mechanical adaptations, and their modifications in different animals forms a most fascinating field in itself, and besides this it gives us an insight into the blood relationships and degrees of kinship existing between the multitudes of animal forms found in nature. In the study of comparative anatomy we are constantly surprised to find that structures in different animals which at first sight appear to be entirely different are really the same organs which have been simply changed in a superficial way to serve some new purpose. For example, the front wing of a bee and the hard shell-like wing cover of a beetle are fundamentally the same thing, both being front wings—that of the beetle being hardened to serve as a protection to the hind wing. Again, the ovipositor of a katydid and the sting of a bee are identical in their fundamental structure, differing in details simply because they are used for different purposes. Hence, in the study of anatomy we must always be alert to discover what any special part corresponds with in related species. In order to do this, however, it is often necessary to know the development of an organ in the embryo or in the young after birth or after hatching, for many complex parts in the adult have very simple beginnings in an immature stage.

Thus it becomes evident that the structural study of even one organism soon involves us in the subjects of anatomy, physiology, and embryology, and, if we add to this a study of its senses, its behavior, and its place in nature, the field enlarges without limit. The student of the honey bee realizes that a lifetime might be spent in exploiting this one small insect.

The differences between animals are much greater on the outside than on the inside. In the descriptions of the organs of the honey bee anyone will know what is meant by the "alimentary canal," the "nervous system," or the "respiratory system," but the external parts are so different from those of animals with which we are more familiarly acquainted that no general reader could be expected to know what is meant by the names applied. Moreover, the bee and its allies are so modified externally in many ways that, at first sight, their parts look very different even from those of other insects. Hence, we shall give a preliminary account of the external structure of insects in general, for it is hoped that the reader will then more easily understand the special structure of the honey bee, and that the application of the terms used will appear more reasonable to him.

Since all animals originate in an egg, the change into the adult involves two different processes: One is *growth*, which implies merely an increase in size, the addition of material to material; the other is *development*, which means change in shape and the produc-

tion of a form with complex organs from the simple protoplasmic mass of the egg. The part of development that takes place in the eggshell is known as *embryonic development*; that which takes place subsequent to hatching is known as *postembryonic development*. In insects there are often two stages in the postembryonic development, an active one called the *larval stage* and an inactive one called the *pupal stage*. During the first of these the young insect is termed a *larva*; during the second, a *pupa*. When there is no resting stage the immature creature is often called a *nymph*. The final and fully developed form is an *adult*, or *imago*.

Since this paper is to deal only with the anatomy of the adult, the attractive fields of embryonic and postembryonic development must be passed over, except for a few statements on fundamental embryonic structure, a knowledge of which is necessary to a proper understanding of the adult anatomy.

When the **embryo**, in its course of development, first takes on a form suggestive of the definitive insect, it consists of a series of segments called *metameres*, or *somites*, and shows no differentiation into head, thoracic, and abdominal regions. Typically, each segment but the first is provided with a pair of latero-ventral *appendages*, having the form of small rounded protuberances. These appendages are of different sizes and take on different shapes in different parts of the body, for some of them are destined to form the antennæ, some the mouth parts, others the legs and perhaps the cerci, while the rest of them remain very small and finally disappear. What we know of the embryology of insects is based on the observations of a number of men who have worked mostly on the development of different species. Their observations are not all

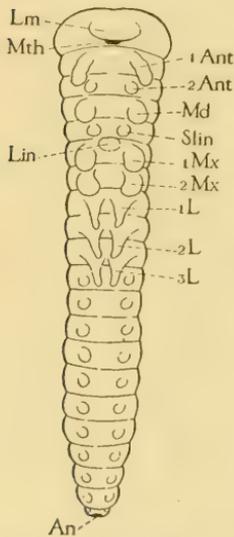


FIG. 2.—Diagram of a generalized insect embryo, showing the segmentation of the head, thoracic, and abdominal regions, and the segmental appendages.

alike, but this is probably due in large part to the fact that the embryos of different insects are not all alike. Embryos have a very provoking habit of skipping over or omitting little and yet important things in their development, but fortunately they do not all omit the same things. Therefore, by putting together all the reliable information we possess, we can make up an ideal embryo which would be typical of all insects. Such a generalized embryo is represented diagrammatically by figure 2.

The first six or seven metameres very early begin to unite with one another and continue to fuse until their borders are lost. These consolidated embryonic segments form the head of the adult insect.

Observers differ concerning the fate of the seventh segment, but it is most probable that a part of it fuses with the sixth segment, thus taking part in the formation of the head, and that a part of it forms the neck or some of the neck plates of the adult.

The appendages of these first seven segments form the antennæ and mouth parts, except one or two pairs that disappear early in embryonic life. It is not certain that the first segment ever possesses appendages, but from it arise the large compound eyes and apparently also the upper lip, or labrum (*Lm*). The appendages of the second segment form the feelers, or antennæ (*1Ant*) of the adult, those of the third (*2Ant*) disappear in insects, but they correspond with the second antennæ of shrimps and lobsters. The appendages of the fourth segment form the mandibles (*Md*). Those of the fifth segment (*Slin*), when present, fuse with a median tonguelike lobe (*Lin*) of the following segment, and the three constitute the hypopharynx, or lingua of the adult. The next pair (*1Mx*) form the maxillæ, while the last (*2Mx*), or those of the seventh segment, coalesce with each other and constitute the adult labium, or lower lip.

The bodies of the head metameres fuse so completely that it is impossible to say positively what parts of the adult head are formed from each. The last, as already stated, possibly takes part in the formation of both the head and the neck. Some embryologists attribute the plates which usually occur in this region to the last embryonic head segment, while others believe they come from the next segment following. Sometimes these plates are so well developed that they appear to constitute a separate segment in the adult, and this has been called the *microthorax*. If this name, however, is given to the embryonic segment from which these plates are said to be derived, it must be remembered that it is not "thoracic" at all and belongs partly to the head. The name *cervicum* has been applied to the neck region with greater appropriateness since it does not imply any doubtful affiliation with adjoining regions. What we really need, however, is not so much a name as more information concerning the development of the rear part of the head and the neck plates in different insects.

The next three segments remain distinct throughout life in nearly all insects, but, since they bear the legs and the wings, they become highly specialized and together constitute the *thorax*. The individual segments are designated the *prothorax*, the *mesothorax*, and the *metathorax*. The legs are formed from the embryonic appendages (fig. 2, *1L*, *2L*, *3L*) of these segments, but the wings are secondary outgrowths from the mesothorax and metathorax and are, hence, not appendages in the strict embryological sense.

The remaining segments, nearly always 10 in number, constitute the *abdomen*. The appendages of these segments, except possibly

those of the tenth, disappear early in embryonic life in all insects, except some of the very lowest species, in which they are said to form certain small appendages of the abdominal segments in the adults.

An **adult insect** is often described as being "divided" into a head, a thorax, and an abdomen, but this is not true in most cases. While all insects consist of these parts, the divisions of the body are usually not coincident with them. The prothorax in the adult is separated from the head by the neck and is very commonly separated from the mesothorax by a flexible membranous area. On the other hand, the mesothorax and metathorax are almost always much more solidly attached to each other, while, in most insects, the metathorax is solidly and widely joined to the first abdominal segment, though in the flies these latter two segments are usually separated by a constriction. In such insects as ants, wasps, and bees a slender, necklike peduncle occurs between the first and second segments of the abdomen, the first being fused into the metathorax so that it appears to be a part of the thorax. This is the most distinctive character of the order Hymenoptera, to which these insects belong.

The **body wall** of insects is hard on account of the thick layer of chitin which exists on the outer side of the true skin. Chitin is a substance similar to horn, being brittle, though tough and elastic. It gives form and rigidity to the body and affords a solid attachment for the muscles within, since insects have no internal framework of bones such as vertebrate animals have. The skin between the segments is soft and unchitinized and thus forms a flexible *intersegmental membrane* which is often very ample and, in the abdomen, allows each segment to telescope into the one in front of it.

The chitin of each segment is not continuous, but is divided into plates called *sclerites*. The most important of these are a *tergum* above and a *sternum* below, but, in the case of the thorax, these two plates are separated on each side by another called the *pleurum*, which lies between the base of the wing and the base of the leg. Pleural plates are sometimes present also on the abdominal segments. These principal segmental plates are usually separated by membranous lines or spaces, which permit of more or less motion between them. Such lines are called *sutures* in entomology, though strictly this term should be applied only to the lines of fusion between adjoining parts.

The terga, pleura, and sterna of each segment are furthermore subdivided into smaller sclerites, which may be termed *tergites*, *pleurites*, and *sternites*, respectively. The sutures between them are sometimes membranous also, but most frequently have the form of impressed lines or narrow grooves. In such cases they are generally nothing more than the external marks of ridges developed on the inside of the body wall to strengthen the parts or to give attachment to muscles. Since these sutures are conspicuous marks on the outside

of an insect, they are usually regarded as morphologically important things in themselves, representing a tendency of the tergum, pleurum, or sternum to separate into smaller plates for some reason. The truth about them would appear to be just the opposite in most cases—they are the unavoidable external marks of an internal thickening and strengthening of the plates. In a few cases they may be the confluent edges of separate centers of chitinization. Hence, most of the sutural lines in insects appear to signify a bracing or solidifying of the body wall rather than a division of it.

Since the body wall of insects is continuous over all the surface it contains no articulations of the sort that occur between the bones in the skeleton of a vertebrate. Although insects and their allies belong to the class of animals known as the Articulata, yet an articulate articulation is simply a flexibility—two chitinous parts of the exoskeleton are movable upon each other simply by the intervention of a nonchitinized, flexible, membranous part. While there are often special ball-and-socket joints developed, these are always produced on the outside of the membranous hinge and simply control or limit the movement of the articulation.

The **head** of an adult insect is a thin-walled capsule containing the brain, the ventral head ganglion of the nervous system, the pharynx and anterior part of the œsophagus, the tracheal tubes, and the muscles that move the antennæ and the mouth parts. Its shape varies a great deal in different insects, being oval, globular, elongate, or triangular. In some it is flattened dorso-ventrally so that the face is directed upward and the mouth forward, but in most, including the bee, it is flattened antero-posteriorly so that the face looks forward and the mouth is directed ventrally. In a few it is turned so that the face is ventral. The walls of the head are usually divided by sutures into a number of sclerites, which in general are located and named as follows: The movable transverse flap forming the upper lip is the *labrum*. Above it is a sclerite called the *clypeus*, which is a part of the solid wall of the head and carries the anterior articulations of the mandibles. The clypeus is sometimes divided transversely into an *anteclypeus* ("clypeus anterior," "epistoma") and into a *post-clypeus* ("clypeus posterior"). Above the clypeus is the *front*, a plate usually occupying the upper half of the face between the compound eyes and carrying the antennæ. The top of the head is called the *vertex*, but does not constitute a separate sclerite. The sides of the head below the compound eyes are often separated by sutures from the anterior and posterior surfaces and are known as the *genæ*. The back of the head is formed by the *occiput*, which surrounds the large opening or *foramen magnum* that leads from the cavity of the head into that of the neck. The parts posterior to the genæ, carrying the posterior mandibular articulations,

are sometimes separated from both the occiput and the genæ and are known as the *postgena*. In a few insects, especially beetles, one or two median plates occur in the ventral wall of the head posterior to the base of the labium. These are the *gular sclerites*. Finally, small plates are sometimes found about the bases of the antennæ and between the bases of the mandibles and the genæ. The latter have been termed the *trochantins of the mandibles*. The term *epicranium* is often used to include all the immovable parts of the head, but is frequently applied only to the dorsal parts. Most of these sclerites preserve a pretty definite arrangement in the different orders, and they are probably homologous throughout the entire insect series, though they are in some cases very much distorted by special modifications and are often in part or wholly obliterated by the disappearance of the sutures. Embryologists are coming to the conclusion that the sclerites of the head have no relation to the primitive segments. The latter very early consolidate into a head with a continuous wall, while the sutures defining the sclerites are formed later. Some of the older entomologists were led, from a study of the sclerites, to suppose that the head consisted of a number of segments, but it has been shown that these anatomical segments do not correspond with the embryonic ones.

The appendages growing from the front of the face are the antennæ (fig. 9A, *Ant*) or "feelers" and consist of a series of joints or segments.

At the lower edge of the face is the front lip or *labrum* (fig. 9A, *Lm*), behind which are the median *epipharynx*, the paired *mandibles* (*Md*) and *maxillæ*, the median *hypopharynx*, and the *labium* or under lip. All these organs together constitute what are known as the *mouth parts* or *trophé*. They vary greatly in shape and appearance in different insects according to the nature of the food, but their typical form is usually taken to be that shown by the lower insects which feed on solid food and have biting mouth parts. Figure 3, representing the jaws and lips of the common black cricket, is given as an example of generalized insect mouth parts.

The *labrum* (fig. 9A, *Lm*) is usually a simple transverse flap in front of the mouth, being developed, as already shown, from a similarly situated lobe on the first segment of the embryo (fig. 2, *Lm*).

The *epipharynx* (fig. 19, *Ephy*) is a sort of dorsal tongue, and is situated on the membrane leading into the mouth from behind the labrum.

The *mandibles* (figs. 3A; 9A, *Md*) are typically formed for biting, being heavy organs situated immediately behind the labrum and working sidewise on a hinge articulation with the head. Their cutting edges are usually notched and toothed, though smooth in the worker bee.

The **maxillæ** (fig. 3 B and B) are complicated appendages in their typical form. Each consists of a principal piece called the *stipes* (*St*), which is hinged to the head by means of a smaller basal piece, the *cardo* (*Cd*). Terminally the stipes bears an outer lobe, the *galea* (*Ga*), and an inner lobe, the *lacinia* (*Lc*). On the outer side, at the base of the galea, it carries a jointed appendage called the *maxillary palpus* (*Plp*).

The **hypopharynx** (fig. 3 C and D, *Hphy*) is a median, ventral, tonguelike organ, called also the *lingua*, situated either on the upper surface of the labium or on the membrane between this organ and the mouth. It is developed principally from a median lobe of the head of the embryo behind the mouth (fig. 2, *Lin*), but some entomologists claim that it is compounded of this lobe and two smaller lateral ones developed from the appendages of the fifth embryonic head segment (fig. 2, *Slin*), the *superlinguæ*.

The **labium** (fig. 3 C and D) constitutes the under lip of the adult, but it is formed from the two appendages of

the seventh segment in the embryo, which fuse with each other. For this reason it is often called the *second maxilla*. It consists of a basal *submentum* (*Smt*) bearing the *mentum* (*Mt*), which in turn carries three parts, a median *ligula* (*Lg*) and two lateral *palpigera* (*Plg*). The latter support the *labial palpi* (*Plp*), while the ligula bears four terminal lobes, of which the median ones are called the *glossæ* (*Gls*) and the lateral ones the *paraglossæ* (*Pgl*). If we should cut the labium into two parts along its midline we should see that even in the adult stage each half is very similar to one maxilla. The only discrepancy to be noticed in the example given (fig. 3) is that there

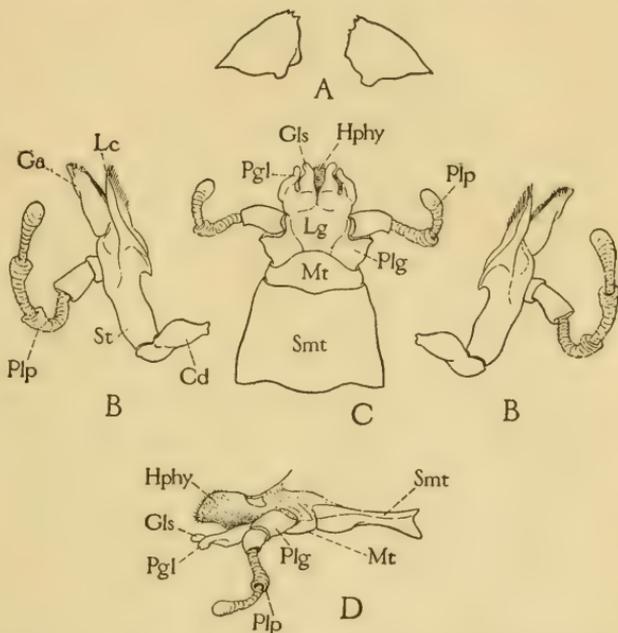


FIG. 3.—Example of generalized insect mouth parts, from common black cricket (*Gryllus pennsylvanicus*): A, mandibles; B, B, maxillæ, ventral view; C, labium or second maxilla, ventral view; D, labium, lateral view.

is no maxillary palpiger, but many insects possess a corresponding part in the maxilla, frequently distinguished as the *palpifer*.

The **neck** or **cervicum** is usually a short membranous cylinder which allows the head great freedom of motion upon the thorax. In nearly all insects its lateral walls contain several small plates, the *cervical sclerites*, while, in many of the lower species, dorsal, ventral, and lateral sclerites are present and highly developed. As already stated, the origin of these plates is doubtful. Some entomologists would derive them from the prothorax, others think they come from the last head segment, while still others think that they represent a separate segment. Only pure anatomists, however, entertain this last view and call this supposed segment the "microthorax," for embryologists have not yet reported a metamere between the labial segment and the prothoracic segment. Most embryologists who have studied the subject admit that some of the cervical sclerites may be formed from the last embryonic head somite which carries the labium and probably forms a part of the back of the head. Therefore, if it is desirable to retain the word *microthorax* as a name for a true segment, it can be applied only to this labial metamere.^a

The **thorax**, as has already been stated, is a distinct anatomical region of the body rather than a "division" of the body, since it carries both the legs and the wings and contains the large muscles for each. Since the prothorax does not possess wings, it is not so highly developed otherwise as the two wing-bearing segments, and is, indeed, generally reduced in some ways, some of its parts being frequently rudimentary. Therefore we shall base the following description of a typical segment on the structure of the wing-bearing segments.

A typical thoracic segment, then, presents four surfaces, as does also the entire body. These are a *dorsum* above, a *venter* below, and a *latus*^b on each side. From these names we have the terms "dorsal."

^aIn a former paper on the thorax of insects (Proc. U. S. Nat. Mus., XXXVI, 1909, pp. 511-595) the writer probably drew a too definite conclusion on the subject of the "microthorax." The origin of the neck sclerites has probably never yet been actually observed. Comstock and Kochi (Amer. Nat., XXXVI, 1902, pp. 13-45), in summarizing the segmentation of the head, accredited the gular and cervical sclerites to the labial segment, but did not recognize the latter as taking part in the formation of the true head capsule. Riley, however, in his study of the development of the head of a cockroach (Amer. Nat., XXXVIII, 1904, pp. 777-810), states that in *Blatta* the labial segment does form a part of the back of the head and that the posterior arms of the tentorium are derived from it. Börner (Zool. Anz., XXVI, 1903, pp. 290-315) and Crampton (Proc. Acad. Nat. Sci. Phila., 1909, pp. 3-54) believe that the cervical sclerites are derived principally from the prothoracic segment. The notion that they constitute a separate segment, the "microthorax," equivalent to the maxilliped segment of the centipedes, has been elaborated principally by Verhoeff in his numerous writings on the Chilopoda and Dermaptera.

^bThe writer introduces this word here because he knows of no other term applied to the side of the segment in this sense.

“ventral,” and “lateral.” The chitinous parts of the dorsum constitute the *tergum*; of the venter, the *sternum*; and of the latus, the *pleurum*.

The *tergum* of the wing-bearing segments usually consists of two plates—a front one or true *notum* (fig. 4, *N*) carrying the wings, and a posterior one, which the writer has termed the *postnotum* or *pseudonotum* (*PN*), having no connection with the wings. The first is often more or less distinctly marked into three transverse parts called the *prescutum* (*Psc*), *scutum* (*Sct*), and *scutellum* (*Scl*). In such cases the exposed part of the postnotum is called the *postscutellum* (*Pscℓ*). From either the anterior or the posterior margin of the *tergum*, or from both, a thin transverse plate projects downward into the interior of the thorax for the attachment of muscles. These plates are the *phragmas* (*Aph* and *Pph*). The notum supports the wing on each side by two small lobes, the *anterior* and *posterior notal wing processes* (*ANP* and *PNP*). Behind the latter is the attachment of the *axillary cord* (*AxC*) or basal ligament of the wing. A large V-shaped ridge on the under surface of the notum having its apex forward is the “*entodorsum*.” (A better name would be *entotergum*.)

The *pleurum* consists principally of two plates, the *episternum* (fig. 4, *Eps*) and the *epimerum* (*Epm*) lying before and behind a vertical groove, the *pleural suture* (*PS*), which extends from the *pleural coxal process* (*CxP*) below to the *pleural wing process* (*WP*) above. The pleural suture marks the position of a heavy internal ridge, the *pleural ridge* or *entopleurum*. The epimerum is connected with the postnotum (*PN*) behind the base of the wing. These parts occur in almost all insects. In some of the lower ones another plate is present in front of the episternum which may be called the *preepisternum* (*Peps*).^a Lying along the upper edge of

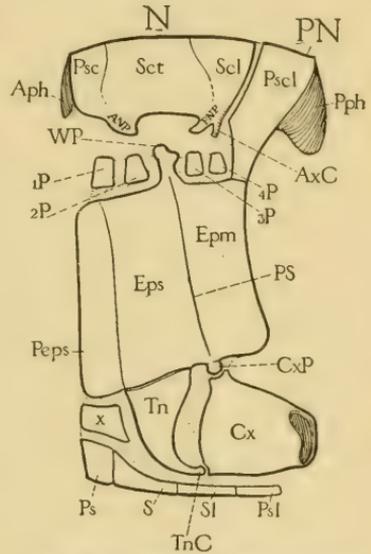


FIG. 4.—Diagram of generalized thoracic segment, left side.

^a Objection may be made to the use of the term “preepisternum” on the ground that it combines a Latin prefix with a word compounded of Greek elements. The same may be urged against “prephragma,” “postphragma,” “preparaptera,” and “postparaptera,” words introduced by the present writer in a former paper on the thorax (Proc. U. S. Nat. Mus., XXXVI, 1909, pp. 511–595). However, we are barred from making up equivalent terms with the Greek prefixes *pro* and *meta* because these are used to designate the first and the third

the pleurum and associated with the under surface of the wing base are several small plates known as the *paraptera* (*P*).^a Two lie above the episternum in front of the pleural wing process and are the *episternal paraptera* or *preparaptera* (*1P* and *2P*), while one or occasionally two are similarly situated behind the wing processes and are the *epimeral paraptera* or *postparaptera* (*3P* and *4P*). The preparaptera afford insertion for the muscle concerned in the extension and pronation of the wing.

The *coxa* (*Cx*), or basal segment of the leg, is hinged to the segment by a dorsal articulation with the pleural coxal process (*CxP*), and by a ventral articulation (*TuC*) with a plate called the *trochantin* (*Tu*) lying in front of it and connected above with the lower end of the episternum (*Eps*). Hence, while the leg is of course continuous all around its base, by means of membrane, with the body-wall, its movement is limited to a hinge motion by these two special articulations of the chitin.

The **sternum** or ventral plate of the segment is not so complicated as are the tergum and pleurum. It is often divided transversely into three parts, however, and some authors say typically into four. These parts have been named the *presternum* (*Ps*), *sternum proper* (*S*),

segments of the thorax or their respective parts. Entomologists have already established the system of referring a part to the front or back of any individual segment by the Latin prefixes *pre* (or *præ*) and *post* as used in "prescutum," "presternum," "postscutellum," and "poststernellum." Furthermore, *pre* and *post* are so indiscriminately used in English combined with Latin, Greek, and even Anglo-Saxon words that they may be regarded as general property. Hence, in order not to sacrifice an anatomical system, which certainly needs to be fostered in every way, the writer has preferred to sacrifice strict grammatical rules by applying *pre* and *post*, regardless of the origin of the noun in the case, to designate anterior and posterior parts of the same segment. We already use such hybrid terms as "presternum," "mesotergum," and "metatergum."

The name "preepisternum" has been applied by Hopkins (Bul. 17, Pt. I, technical series, Bur. Ent., U. S. Dept. Agr., 1909) to a part of the mesepisternum of *Dendroctonus*—a plate apparently not homologous with the preepisternal element of the thorax in primitive insects.

^aThe name "parapterum" is taken from Audouin's term *paraptère* (Ann. des Sci. Nat., I, 1824, pp. 97–135, 416–432), and its application, as used by the present writer, is based on Audouin's definition given in his Chapter III, "*Considerations générales sur le Thorax*," where he says (p. 122): "Finally there exists a piece but little developed and seldom observed, connected with both the episternum and the wing. It is always supported by the episternum and is sometimes prolonged ventrally along its anterior margin, or again, becoming free, passes in front of the wing and may even come to lie above the base of the latter. At first we designated this sclerite by the name of *Hypoptère* but on account of its change of position relative to the wing base we now prefer the name of PARAPTÈRE." The first part of his description leaves no doubt that Audouin referred to the little pleural plate beneath the front of the wing which is usually very inconspicuous except in carefully dissected

sternellum (*Sl*), and *poststernellum* (*Psl*). In some of the lower insects a plate (*x*) occurs at each side of the presternum or of the sternum which seems to fall in line with the preepisternum of the pleurum. This has been variously called a *part of the presternum*, the *coxosternum*, an *accessory sternal plate*, and the *sternal laterale*. The inner surface of the sternum carries a large two-pronged process called the *furca* or *entosternum*.

This plan of structure for the mesothorax and the metathorax prevails throughout all insects. The honey bee probably presents the greatest departure from it, but even

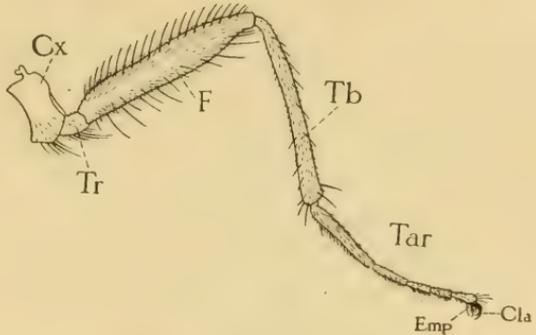


FIG. 5.—Typical insect leg.

here the modification consists principally of a suppression of the sutures of the pleurum resulting from a condensation of the parts.

The leg (fig. 5) of an adult insect consists of a number of joints or segments. It is attached to the body, as just described, by a thick

specimens. In such preparations, however, one finds that there are in most cases two sclerites here instead of one, and, furthermore, that one or occasionally two others are similarly situated beneath the rear part of the wing base behind the pleural wing process. The present writer has, therefore, made the term "paraptera" cover this whole row of little plates, distinguishing those before and those behind the pleural wing process by the designations given above.

In the latter part of Audouin's definition it would seem that he may have confused the rudimentary tegula as it exists in some insects with the parapterum, but even this is not probable since he says it is always connected with the episternum, which is never true of the tegula. In his description of the thorax of beetles, *Dytiscus*, *Carabus*, *Buprestis*, and *Curculio*, it is evident that he regards the anterior upper part of the episternum as the parapterum fused with the latter plate. In fact, in each case he definitely states that such is the case and, in describing *Dytiscus circumflexus*, he says (p. 420): "The episternum, the parapterum, and the epimerum all fuse dorsally and constitute a support for the wings and tergum." While Audouin is undoubtedly mistaken in this homology, especially in the mesothorax, he at least shows that his "paraptère" is a part of the pleurum. Hence modern writers such as Packard and Folsom who make the term "paraptera" synonymous with "tegulae" are certainly wrong. The tegula is a dorsal scale or its rudiment at the humeral angle of the wing, while the parapterum is a co-existent sclerite below this part of the wing base. The present writer agrees with Comstock and Kellogg, who, in their *Elements of Insect Anatomy* (first edition), define the little sclerite in front of the base of the wing in the locust, articulated to the dorsal extremity of the episternum, as the "parapteron," though in this insect there are here really two of these parapteral plates instead of one.

basal joint called the *coxa* (*Cx*). Beyond this is a smaller joint called the *trochanter* (*Tr*), this is followed by a long and strong segment, the *femur* (*F*), which extends outward from the body, while bending downward from its distal end is the long and slender *tibia* (*Tb*), followed finally by the foot, or *tarsus* (*Tar*). The tarsus itself consists typically of five small segments of which the last bears a pair of *claws* (*Cla*). The under surfaces of the tarsal joints are often provided with small cushions or pads called *pulvilli*. Those between the claws are generally specially prominent and are called the *empodia* (*Emp*). The leg varies greatly in shape in different insects but usually preserves all of these parts. The segments of the tarsus, however, are frequently reduced in number.

The **adult wing** is a thin expanse of *membrane* supported by hollow branching rods called *veins*. It originates as a hollow outgrowth of the body-wall, but soon becomes flattened out dorso-ventrally and the

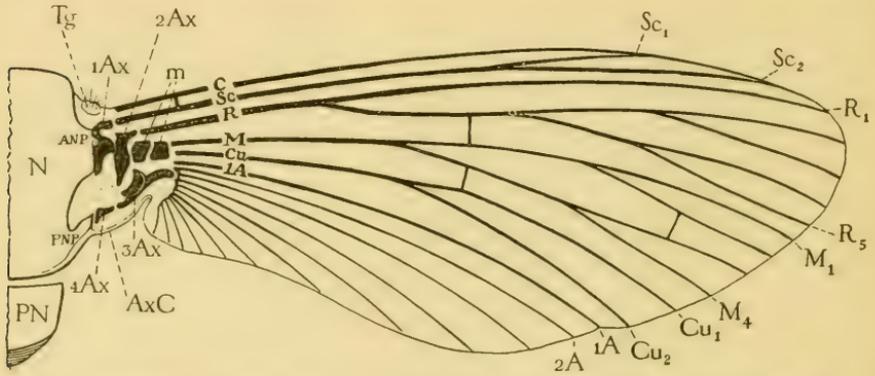


FIG. 6.—Diagram of generalized insect wing and its articulation to first plate (*N*) of the tergum.

contained tracheæ or air tubes mark out the courses of the veins. These veins form various patterns in different insects, but they can all be derived by modification from one fundamental plan. This plan is shown diagrammatically by figure 6. The first vein, which usually forms the anterior margin of the adult wing, is the *costa* (*C*). The next vein is the *subcosta* (*Sc*), which in typical cases divides into two branches (*Sc*₁ and *Sc*₂). The third and usually the principal vein is the *radius* (*R*). It divides dichotomously into five branches (*R*₁ to *R*₅), the anterior branch of the first fork remaining single. The next vein is the *media* (*M*), which forms four branches (*M*₁ to *M*₄). The fifth is the *cubitus* (*Cu*), which again is two-branched. The remaining veins are called the *anals* and are designated individually as the *first anal* (*1A*), *second anal* (*2A*), etc.

Several *cross-veins* of common recurrence should be noted. The first is situated near the base of the wing between the costal and subcostal veins and is known as the *humeral cross-vein*. A second

occurs between the radius and the media near the center of the wing and is called the *radio-medial cross-vein*. Another one, the *medio-cubital*, is similarly located between the media and the cubitus, while a fourth, called the median, occurs between the second and third branches of the media. The areas of the wing surface inclosed by the veins, the cross-veins, and the margins of the wing are known as the *cells*.

A great many different names are applied by different entomologists to the veins of the wings, both of the same and of different insects. The nomenclature here given is the one first consistently applied by Comstock and Needham and now used by a large number of entomologists working in different orders of insects.

The wing is articulated at its base (except in mayflies and dragonflies) to the anterior and posterior wing processes of the notum (fig. 6, *ANP* and *PNP*) and to the wing process of the pleurum (fig. 4, *WP*) by several small articular sclerites called *axillaries*. Two of these, the *first* (*1Ax*) and the *fourth* (*4Ax*), form a hinge with the anterior and the posterior notal wing processes, respectively, while the *second* (*2Ax*) articulates below with the wing process of the pleurum, constituting thus a sort of pivotal element. The *third axillary* (*3Ax*) intermediates between the bases of the anal veins and the fourth axillary—except when the latter is absent (as it is in nearly all insects except Orthoptera and Hymenoptera), in which case it articulates directly with the posterior notal process. The thin membrane of the wing base may be called the *axillary membrane* (*AxM*). On its anterior edge is a hairy pad, the *tegula* (*Tg*), which is sometimes a large scale overlapping the humeral angle of the wing. The posterior margin of the axillary membrane is thickened and may be called the *axillary cord* (*AxC*) or *basal ligament* of the wing.

The base of the costa is not directly associated with any of the axillaries, but is specially connected by tough membrane below with the episternal paraptera. The subcosta abuts against the end of the curved neck of the first axillary. The radius is either attached to or touches upon the anterior end of the second. The media and cubitus are usually associated with each other at their bases and also more or less closely with one or two *median plates* (*m*) in the wing base. These plates, however, are not of constant shape and occurrence as are the articulating axillaries. The anals are generally attached to the outer end of the third axillary, which acts as a lever in the folding of the wing.

A few insects have a generalized wing almost identical with the diagram (fig. 6), but most of them depart from it in varying degrees. Few go so far, however, as the honey bee, whose venation is very different, but yet the fundamental basal structure is the same even

here, as will be shown in the special description of the wing of the bee.

The **abdomen** consists almost always of 10 segments. There are never any more than this number well developed in adult insects, and if there are fewer the reduction is due to a modification of the terminal segments to accommodate the external organs of reproduction. The posterior opening of the alimentary canal is at the end of the tenth segment, which carries also two small appendages at the sides of the anus. These are called the *cerci* (fig. 8, *Cer*). In some insects they are short, styletlike processes, in others they are long and many jointed, while in many they are absent. The cerci are supposed to be developed from the embryonic appendages of the tenth segment, although, on the other segments, these appendages disappear before the embryo hatches, except in some members of the lowest wingless order of insects, which have a pair of cercuslike appendages on each segment of the abdomen.

Each abdominal segment presents a tergum above and a sternum below; the former usually also reaches far down on the sides and overlaps the edges of the sternum. In some insects one or more small pleural plates intervene between the tergum and the sternum, but the abdominal pleura are never developed in any way suggestive of a thoracic pleurum. Very frequently there is present an upper pleural plate, or *epipleurite*, adjoining the edge of the tergum and a lower, or *hypopleurite*, adjoining the edge of the sternum. The line separating these two sclerites, however, is horizontal and can not correspond with the vertical suture of a thoracic pleurum between the episternum and the epimerum extending from the base of the leg to the base of the wing.

The most complicated structures on the abdomen are the external organs of reproduction. In the male these serve as *clasp ing organs* and take on a great variety of forms in different species. The organs in the female form an *ovipositor* and are of much more definite and constant structure.

The *ovipositor* (fig. 8), in its most perfect development, consists of three pairs of long, closely appressed bladelike processes called *gonapophyses* (*1G*, *2G*, *3G*). These six pieces fit neatly together and form an organ by means of which the female makes a hole in the ground or in the bark of a tree, or punctures some other insect, and then places her eggs in the cavity thus produced. An interesting fact in this connection is that the sting of a wasp or bee is simply a modified ovipositor. This can be proved by a comparison of the organs themselves or by a study of their development. Each is formed from six little peglike processes that grow out from the sterna of the eighth and ninth abdominal segments of the larva or young soon after hatch-

ing (fig. 7, *1G*, *2G*, and *3G*). At first there is only one pair of these processes on each of the two segments, but those on the ninth soon split each into two, thus producing two pairs on this segment. The opening of the oviduct (*OvO*) is on the eighth segment between the bases of the first gonapophyses.

The ovipositor of the longhorned grasshopper, shown by figure 8, may be taken as a typical example of this organ. The median pair of gonapophyses on the ninth segment (*2G*) remain slender and fuse at their bases into a small bulblike swelling open below (*ShB*). The pair from the eighth segment (*1G*) form two long blade-like pieces, which fit by sliding articulations upon the lower edges of the corresponding second gonapophyses (*2G*). The first can therefore be worked back and forth while they are braced and held in position by the second pair. The third gonapophyses (*3G*), or the outer pair of the ninth segment (the left one in figure 8 is shown as if cut off near its base), form two long flat blades which are closely appressed against the outer surfaces of the others. In the detailed study of the bee it will be shown how closely the structure of the sting corresponds in every way with that of this ovipositor.

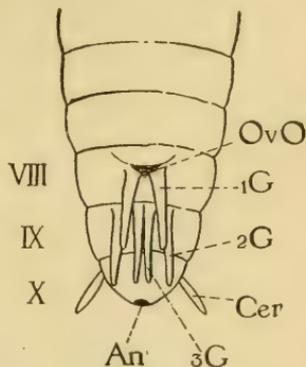


FIG. 7.—Diagram of terminal abdominal segments of a female insect and early stage in development of gonapophyses (*1G*, *2G*, and *3G*), from which is formed the ovipositor of most insects and the sting of wasps and bees.

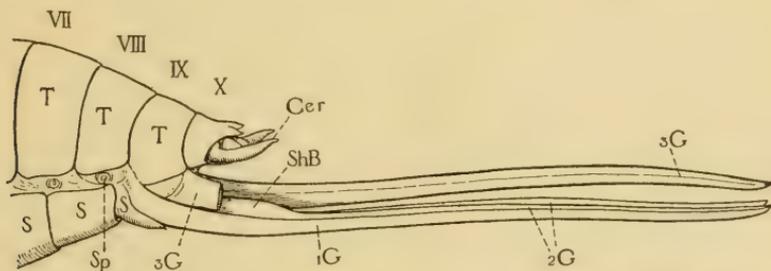


FIG. 8.—Example of a swordlike ovipositor, from a longhorned grasshopper (*Conocephalus* sp.), illustrating the fundamental similarity of structure with the sting of the bee, fig. 36.

Some entomologists have supposed that the original two pairs of gonapophyses represent the embryonic appendages of the eighth and ninth segments, and they would thus establish a homology between the ovipositor or sting and the legs and mouth parts. It has been shown, however, that the true appendages of the abdominal segments disappear in embryonic life while the gonapophyses appear much later, during early nymphal or larval life. Furthermore, each pair

of gonapophyses arises in a median depression on the ventral side of the segment while the true appendages are latero-ventral. Hence, the evidence is very much against this theory and the gonapophyses appear to be special secondary processes of the body wall.

All insects do not have ovipositors of the sort described above. Flies, beetles, moths, and butterflies do not. Such insects simply drop their eggs from the orifice of the oviduct or deposit them in masses upon the external surfaces of various objects. In some of the flies, however, the terminal segments are long and tubular and entirely telescoped into one another. They are hence capable of being protruded in the form of a long tapering tube having the opening of the oviduct near the tip. This enables the insect to deposit its eggs in deep crevices, but the structure is not a true ovipositor—it is simply the abdomen itself stretched out.

Insects breathe through a series of small holes situated along each side of the body. These breathing apertures are called *spiracles* and they lead into a system of internal air tubes called *tracheæ*. There are nearly always 10 spiracles present on each side of the body. Two are located on the thorax, the first between the prothorax and the mesothorax, the second between the mesothorax and the metathorax, while the other eight are situated on the first eight abdominal segments. Some embryologists believe that the spiracles of the prothorax move forward in early embryonic life and unite with each other in front of the hypopharynx to form the salivary opening, their tracheæ constituting the salivary ducts.

After this review of the general external structure of insects we may proceed to a more detailed account of the parts and organs of the honey bee.

III. THE HEAD OF THE BEE AND ITS APPENDAGES.

The head of an insect, as already explained, is a composite organ formed of six or seven primitive segments, each of which, except the first, typically bears a pair of appendages (fig. 2). The antennæ are developed from the embryonic appendages of the second segment, the mandibles from the fourth, the maxillæ from the sixth, and the second maxillæ, or labium, from the seventh. The appendages of the third segment disappear in early embryonic life while those of the fifth segment, when the latter is present, fuse with a median tongue-like lobe of the next segment to form the hypopharynx of the adult.

1. THE STRUCTURE OF THE HEAD.

The general appearance and outline of the head of a worker bee are shown from before and behind by figure 9, A and B. In facial view the head is triangular, with the apex below. The side angles

are rounded and capped by the large compound eyes (*E*). In the opposite direction the head is very much flattened, the greatest diameter being crosswise through the middle of the eyes. The face is convex, while the posterior surface is somewhat hollowed out and fits snugly upon the anterior end of the thorax.

The large lateral eyes (fig. 9 A, *E*) are called the **compound eyes**, because each is composed of a large number of separate eye elements forming the little hexagonal *facets* visible on the surface. All of these facets together constitute the *cornea*, or the transparent outer surface of the eye, which in the bee is densely clothed with long hairs. The dark color of the eye is located in the deeper parts, but these will be described in the section dealing with the nervous system. On the

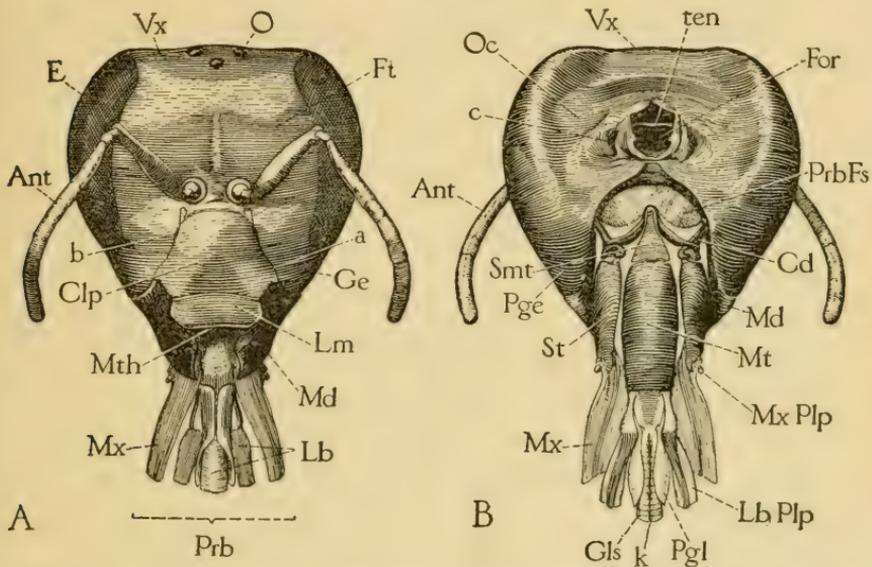


FIG. 9.—A, front view of head of worker bee with mouth parts (*Prb*) cut off a short distance from their bases; B, corresponding view of posterior surface of head.

top of the head between the compound eyes are the three simple eyes, or **ocelli** (*O*), arranged in a triangle with the median ocellus in front.

Between the lower halves of the large eyes and near the center of the face arise the **antennæ** (*Ant*), each of which is inserted into a small, circular, membranous socket of the head wall, and consists of a long, basal, 1-segmented stalk carrying a terminal 11-jointed arm movably articulated to the stalk and generally hanging downward from it. (In the drone the terminal arm consists of 12 joints.)

The **mouth parts** are attached at the lower part of the head, and consist of the *mandibles* (*Md*) laterally and the *maxilla* (*Mx*) and *labium* (*Lb*) mesially. The latter two include the set of elongate blade-like organs surrounding the protrisible "tongue," which together constitute what is commonly known as the *proboscis* (*Prb*).

When not in use the parts of the proboscis are bent back beneath the head. By referring to figure 9B, giving a posterior view of the head, it will be seen that the basal parts of both the maxillæ (*St*) and the labium (*Mt*) are suspended in a large hollow on the back of the cranium. This may be called the cavity or *fossa* of the proboscis (*PrbFs*). Between the mandibles on the front of the head (fig. 9A) is a transverse movable flap, the *labrum* (*Lm*), attached to the lower edge of the front wall of the head and constituting the upper lip. The *mouth* (*Mth*) lies behind the labrum and the mandibles close beneath it.

Below the antennal sockets is a transverse, slightly arched suture (*a*) which turns downward on each side and extends to the inner angles of the bases of the mandibles. The area bounded by this suture is the *clypeus* (*Clp*) and the suture itself may be called the *clypeal suture*.

On the posterior surface of the head (fig. 9B) is seen the pentagonal *foramen magnum* (*For*) by means of which the cavity of the head communicates with that of the thorax and through which pass the nerves, œsophagus, blood vessel, and tracheal tubes. A small rod (*ten*) inside the head arches transversely over the foramen magnum, cutting it into a dorsal and a ventral half. At each side of the foramen is a large pit (*c*) which marks the base of an internal chitinous beam of the head known as the mesocephalic pillar. The opposite end of this pillar unites with the front wall of the head on the clypeal suture below the antennæ, where it produces another smaller pit (*b*).

Below the foramen magnum and separated from it by a wide transverse bridge of the cranial wall is seen the large fossa of the proboscis (fig. 9B, *PrbFs*) having the shape of an inverted **U**. The side walls of this cavity are chitinous and from their upper edges are suspended the maxillæ, while the base of the labium is contained in the membranous floor of the fossa. The base of the labium projects from the head beneath or behind the mouth opening and its dorsal surface forms the floor of a preoral cavity surrounded by the bases of the mouth parts and labrum.

It will be seen from the above description that the head wall of the bee contains no suture except that bounding the clypeus and the one which separates the labrum from the latter. Many of the higher insects have the head wall completely continuous, showing no division at all into sclerites, but, in such forms as a grasshopper or cockroach, and, in fact, most of the lower insects, the head as well as the other parts of the body is made up of a number of plates. Hence this may be regarded as the primitive condition, and it is presumed that the head of the bee has been produced from one whose wall was divided by sutures into a number of distinct parts. Therefore the different

regions of the bee's head may be named according to the sclerites with which they correspond in other insects. Thus, the part of the face above the clypeus and between the compound eyes may be called the *front* (fig. 9A, *Ft*), the parts below the compound eyes the *genæ* (*Ge*), and the top of the head the *vertex* (*Vx*). The area on the back of the head around the foramen magnum may likewise be termed the *occipital region* (fig. 9B, *Oc*) and the parts behind the genæ and the lower halves of the compound eyes the *postgenæ* (*Pge*).

The worker, queen, and drone differ conspicuously in the shape and size of the head, as will be seen by comparing A, B, and C of figure 10. In these drawings the front has been removed in order to show various internal parts, which will be described later. While the head of the worker (A) is triangular in facial view, that of the queen (B) is more rounded and wider in proportion to its length. The head of the drone (C) is much larger than that of the female and is nearly circular in outline. In shape the head of the queen is intermediate between that of the worker and that of the drone, but in size it is somewhat smaller than the head of the worker. The eyes (*E*) of the worker and queen are about equal, but those of the drone are enormously enlarged and are broadly contiguous on the vertex and the upper part of the front. On this account the ocelli (*O*) of the drone are crowded down on the front nearer the bases of the antennæ and the front itself is very much narrowed above. The antennæ of the drone consist of 13 segments, while those of the females have but 12 segments. The mandibles are largest proportionately in the queen and are very small in the drone. Those of the worker have a smooth terminal edge, while this edge is notched in the queen and the drone. The parts of the proboscis are much longer in the worker

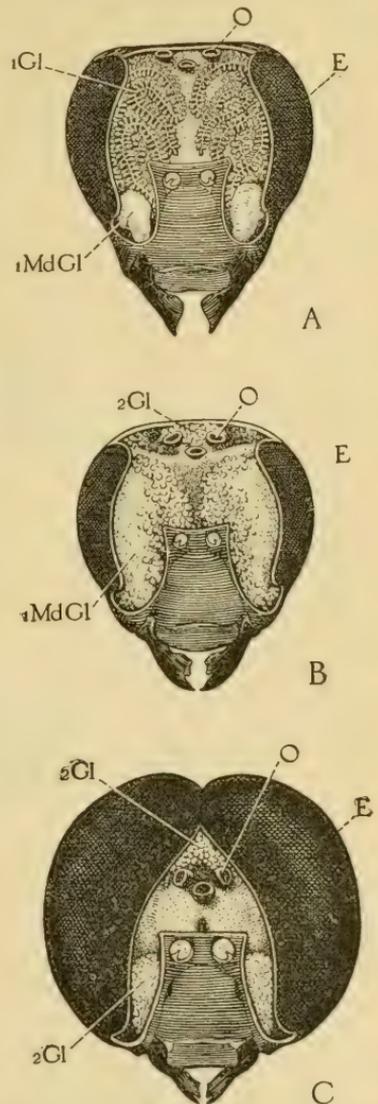


FIG. 10.—A, anterior view of head of worker, with front, antennæ, and proboscis removed; B, corresponding view of head of queen; C, same of drone.

and capable of much more action than in the queen and drone, which are almost entirely dependent upon the workers for their food.

The internal structure of the cranium may be studied best in a longitudinal section of the head (fig. 11). In order to prepare a section for this purpose imbed the head in paraffin and then carefully slice off one side with a sharp knife or razor just outside of the bases of the mandible and antenna. Holding the remainder in the block of paraffin or fastening the whole in a dish of water or alcohol, carefully dissect away the soft parts from the head cavity so as to expose

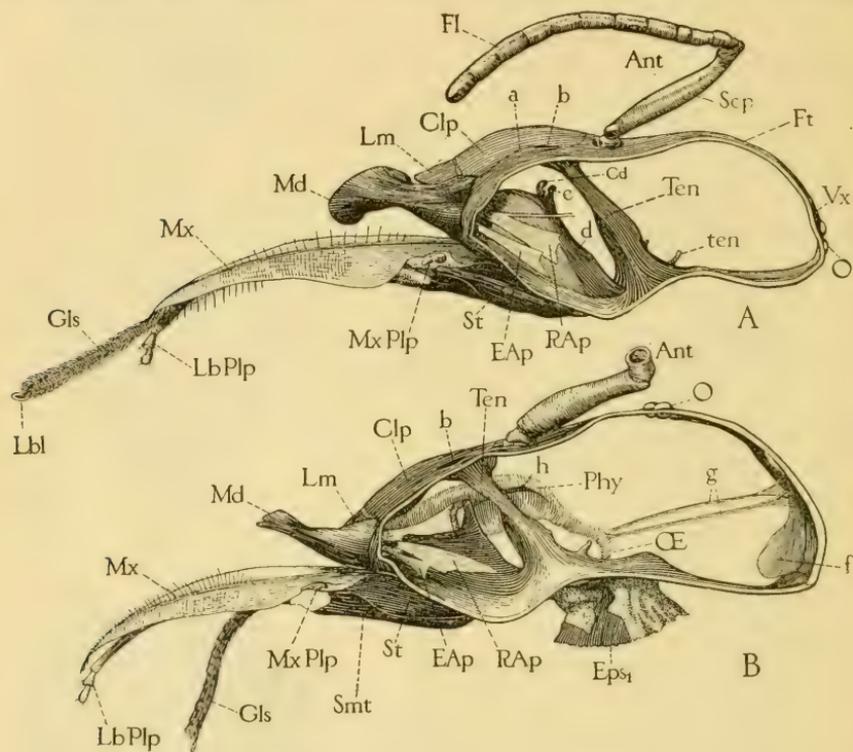


FIG. 11.—A, longitudinal section through head of worker between the median plane and outer edges of mandibles (*Md*) and antennæ (*Ant*) of left side, all internal soft parts removed; B, corresponding section through head of drone, except that the pharynx (*Phy*) and œsophagus (*O*) are not removed.

the internal chitinous parts shown in figure 11 A and B. These figures, however, represent a slice of the head taken from between the median plane and the outer edges of the antennal and mandibular bases of the left side. Thus only the parts on one side of the mid-line are shown. Figure A is from a worker and Figure B from a drone. In the latter the pharynx and œsophagus are retained and the neck is not removed. Figure 20 shows the head cut open from above and the mouth parts removed. A specimen so cut and boiled a short time in caustic soda or potash to remove the soft parts will be found a valuable adjunct to this study.

The principal parts of the internal skeleton of the head, or *catocranium*, consist of two large, oblique, strongly chitinous bars forming a brace between the anterior and the posterior walls of the head (fig. 11 A and B, *Ten*, showing the parts on the left side only, and fig. 19, *Ten*). These bars have been named by Macloskie (1881) the *mesocephalic pillars*. As already pointed out the base of each is marked externally by a conspicuous pit (fig. 9 B, *c*) laterad of the foramen magnum, and its facial end by a smaller pit (fig. 9 A, *b*) in the clypeal suture near the upper end of each side of the latter. The bases of these pillars are connected by the slender bar (fig. 11 A, *ten*), already noticed, arching over the foramen magnum (fig. 9 B, *ten*). This bar and the two pillars represent what is called in other insects the *tentorium*. In the embryo the tentorium is formed from tubular ingrowths of the head wall which unite internally and assume different shapes in different insects. Since the air tubes of the body also first appear as tubular ingrowths of the body wall, some entomologists have supposed that the hollow tentorial ingrowths of the head represent the spiracular tubes of the head which are, otherwise, lacking. However, there is not sufficient evidence to support such a view as this, and there is no reason why the tentorium should not have been originally designed simply to give greater rigidity to the walls of the head where the latter support the appendages.

The usual form of the tentorium in the lower insects is that of an X, with a large central body, situated like a brace across the lower part of the head, having two of the arms directed anteriorly and laterally and two directed posteriorly and laterally, and while the former are said to be ingrowths from the mandibular segment, there is some difference of opinion concerning the segment to which the latter belong. Riley states that they are formed in the labial segment of the cockroach and Carriere and Burger describe the same thing for the mason bee. Other authors have ascribed them to the maxillary segment, but they may, in later stages, lie in this segment and thus appear to belong to it, while they originated in the one following, having moved forward on account of the condensation of the back part of the head. The tentorium of the honey bee, consisting as it does of the two great mesocephalic pillars (fig. 11 A and B, *Ten*) and the small arched bar (*ten*) is so highly modified that it is hard to see just how its parts are to be homologized with the parts of an X-shaped tentorium. Probably the two pillars represent the separated halves of the X, while the slender arch is an additional structure. In any case we have not enough evidence to warrant us in regarding the tentorial invaginations as modified tracheae, or their external pits as rudimentary spiracles. Similar processes extend inward from the walls of the thorax to strengthen it or to give attachment of muscles. Such processes in general form the

entoskeleton and are individually called *apodemes*. Those of the head constitute the *entocranium*, those of the thorax the *entothorax*.

The side walls of the fossa of the proboscis form two high, thin, vertical plates, as seen from the interior of the head (fig. 11), in front of the mesocephalic pillars. The posterior edge (*d*) of each of these plates is so much thicker than the rest of it in the worker that it appears at first sight to be a separate rod. Its upper end projects above the body of the plate as a free arm (*e*) to which is articulated the basal piece of the maxilla (*Cd*). It thus constitutes the *maxillary suspensorium*. (Macloskie includes under this term both the arm of the cranial wall and the cardo of the maxilla.)

The head of the drone (fig. 11 B) presents, besides the parts described, a thin plate (*f*) depending from the vertex of the cranium along the line between the compound eyes.

Besides these apodemes of the cranial wall itself there are others which project into the head cavity from the bases of the appendages to afford points of insertion for their muscles. These are specially developed in connection with the mandibles and will be described in the discussion of these organs. Still other internal chitinizations are developed in the walls of the pharynx, but these likewise will be described later.

2. THE ANTENNÆ AND THEIR SENSE ORGANS.

The antennæ of the bee are the two slender, jointed appendages movably attached to the center of the face, where each is inserted into a circular membranous area or socket just above the upper part of the clypeal suture. Their general shape and position are shown by figures 9 A, 11 A, and 19, *Ant.* Each is seen to consist of two parts, forming a prominent elbow with each other, and usually so held that the first or proximal part extends outward and upward from its frontal attachment and carries the other in a pendent position from its distal end. The first part thus forms a basal stalk, called the *scape* (figs. 9 A; 19, *Scp*), consisting of a single joint inserted into the antennal socket of the front by a prominent basal condyle bent toward the face. This articular knob is attached to the rim of the socket by a circle of membrane, but it is also pivoted on a slender peglike process projecting upward from the lower edge of the socket. Hence, while the flexible membrane allows each antenna to revolve freely in any direction, the latter is at the same time held firmly in position by the pivot. The antennæ are moved by special sets of muscles inserted upon their bases within the head. The second or distal division of the antenna is cylindrical and longer than the first, forming a flexible *flagellum* (fig. 9 A; 19, *Fl*) hanging downward from the distal end of the scape. It is composed of 11

small joints in the worker and queen and of 12 in the drone. The male antenna thus consists of 13 joints in all, while that of the female has but 12. The first joint of the flagellum is freely articulated to the scape, but the others do not have much play upon one another, though they give flexibility to the flagellum as a whole.

Each antenna is a hollow tube containing the large antennal nerve, minute extensions of the tracheal system, and the small muscles which move the segments upon one another.

Popularly the antennæ of insects are known as the "feelers," because they are constantly moved about in all directions with a nervous kind of motion as if the creature were feeling its way along by means of them. In fact "feelers" is a better name for these appendages than the scientific term, for there can be no doubt that the sense of touch is very highly developed in them and that by means of them insects acquire a great deal of information concerning their surroundings and their companions. Moreover, a large mass of evidence derived from experiments shows unquestionably that the organs of smell also are located upon the antennæ in a great many if not all insects, while some investigators believe that in some species they carry in addition the organs of hearing.

The study of the senses of insects is a most elusive subject, and becomes more so the more we ponder on the results of experiments. In the first place, it is manifestly impossible for us to acquire any real knowledge of an insect's sensations, for what is to us an odor, a taste, a color, or a sound may be something quite different to such a differently organized creature. We can, however, by experiments determine that some things which give us the sensation of an odor are perceived also by insects when placed near them. Also it can be shown that some of them distinguish substances of different taste in their food, and likewise that they perceive movement and distinguish the colors and in a vague way the outlines of objects. Furthermore, it is known that some of their perceptions are more delicate than ours, and that some insects at least see color where we see none. They may even possess senses of which we have no conception.

Hence, while it can be positively stated that insects perceive differences of touch, taste, smell, sound, and light, and act accordingly, we can not say what the sensations they acquire are like. In fact we do not know that they have conscious sensations at all. What looks like an action due to intelligent perception may be purely a reflex one, unaccompanied by any sensation. This of course involves the question as to whether such creatures or insects are possessed of consciousness or not—a question which can not be answered one way or the other.

Understanding, then, that our knowledge of insect senses amounts only to this, that what gives us the sensation of light, sound, taste,

touch, or smell makes also some sort of an impression on the insect and varies in degree and kind much as it does in us, we may go on to a study of the senses located on the antennæ.

Here, again, however, we are confronted by a difficulty, for while, at first thought, it seems very easy to hold some strong-smelling substance near the antennæ of a beetle, ant, or bee and observe the evident displeasure with which the creature turns away, yet we may be entirely wrong if we conclude that the insect "smells" the substance that repels it. Strong-smelling, volatile liquids may simply produce pain in some of the delicate nerve endings of the antennæ. Some other kind of a being, experimenting on our senses, might close up our nose and mouth and prove that we smell by means of our eyes on observing the blinking we should perform when strong formalin or ammonia was held close to the face. Furthermore, irritant gases and volatile liquids affect the mucous membranes of our noses and throats in a way quite independent from the odor that we perceive, and there is no reason why the same may not be true of insects. As pointed out by Forel, experiments on the sense of smell should be made with odorous substances that the insect meets with in a state of nature, which would be principally the materials it feeds on. Insects are indifferent to almost every mildly odorous substance not used as food, which, however, does not prove that they do not smell them.

Again, in many cases, it would be difficult to decide whether the results of an experiment should be accredited to smell or sight. For example, every bee keeper knows that hungry bees are attracted to honey a long distance from their hives, and it would seem almost self-evident that they are guided by a sense of smell. Yet one might contend that they find the honey by sight, as, indeed, is claimed by a number of entomologists who have made experiments on the olfactory powers of bees. This question has been decided in some other insects by painting the eyes with some opaque substance or by removing the antennæ, but the evidence is not conclusive on either side in the case of bees.

Experiments made by a large number of competent investigators, including Lubbock, Schiemenz, and Forel, have proved conclusively that the organs of the sense of smell in insects are located principally on the antennæ. The most interesting of these experiments are perhaps those which Forel (1903) made on carrion-feeding beetles. He found the dead and putrid bodies of a hedgehog and a rat infested by a swarm of these beetles belonging to several genera. He collected more than 40 specimens from the carcasses and removed their antennæ. Then he placed them all at one place in the grass and moved the dead bodies to a distance of 28 paces from the beetles where he concealed them in a tangle of weeds. Examination the next day

revealed the fact that not one of the mutilated beetles had found the carcasses. Repeated experiments gave the same results—no beetle without its antennæ was ever found on the dead animals, although at each examination new individuals of the several species were present. It might be supposed that the mutilation itself distracted the beetles to such an extent that they did not care to eat. In order to test this point Forel next cut off all the feet on one side of the body from a dozen intact beetles and changed the location of the dead bodies again. The next day five of this lot were found on the carcasses.

The same results have been obtained from experiments on other insects. Ants distinguish between their comrades and enemies by means of their antennal sense organs. Males of the silkworm moth and many other moths and butterflies perceive the presence of the females and are guided to them by an evident sense of smell located on the antennæ, for they fail completely to find them when these appendages are removed, although one immediately recognizes a female when placed in contact with her.

Similar experiments have been made on the bee, testing the ability of the workers to find honey hidden from their sight. The results, according to Forel, seem, curiously enough, to indicate that bees can perceive odors but a very short distance from their heads. Forel found that hungry bees in a cage would pass and repass hundreds of times within a few millimeters of some honey concealed from their sight by a lattice without discovering it. They ate it greedily, however, when the lattice was removed, though it had been perfectly accessible to them all the time. Forel believes that "bees guide themselves almost exclusively by vision," and Lubbock holds the same opinion. At the same time it would probably be a very difficult matter to convince many practical bee keepers that bees do not "smell" from long distances. It is a well-known fact that at times when nectar is scarce bees are attracted in large numbers to the houses of an apiary where honey is stored, though, when the natural flow is sufficient, they pay no attention to it. Tests of the olfactory sense should undoubtedly be made under natural conditions. Bees inclosed in a box with some honey concealed from their sight might not be able to locate it in such close quarters though they might be smelling it all the time. An odor in a room may so fill the air that it does not seem to come from any particular direction and we ourselves would have to exert our intelligence to discover its source.

While, then, it does not seem probable that bees have such limited olfactory powers as some investigators claim their experiments indicate, it may be accepted as proved that the organs of smell are located principally on the antennæ. It has already been stated that the sense of touch also is very highly developed on these organs, although in a less sensitive degree it is distributed over most of the other parts of

the body. It is again specially developed on the palpuslike appendages of the sting. (See figs. 36 and 37. *StuPlp.*) Sections of a bee's

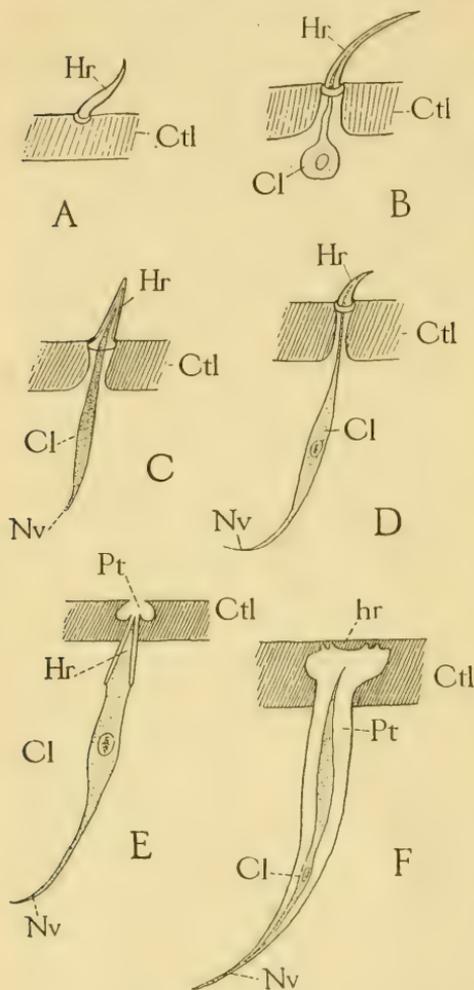


FIG. 12.—Antennal hairs and sense organs (after Schiemenz). A, example of antennal hairs (*Hr*) imbedded in cuticle (*Ctl*) but having no nerve connection; B, hollow hair containing prolongation of special cell (*Cl*); C, D, straight and curved tactile hairs connected with basal cells (*Cl*) and nerve fibers (*Nv*); E, conical hair (*Hr*) sunken in a pit (*Pt*) of the cuticle, probably an olfactory organ; F, closed sac shut in by thin disc (*hr*) on surface of antenna and containing a delicately poised cell (*Cl*) with nerve connection (*Nv*).

antenna show that there are on its surface a great number of minute structures of several different kinds, though all apparently are to be regarded as modified hairs, which are undoubtedly the sense organs. Now the difficulty arises of deciding which of these to assign to the sense of touch and which to the sense of smell. Different authors have made such different interpretations of the sense organs of insects that the student attempting to get information on the subject from books must soon be discouraged by their conflicting statements. But it must be realized that only intelligent guessing is possible where several senses are located on the same part. In the case of the bee some authors have ascribed even a third sense, that of hearing, to the antennæ, but there is little evidence that bees possess the power of hearing. The senses of taste and touch are possessed by the mouth parts, and some entomologists think that they contain organs of smell also. Thus, the organs of sight are apparently the only ones that can not be confused with some other sense.

The best account of the antennal sense organs of the bee is that of Schiemenz (1883), whose drawings are here reproduced (fig. 12) and whose text is the basis of the following descriptions. The organs consist, as before stated, of modified hairs and their basal

insertions which are connected with the ends of nerve fibers. Some of them stand exposed on the surface of the cuticle while others are sunken into, or entirely concealed within, pits of the integument. In addition to these, there are two other kinds of special hairs on the antennæ which have no nerve connections, while, finally, the ordinary hairs, such as are found on all parts of the body, occur also on them, especially on the scape.

The special hairs not provided with nerve endings are of two sorts. One is a solid curved or hooked hair (fig. 12 A, *IIr*) which is simply articulated into a socket of the cuticle (*Ctl*), while the other (B) is hollow and is situated over a channel through the cuticle, and contains a prolongation of a specially enlarged epithelial cell (*Cl*) lying beneath it. These hairs can not be regarded as sensory, since they have no communication with the central nervous system, and it is not clear just what purpose they do serve.

The simplest sensory organ is a short, hollow, conical hair (C, *IIr*) arising directly from the surface of the cuticle, over a wide opening through the latter, and containing the end of a sensory cell (*Cl*) connected with a nerve fiber (*Nr*), which goes into the main trunk of the axial antennal nerve. A modified form of this organ consists of a curved hair (D, *IIr*) set into a small depression over the cuticular channel. Such hairs are probably tactile in function; that is to say, by means of them the bee can perceive that its antennæ are in contact with some surface. The general integument is too thick and dense to allow of any sort of delicate touch sensation being communicated through it, but if one of these movable hairs brushes against an object the nerve within it must be at once stimulated. Tactile or touch hairs are distributed especially over the outer surface of the antennæ and at its apex, but occur also scattered over the other parts of the body and on the mouth parts.

Microscopic sections of the antennæ reveal still other organs which are not so apparent on the surface as the hairs just described. One of these is shown at E of figure 12. It consists of a small pit (*Pt*) in the integument, widened basally, and having a small papilla on its floor, in whose summit is the opening of a still deeper cavity which also expands toward its deeper end. This inner cavity is almost filled up by a conical plug (*IIr*) which arises from its floor and ends just below the aperture into the outer pit. The plug contains a thick nerve ending which arises from a ganglion cell connected with the antennal nerve by a nerve fiber. Ten or more of these sense organs occur on the terminal and the first three segments of the flagellum. It is evident that each is simply a sensory hair which has been doubly sunken into a cavity of the integument.

As before stated, it has been conclusively proved by several investigators that bees perceive odors, and it is said that if the antennae are covered with shellac, bees can distinguish between distasteful substances only by means of the proboscis. Schiemenz and most other writers on the subject therefore conclude that the sunken cones are the organs of smell, since, being below the surface, they could not be organs of touch. Some other authors, however, among whom are Cheshire, regard these inclosed cones as hearing organs. They suppose that the sound waves of the air enter the pit, as into an ear cavity, and these set up a vibration in the cone which stimulates the attached nerve ending. However, the appearance of one of these cones would suggest that it is too stable a structure to be affected by sound waves, so the olfactory theory seems much more probable.

Finally, Schiemenz describes the most specialized of all the antennal sense organs as a closed cavity (*Pt*) in the cuticle (*Ctl*) extending into the hollow of the antenna as a long, curved, tapering sac. This is shown at F of figure 12. A nerve (*Nv*) enters the lower extremity of the pouch, expands slightly into a nucleated ganglion cell (*G*), and then extends toward the top as a delicate spindle drawn out into a fine tapering point. The surface covering of the pit is a thin layer of chitin presenting several concentric light and dark rings surrounding a central disc (*hr*). Sections show that this appearance of rings is due to circular thickenings of the membrane, and Schiemenz points out that the central disc is probably a modified hair, while the whole structure is to be regarded simply as a modification of a tactile organ such as that shown at D with the nerve-ending and its ganglion inclosed in a sac. These organs are most abundant on the antennae of the drones, where they are situated, especially on the under surface, so close together that but little space is left between them for the tactile hairs, while in the workers and queens they are farther apart and are interspaced with many tactile hairs. Hence, whatever sense they accommodate must be much more highly developed in the males than in the females. Schiemenz described these organs, as well as the sunken cones, as organs of smell. He ascribed only the senses of touch and smell to the antennae, and both Cheshire and Cowan concur in his view of the closed pits. Arnhart (1906), however, argues that an organ of smell must be open to the air in order to permit the ingress of odor particles. Such an organ is constituted by the sunken cones, but the closed pits have nothing to recommend them for an olfactory function. Arnhart then further points out that the buried sacs, inclosing a delicately poised nerve-ending and covered by an external tympanum, have all the mechanical elements of an organ of hearing. He finally argues that bees must hear, since they produce special sounds such as the piping of the queens, and that, since no possible

organs of hearing have been discovered on any other part of the body, some of the antennal sense organs must be auditory in function. His conclusion from these premises is, of course, inevitable that the closed sacs on the antennæ are the hearing organs of the bee. What invalidates the argument, however, is the fact that no one has yet produced any actual evidence that bees perceive sound.

The following, then, may be stated as a general summary of the evidence concerning the antennal senses and their sense organs in the bee: (1) The antennæ are highly sensitive to touch and are the seat of the sense of smell. (2) They are covered by several kinds of minute structures which are modified hairs containing special nerve-endings. (3) By inference, it would seem certain that these are the sense organs, but we can only form an opinion, based upon their structure, as to which are tactile and which olfactory. (4) One set of organs does not appear to belong to either of these categories and their structure suggests an auditory function, but, in the absence of evidence that bees hear, the purpose of these organs must be regarded as problematical.

3. THE MANDIBLES AND THEIR GLANDS.

The mandibles (fig. 9 A, *Md*) are the dark, strongly chitinous appendages of the head, commonly called the jaws, situated at each side of the mouth, anterior to the base of the proboscis. In all insects with biting mouth parts the jaws work sidewise, each being attached to the head by an anterior and a posterior articulation. They can thus swing in and out on a longitudinal axis in such insects, as the bee, that carry the head with the mouth directed downward, or in the same way on a vertical axis in those that carry the head with the mouth forward.

Both mandibular articulations are of the ball-and-socket type, although in the bee the socket is a very shallow one, the anterior consisting of a condyle on the outer angle of the clypeus fitting against a facet on the mandible, and the position of a facet on the lower edge of the postgena receiving a condyle from the mandible. The motion of the mandible is thus reduced to a hinge-joint movement, and, on this account, insects can only bite and crush their food; they can not truly chew it, since their jaws are incapable of a grinding motion. Each mandible is, of course, as pointed out in the introduction, really suspended from the head by a continuous membrane between its base and the cranium, being simply a modified saclike outgrowth of the head wall. The two articulations are productions of the chitin on the outside of this membrane.

Figure 9 A shows the location and shape of the mandibles (*Md*) of the worker as seen in a facial view of the head. Figure 11 A

shows the appearance of the left mandible in side view, while the right one is shown detached from the head in figure 13 A. The mandibles differ conspicuously in size and shape in the three forms of the bee as already described and as shown in figure 10 A, B, and C. That of the worker is hollowed out somewhat on the distal half of its inner face (fig. 13 A, *Md*) forming a spoon-shaped organ, the edge of which is smooth and rounded. The mandibles of both the queen (fig. 10 B) and the drone (C), however, are pointed at the apex and have a conspicuous subapical notch. Those of the drone

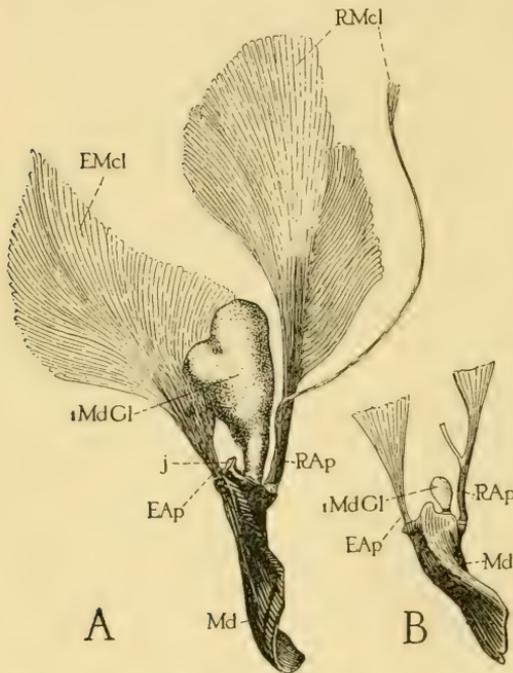


FIG. 13.—A, right mandible of worker, anterior view, with extensor and flexor muscles (*EMcl* and *RMcl*) and mandibular glands (*iMdGl*) attached; B, corresponding view of mandible of drone, with muscles cut off a short distance from their bases.

are smaller than those of either form of the female, but appear to be especially small on account of the great size of the drone's head. The mandible of the worker is undoubtedly to be regarded as the specialized form, since the notched mandible of the drone and queen is of the ordinary Hymenopteran type. Both the drone and the queen are, under normal circumstances, fed almost entirely by the workers, and they probably never have any use for their jaws as feeding organs. The queen needs her large, sharp-pointed mandibles for biting her way out of the thick wax cell in which she is reared, but the drone, on the other hand,

being reared in an ordinary cell resembling that of a worker, except in size, is easily able to cut through the thin cell cap with his comparatively weak jaws. The workers, however, have numerous uses for their mandibles, such as biting through the cell caps, eating pollen, and modeling wax. The last is the especial function of the worker mandible, and probably it is to accommodate this purpose that it has acquired its specialized spoonlike shape.

Each mandible is moved by two sets of muscles within the head. The outer one constitutes the *extensor muscle* (fig. 13 A, *EMcl*) and the inner the *flexor muscle* (*RMcl*). The latter is the stronger of

the two, since all the work of the mandible falls upon it, the extensor being used simply to open the jaw. While these muscles have their origins on the walls of the head, they are not inserted directly upon the mandibles, but on large apodemes (fig. 13 A, *EAp* and *RAp*) attached to the edges of the mandible.

A gland opens at the inner margin of each mandible between the anterior articulation and the base of the apodeme of the flexor muscle (fig. 13 A and B, *MDG1*). In the worker it consists of a large sac covered with secreting cells lying within the front part of the head between the clypeus and the compound eye (fig. 10 A, *MDG1*). These mandibular glands may be most easily studied by removing the front as shown in figure 10 A, B, and C. In order to do this, pull the head from the thorax and allow the prothoracic legs, which will usually come off with the head, to remain attached to it. Next melt a small hole in the bottom of a paraffin dish with a heated needle and fasten the head face upward into this, the attached legs helping to anchor the head in the paraffin. Cover the specimen with weak alcohol and by means of sharp needles remove the part of the front on either side between the clypeus and the lower half of the compound eye in the worker and drone and the entire front of the queen. In figure 10 the whole front is removed in all three forms in order to expose other internal parts of the head.

The mandibular gland (*MDG1*) is of greatest size in the queen (fig. 10 B), though it is large in the worker (fig. 10 A and fig. 13 A), but it is reduced in the drone (fig. 13 B) to a very small oval sac, which is hidden by another gland (*2G1*) in front (fig. 10 C). It was first described by Wolff (1875) as an olfactory mucous gland (*Riechschleimdrüse*) and was supposed by him to secrete a liquid which was poured upon the roof of the mouth in order to keep this surface, on which Wolff thought the olfactory organs were located, in a moist condition capable of absorbing odor particles. There is absolutely no evidence, however, of the presence of organs of smell in the mouth, and furthermore, as pointed out by Schiemenz (1883), the gland varies in the three forms of the honey bee according to the size of the mandible, which is proportionately largest in the queen and smallest in the drone. Of the three, we should expect the drone or the worker to have the sense of smell most highly developed, and hence, even if we did not know that the sense of smell is located in the antennae, it would seem more reasonable to suppose that the glands of the mandibles are connected in some way with the functions of these organs themselves.

The mandibles, as already stated, are used for eating pollen and as tools for manipulating and modeling wax. Therefore, according to Arnhart (1906), since the queen does not eat raw pollen, the product

of the mandibular glands must be intended for softening the wax when it is worked in the jaws. The secretion of the glands is said to be very volatile and strong smelling and to have an acid reaction. It is probably entirely possible that it may have a solvent effect upon the wax, or even, when mixed with it, change somewhat the chemical composition of this substance; in fact, some investigators claim that the wax of the comb differs chemically from that freshly taken from the wax plates. Even this explanation, however, does not seem entirely satisfactory, for the only occasions on which the queen has anything to do with wax is when she gnaws her way out of her cell after hatching or bites her way into the cells of young queens in order to sting them. However, these occasional uses by the queen of her mandibles appear to be important enough to maintain the large size of these organs in the queen, and it may be reasonable to assume that the demand upon their glands is likewise a large one when it does

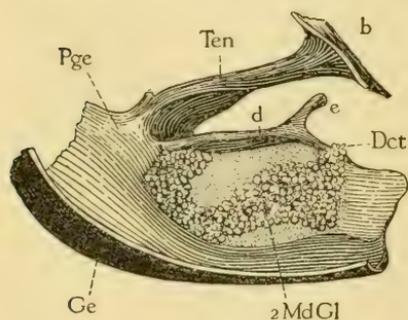


FIG. 14.—Internal mandibular gland (*2MdGl*) of worker, lying against inner wall of postgena (*Pgc*) and opening (*Det*) at inner edge of base of mandible.

occur. Yet the mandibles of the queen are toothed and sharp pointed, which should provide her with sufficient cutting power both to emerge from her own cell and to enter the cells of other queens, and so, on the whole, the opinion of Schiemenz that the secretion of the mandibular gland is merely salivary in function would seem to be the simplest explanation and the most logical one. However, an actual test should certainly be made to determine whether the worker's

manipulation of the wax with her mandibles produces any change in it, and to discover whether the queen simply bites her way mechanically through the wall of the cell or at the same time softens the wax by a secretion from her mouth. The male in any case has little use for his mandibles, and the glands are so small that they must certainly be functionless.

A second mandibular gland (fig. 14, *2MdGl*) is present in the worker. It consists of a delicate, flattened, racemose mass lying against the internal face of the wall of the fossa of the proboscis, whose duct opens into the mouth cavity at the posterior inner edge of the mandible. This gland was first described by Bordas (1895) as the *internal mandibular gland*. According to him, it corresponds with a similar gland in the Bombidæ (bumblebees) and in the Vespidæ (yellow jackets) and to the maxillary glands of other Hymenoptera. Nothing is known of its secretion.

4. THE PROBOSCIS.

The conspicuous group of mouth appendages in the honey bee, forming what is commonly known as the *proboscis* (fig. 9 A, *Prb*),

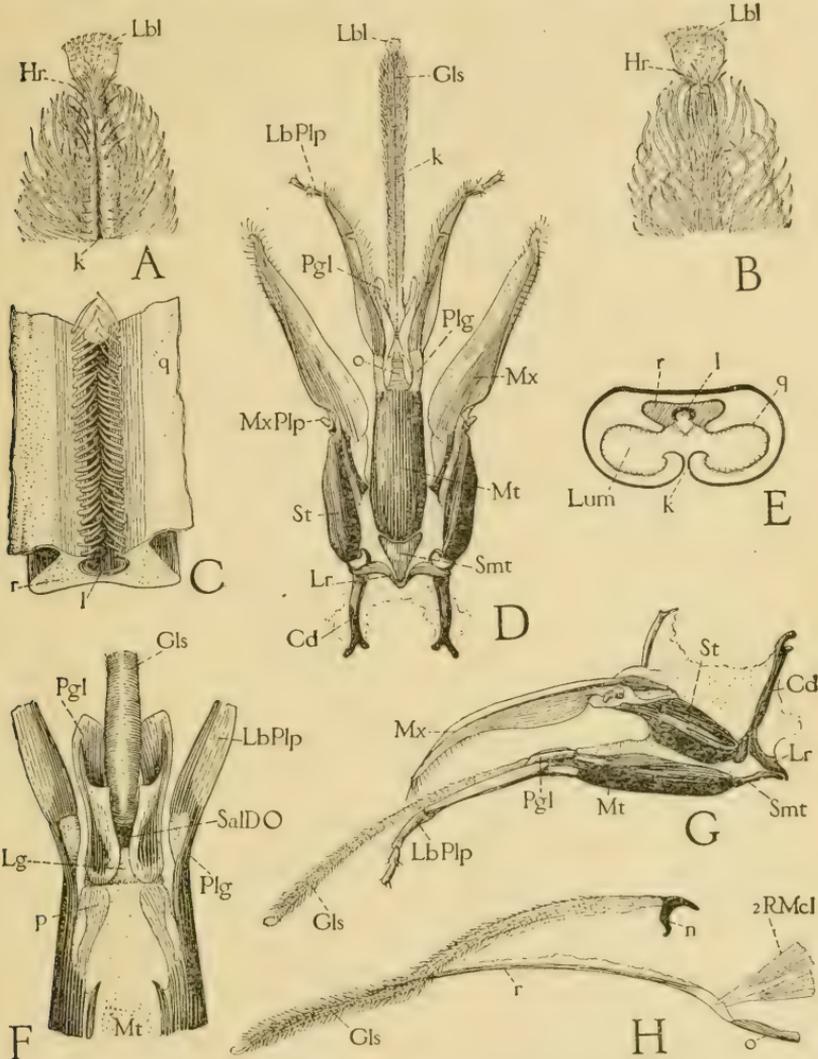


FIG. 15.—Mouth parts of the worker: A, tip of glossa, showing labellum (*Lbl*), guard hairs (*Hr*), and ventral groove (*k*); B, same, from above; C, small piece of glossal rod (*r*) with adjoining parts of walls (*q*) of glossal canal attached, showing ventral channel (*l*) guarded by rows of hairs. D, parts forming the proboscis, labium in middle and maxillae at sides, flattened out, ventral view; E, cross section of glossa showing its invaginated channel (*Lum*) and position of rod (*r*) along its dorsal wall, and likewise position of channel (*l*) of rod along median line within the glossal channel; F, end of mentum (*Mt*) and bases of ligula (*Lg*) and labial palpi (*LbPlp*), showing opening of salivary duct (*SalDO*), dorsal view; G, lateral view of proboscis showing parts on left side; H, lateral view of glossa (*Gls*) with its rod (*r*) torn away at base showing attachment of retractor muscles (*2RMcl*).

by means of which the bee takes up liquid food, consists of what correspond with the maxillae and the labium of insects that feed on solid

food alone. By separating the parts of the proboscis a little (fig. 9 B) it will be seen that, while there are five terminal pieces present, three of them arise from one median basal sclerite (*Mt*), the two wider lateral appendages (*Mx*) being carried each by a separate lateral basal piece (*St*). The median group constitutes the *labium* and the separate lateral parts the *maxillæ*.

If the reader will now turn again to figure 3 C (p. 17), which may represent any generalized insect labium, and compare with it the drawing of the bee labium, forming the median series of parts in fig. 15 D, he will at once be able to identify the parts of the latter. The principal elongate median basal plate is the *mentum* (*Mt*), the small triangular plate at its base is the *submentum* (*Smt*), and the two jointed lateral appendages of the mentum are the *labial palpi* (*LbPlp*), each carried by a basal *palpiger* (*Plg*). It is only the parts of the bee's labium that lie between the palpi which are actually different from those in the generalized diagram where they consist of the four lobes of the *ligula* (*Gls* and *Pgl*). But even here it will be seen that the two small lobes (*Pgl*) in the bee's labium, partly concealed within the bases of the palpi, correspond with the *paraglossæ*. Hence we have only the long median appendage to account for and it is unquestionably the representative of the *glossæ* (*Gls*) which are here fused together and drawn out into this flexible tonguelike organ. In fact, a comparison with the mouth parts of other Hymenoptera in which the elements are much less modified leaves no doubt of this being the true interpretation of the bee's labium. It is simply an example of how nature constantly prefers to modify an already existing part to serve some new purpose rather than to create a new organ.

If, then, we bear in mind that the slender median appendage of the bee's labium represents the *glossæ* of other insects, we may for convenience call it the "tongue," as it is popularly termed, or, since it is a single organ, there is probably no grammatical objection to calling it the *glossa*. The word "tongue," however, to use it properly, should be applied to the true *lingua* or *hypopharynx* (fig. 3 C and D, *Hphy*) which arises from the upper surface of the labium. Many of the older entomologists, adopting the notion from Kirby and Spence, who defined the term in 1826, regarded the *glossa* of the bee as the homologue of the *lingua* in other orders. Even Packard in his Text-book of Entomology calls the *glossa* the "hypopharynx." Cheshire named it the "ligula," and his mistake has been perpetuated by several other writers on bee anatomy, including Cook and Cowan. The term *ligula* properly includes both the *glossa* and the *paraglossæ*, or should signify the basal piece from which these four lobes arise (fig. 3 C, *Lg*), so that it can not be applied to the *glossa* alone.

The derivation of anatomical names counts for nothing in their application—this must be determined by scientific usage and priority. Thus, *glossa* is the Greek word for “tongue,” but it was first applied in entomology to the median lobes of the labium; *lingua* is its equivalent in Latin and was first given to the true tongue or hypopharynx in insects; *ligula* is a diminutive derivative from “lingua” and has come to be applied collectively to the terminal parts of the labium beyond the mentum but not including the palpi. Hence, all these words mean the same thing by their origins, but their anatomical applications should be carefully distinguished. In this paper therefore the slender median appendage (*Gls*) of the labium will be called the *glossa*, or, for convenience, the *tongue*, but with the strict understanding that the organ in question is not the true tongue. This latter should be called the “hypopharynx,” but, as will be shown later, it is absent in the bee.

The glossa of the bee (figs. 9 B; 11 A and B, and 15 D, F, and G, *Gls*) is covered with long hairs which increase in length toward the end. The tip is formed of a small spoon-shaped lobe, the *labellum* or *bouton* (*Lbl*), which is covered by short delicate processes branched at their ends (fig. 15 A and B, *Lbl*). The long hairs of the glossa are arranged in circles and the transverse rows of hair bases give the tongue a multiarticulate appearance. Surrounding the dorsal side of the base of the labella and forming two short subterminal rows on the ventral side of the glossa are a number of stiff, outwardly curved, spinelike hairs (*Hr*). These hairs have been described as taste organs, but their appearance would suggest that they are simply protective spines guarding the delicate tip of the tongue. Between the two ventral rows of these spines is the termination of a groove (*A, k*) which extends along the midline of the under surface of the glossa (*D, k*) to its base (fig. 9 B, *k*). The cleft of this groove is covered by two fringes of converging hairs whose tips are inclined also toward the tip of the tongue.

Let us now return to a study of figure 15 D. The series of lateral pieces as already explained are the maxillæ. A comparison with figure 3 B representing a generalized maxilla will show that these organs in the bee have suffered a greater modification than has the labium, but the parts can yet be quite easily made out. The main basal plate (*St*) is the combined *stipes*, *subgalea*, and *palpifer*, the basal stalk is the *cardo* (*Cd*), and the little peglike process (*MaxPlp*) at the outer end of the stipes is the greatly reduced *maxillary palpus*. Hence, we have left only the terminal bladelike lobe (*Max*) to account for, and it is evident that it must be either the galea or the lacinia (see fig. 3 B, *Ga* and *Lc*) or these two lobes combined. Here again a comparative knowledge of the mouth parts of Hymenoptera comes

to our aid and shows clearly that the part in question is the outer lobe or *galca*, for the inner one becomes smaller and smaller in the higher members of the order and finally disappears.

The base of the submentum is connected in the bee with the upper ends of the cardines by a flexible, widely V-shaped band, the *lorum* (*Lr*). The posterior angle of the submentum rests in the apex of the lorum, while the tips of the loral arms are movably articulated with the distal ends of the cardines. The name "lora" was given to this structure by Kirby and Spence, but "lorum" is more correct, since this is the Latin form of the word (meaning a thong or lash). Some recent entomologists have spoken of the structure as consisting of two rods, thus making the word do duty as a plural, but the thing itself is all one piece. Cheshire and some others have incorrectly applied the name to the submentum.

The lorum is peculiar to the Hymenoptera, and the reason for it is clear when we examine the attachments of the parts of the proboscis to the head. As already stated, the maxillæ and labium are suspended in a large cavity on the back of the head which may be called the *fossa of the proboscis* (fig. 9 B, *PrbFs*). The maxillæ are articulated by their cardines (*Cd*) to the maxillary suspensoria (fig. 11 A, *c*) at the upper edges of the side walls of the fossa. The labium, on the other hand, is not attached to the solid walls of the cranium but is suspended in the membranous floor of the fossa. This is to afford it freedom of movement during feeding, but, in order to give it more substantial support and to make the regulation of its motions possible, the submentum is slung to the ends of the cardines by the lorum.

The terminal lobes of the labium and maxillæ when not in use are ordinarily folded down beneath the head against the mentum and stipites (fig. 19). When, however, the bee wishes to imbibe a thick liquid such as honey or sirup in large quantity, these parts are straightened out and held close together so as to form a tube between them leading into the mouth, the terminal joints of the labial palpi alone diverging from the rest (fig. 11 A).

The action of the mouth parts while feeding may be observed quite easily if some bees are given a small amount of honey and then watched through a lens while they are eating. A most convenient method is to put a few workers in a small screen-covered cage, such as are used for queen nurseries, spread a small drop of honey on the wire, and then place the cage under a simple microscope. It will be seen that the maxillæ are held almost stationary but that the base of the labium slides back and forth between the maxillary bases with a very regular to-and-fro movement as if the honey were being either pumped or sucked up into the mouth. It is probable that there is a sucking force exerted by the pharynx (fig. 11 B, *Phy*) but not

by the honey stomach (fig. 44, *HSt*), which latter, as Cheshire remarks, could no more suck honey through the œsophagus than a balloon could suck gas from a pipe. The liquid undoubtedly runs up the temporary tube between the blades of the mouth parts first by capillary attraction, but it must be greatly assisted along its way to the mouth by the retraction of the labium. The load brought up when this is pulled back is then sucked into the mouth by the pharynx while the labium immediately goes out again after more. It acts thus as a sort of mechanical feeder and this function is probably derived from the lapping motion of the under lip in wasps and hornets.

The mentum (fig. 15 D and G, *Mt*) is hinged freely upon the submentum (*Smt*), the latter, as already described, is set into the socketlike angle of the lorum, while, finally, the arms of the lorum are articulated to the distal ends of the cardines of the maxillæ. Now, when the labium is retracted by means of muscles attached to the mentum, the submentum turns in the loral socket and assumes a position at right angles to the mentum while the lorum itself turns somewhat on its articulations with the cardines. This great freedom of motion is permitted by the loose membrane of the fossa in which both the maxillæ and the labium are suspended.

The observer, however, can not fail to note that beside this motion of the entire labium the tongue itself, or glossa (*Gls*), performs a conspicuous independent movement of its own. It is by far the most active member of the mouth parts during feeding, being actively thrust out and retracted while its tip is constantly moved about in a way suggestive of its being delicately perceptive of taste or touch or perhaps to both of these senses. So great is the retractile power of the tongue that its tip, which normally extends far beyond the end segments of the labial palpi, can be drawn back entirely within the latter. This contractile activity appears at first sight to be due to elasticity, but a closer examination will show that the entire ligula, i. e., the paraglossæ (*Pgl*) as well as the glossa (*Gls*), moves back and forth and that the action is due to a retraction of the base of the ligula (fig. 15 F, *Lg*) into the anterior end of the mentum (*Mt*). The ligula is supported on a membranous cone at the end of the mentum whose walls are strengthened by three thin chitinous plates, two above (F, *p*) and one below (D, *o*). By the contraction of muscles situated within the mentum (fig. 16, *IRMcl*) and inserted upon the base of the ligula the latter is pulled into the end of this cone whose walls, including the chitinous plates, simply turn inward.

But the tongue does possess also a contractile power of its own by means of which it actually shortens its length. A flexible rod arising from the median ventral supporting plate (fig. 15 D, *o*) of the ligula extends throughout its length. The base of this rod is curved down-

ward and has two muscles attached to it. This is shown by figure 15 H, where the rod (*r*) is torn from the glossa (*Gls*) basally so as to show the muscles (*RMcl*) inserted upon it and its connection with the plate (*o*). By the contraction of the muscles the rod bends at its base and is drawn back into the mentum. The glossa thus shortens and becomes bushy just as does a squirrel's tail when one attempts to pull the bone out of its base.

The protrusion of the parts is due to the pressure of blood driven into the ligula from the mentum, while probably the glossa extends also by the straightening of its rod as the muscles relax. Wolff described a protractor muscle at the base of the ligula. The rod of the tongue is certainly not in itself contractile, as supposed by Cheshire, who looked for evidence of muscular striation in it. It has mostly a transparent and cartilaginous appearance, but is presumably chitinous.

The mouth parts, their action in feeding, and the muscular mechanism by which they are moved have been elaborately described and illustrated by Wolff (1875) in his monograph on the organs of smell in bees. Most unfortunately, however, Wolff's paper was written to show that the seat of the sense of smell is in the mouth, a most erroneous notion, and the title of his paper based on this notion has caused little attention to be paid to this work on the mouth parts of the bee, which is one of the best anatomical treatises ever produced on the mouth parts of any insect.

It still remains for us to describe the details of the glossa and its particular function in feeding. The tongue is not a solid appendage nor yet is it truly tubular. A compromise is effected by the longitudinal groove (fig. 15 A and D, *k*) on its ventral surface which expands within the tongue into a large cavity occupying half of its interior (E, *Lum*). The glossal rod (*r*), which has already been mentioned, lies in the dorsal wall of this channel and is, hence, really not an internal but an external structure. The rod is itself grooved along its entire ventral length (E, *l*) and this groove again is converted into a tube by two rows of short hairs which converge from its margins. The lips of the ventral groove of the glossa are so deeply infolded that its cavity is almost divided along the midline. Hence, the glossa might be described as containing three channels—a small median dorsal one (*l*) and two large latero-ventral ones (*Lum*).

The glossal rod (fig. 15 C, *r*) is very flexible but not contractile, as already stated, and is mostly clear and cartilaginous in appearance, its ventral groove (*l*) alone being lined by a deposit of dark chitin (fig. 15 C and E). Its shape in section is sufficiently shown by the figures. The walls of the large channels of the proboscis consist of a delicate membrane (C and E, *g*) covered with very small hairs.

The entire ventral cavity (*Lum*) with the rod (*r*) can be evaginated through the ventral cleft (*k*) by blood pressure from within. As Cheshire points out, this permits of the channels being cleaned in case of clogging by pollen or any foreign matter.

It is supposed that these glossal tubes are of especial service to the bee by enabling it to take up the smallest drops of nectar—quantities that would be lost in the clumsy tube formed between the parts of the labium and the maxillæ. The suction must be in large part capillary attraction, but here again the shortening of the glossa by the retraction of its rod must squeeze the contained nectar out of the upper ends of the channels where it is received upon the ventral flaps of the paraglossæ (fig. 15 F, *Pgl*), from which it runs around the base of the tongue (*Gls*) within the paraglossæ to the dorsal side of the mentum (*Mt*) and so on to the mouth.

The maxillæ and labium of both the queen and the drone (fig. 11 B) are smaller and weaker than those of the worker, and neither of these two forms is capable of feeding itself to any extent. If a hungry queen be given some honey she attempts to eat it and does imbibe a small quantity, but at the same time she gets it very much smeared over her head and thorax.

The mouth is hard to define in insects; practically it is the space surrounded by the bases of the mouth parts, but strictly speaking it is the anterior opening of the alimentary canal situated behind the bases of the mouth parts (fig. 19, *Mth*). Yet the enlargement of the alimentary canal (*Phy*) immediately following this opening is never spoken of as the mouth cavity but is called the pharynx. On the other hand the so-called epipharynx (*Ephy*) and hypopharynx (absent in the bee) are located in front of this opening and are consequently not in the pharynx at all, the former being attached to the under surface of the labrum and clypeus, while the latter is situated on the upper surface of the base of the labium. These and numerous other inconsistencies in the nomenclature of insect morphology have to be endured because the parts were originally named for descriptive purposes by entomologists who were not familiar with scientific anatomy. In this paper the term *mouth* will be applied to the true oral opening (fig. 19, *Mth*). The space in front of it between the bases of the mouth parts may be called the *preoral cavity*.

The duct of the salivary glands of insects in general opens upon the base of the labium in front of the hypopharynx. In the honey bee the salivary opening is on the dorsal side of the base of the ligula between the paraglossæ (fig. 15 F, *SalDO*). This alone would show that the glossa is not the hypopharynx of the bee, as many authors have supposed, for otherwise the opening of the salivary duct should be ventrad to the base of the glossa. In fact, this makes it clear that

the bee does not possess a hypopharynx. There is, however, a conspicuous chitinous plate located on the anterior part of the floor of the pharynx (fig. 19, *s*) having two terminal points hanging downward over the lower lip of the oral aperture, but, although this plate is truly hypopharyngeal in position, it is not the homologue of the organ called the hypopharynx in other insects. It is variously developed in all Hymenoptera, being simply a chitinization of the floor of the pharynx, and should be called the *pharyngeal plate* (*Schlundbein* of Wolff). It will be more fully described in connection with the alimentary canal. If a hypopharynx were present it should be situated on the upper side of the labium (see fig. 3 D, *Hphy*) but there is here present only a plain arched membranous surface in the honey bee and other typical Hymenoptera.

The external location of the salivary opening enables the saliva to be mixed with the food before the latter enters the mouth. This is necessary in insects since the jaws are also on the outside of the

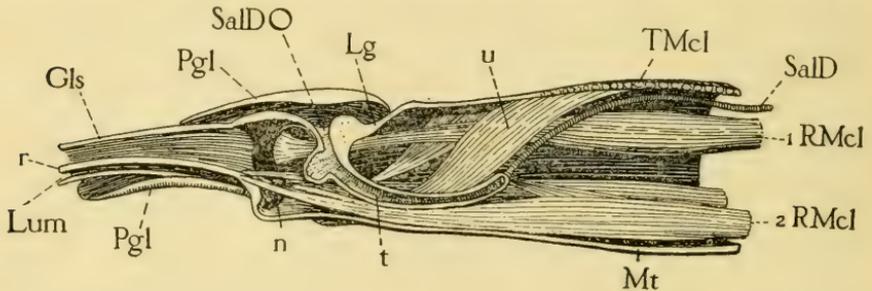


FIG. 16.—Median section through distal half of mentum (*Mt*) and base of ligula (*Lg*) of worker, showing opening of salivary duct (*SalDO*), and muscles connected with ligula and the "salivary syringe" (*t*).

mouth, and whatever chewing or crushing the food receives from them is consequently done in the preoral cavity.

In some insects the saliva is used for other purposes than digestion. For example, the saliva of some predaceous insects with piercing mouth parts belonging to the order Hemiptera is poisonous, and when one of these insects "bites," the saliva is injected into the wound by a special pump. The bite of the mosquito is made painful likewise by an irritant secretion from a part of the salivary glands. Bees appear to have the power of letting their saliva run down the tongue when necessary to dissolve a hard substance like sugar and render it capable of being taken up in solution, for they do not eat sugar with their mandibles. Moreover, there is even a sort of pump or so-called "salivary syringe" at the termination of the salivary duct in the ligula, by means of which the secretion can be forcibly ejected from the opening.

The salivary opening on the base of the ligula (fig. 15 F, *SalDO*) leads into a deep transverse pit with collapsible cartilage-like walls having its deepest part turned horizontally toward the base of the

labium (fig. 16, *l*). The salivary duct (*SalD*) bends downward in the anterior part of the mentum (*Mt*) and opens into the posterior end of the pit (*t*). When the retractor muscles (*IRMcl*) of the ligula pull the latter back into the mentum the lips of the salivary pit must necessarily be closed. The simultaneous contraction of the elevator muscle (*u*) attached to the roof of the horizontal part of the pit must expand the latter and suck the saliva from the salivary duct. When, finally, these muscles relax and the ligula is driven out by blood pressure in the mentum, probably produced in part by the contraction of its dorsal transverse muscles (*TMcl*), the saliva in the temporarily formed bulb must be squirted out upon the base of the tongue. Wolff (1875) calls each dorsal longitudinal muscle of the mentum (*IRMcl*)—the two inserted upon the basal hooks (*n*) of the glossa (fig. 15 II and fig. 16)—the *retractor linguae longus*. The large ventral retractor muscle of each side (*IRMcl*) he calls the *retractor linguae biceps* since its anterior end divides into two parts, one of which is inserted by a tendinous prolongation upon the base of the glossal rod (fig. 15 II and fig. 16, *r*) and the other upon the base of the ligula. The use of the word “lingua” in these names is objectionable because, as already explained (page 45), the lingua is properly the true tongue or hypopharynx. “Ligula” should be substituted for “linguae.” The dilator muscle (fig. 16, *u*) of the salivary pit (*t*) is termed the *protractor linguae* by Wolff because, as he supposes, when the ligula is pulled back into the mentum the position of this muscle is reversed, so that a contraction of its fibers would help to evert the ligula.

The glands that furnish the saliva lie within the head and the thorax and will be described later in connection with the alimentary canal and the process of digestion.

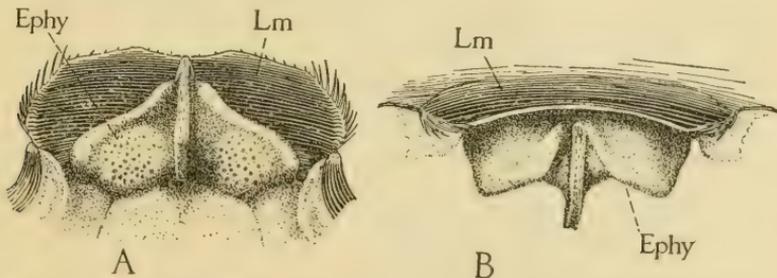


FIG. 17.—Epipharynx (*Ephy*) and labrum (*Lm*) of worker: A, ventral view; B, anterior view.

5. THE EPIPHARYNX.

The epipharynx of insects in general may be described as a dorsal tongue, it being a median lobe developed on the roof of the preoral cavity from the under surface of the clypeus or labrum and situated opposite the hypopharynx.

The epipharynx of the bee is a large three-lobed appendage depending from the roof of the preoral cavity just in front of the mouth (fig. 19, *Ephy*). Seen from below it is triangular (fig. 17 A) with the apex forward. Its median lobe has the form of a high, vertical, keel-like plate, while the lateral lobes are rounded but have prominent elevated edges converging toward the front of the keel. The appearance in anterior view is shown by figure 17 B. Situated on the posterior parts of the lateral lobes are a number of sense organs, each consisting of a small cone with a pit in the summit bearing a small hair (fig. 18). These are regarded as organs of taste.

Wolff (1875) made a most thorough study of the epipharynx, which he called the "palate sail" (*Gaumensegel*) on account of the high median crest. His drawing is the standard illustration of the organ found in nearly all books on the anatomy of the honey bee

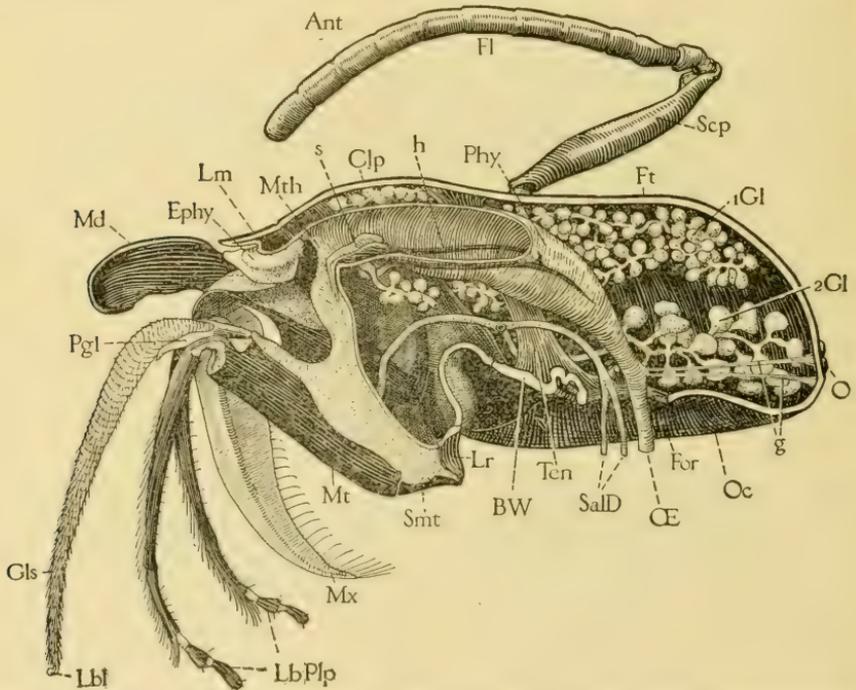


FIG. 18.—Sense organs, probably of taste, from epipharynx.

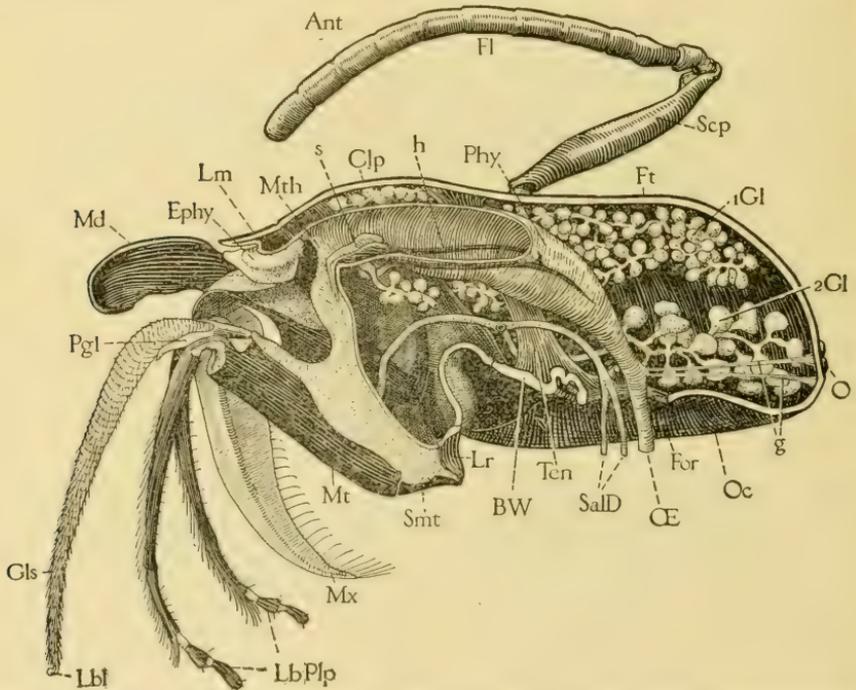


FIG. 19.—Median longitudinal section of head of worker, but with entire labium attached, showing internal organs except muscles and brain.

and in most works on general insect anatomy and the sense organs. Wolff, however, regarded the sensory cones as having an olfactory function, and this led him to erroneous conclusions regarding the functions of several other organs. For example, he thought that the mandibular glands poured a liquid upon the surface of the

epipharynx which kept it moist and capable of absorbing odor particles, while he explained the inhalation of the latter into the preoral cavity as brought about through the contraction of the air sacs situated about the mouth. Wolff's anatomical researches are without doubt some of the best ever made on the bee, and it is due to his mistaken idea of the location of the sense of smell, which, as already explained, is on the antennæ, that we have received from him a most excellent account and detailed drawings not only of the epipharynx but of the mandibular glands, the mouth parts, the salivary "pump," and the respiratory organs.

IV. THE THORAX AND ITS APPENDAGES.

1. THE STRUCTURE OF THE THORAX.

The apparent thorax of the bee (fig. 20, T_1-IT , and fig. 21) and of most other Hymenoptera is not exactly the equivalent of the thorax in other insects. The middle division of the body, so conspicuous in this order, consists not only

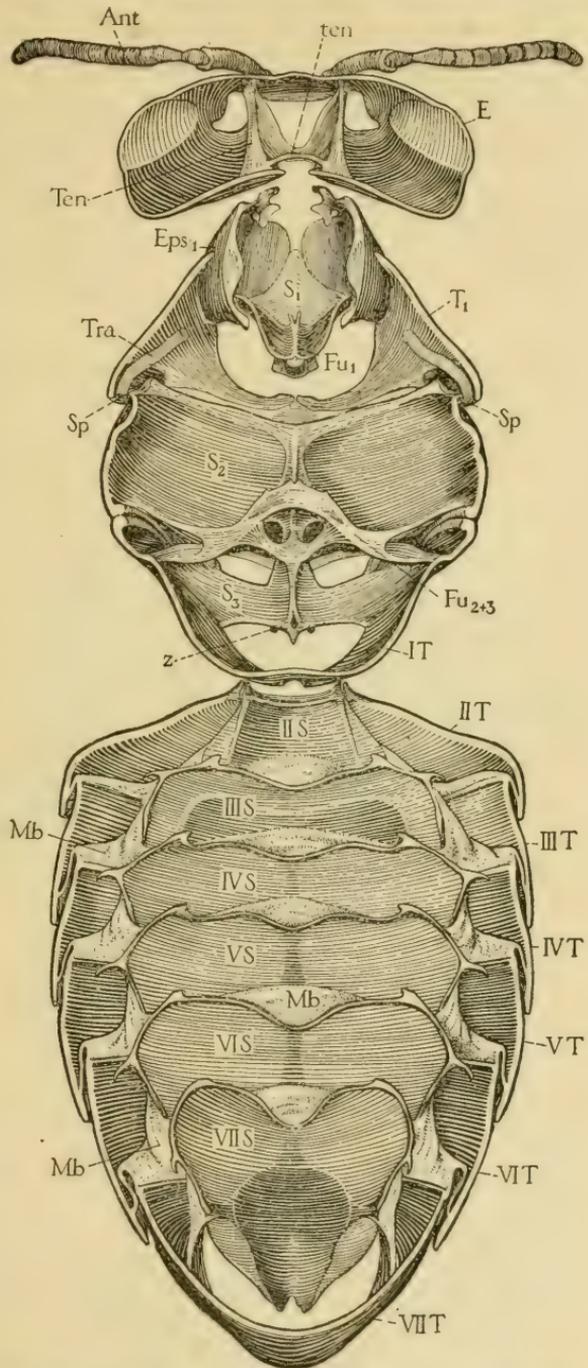


FIG. 20.—Dorsal view of ventral walls and internal skeleton of body of worker.

of the three leg-bearing segments, which alone

constitute the thorax of all other insects, but also of the first abdominal segment. The conspicuous necklike constriction posterior to the base of the hind legs (fig. 21, *Pd*) is, therefore, between the first and the second abdominal segments (fig. 1, *IT* and *IT'*).

The thorax of the honey bee at first sight looks entirely different in structure from that of all other insects except related Hymenoptera, in the higher families of which group it is more highly modified than in any other order of the whole series of insects. When, however, we examine the thorax of one of the lowest members of the Hymenoptera, such as a sawfly, we are surprised to find that, in each segment, the structure agrees very closely with our ideal diagram of a general-

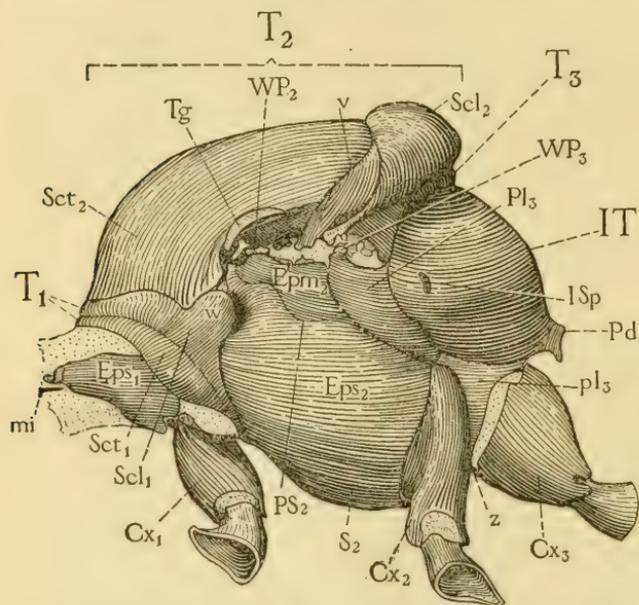


FIG. 21.—Thorax of worker, left side, with intersegmental lines somewhat exaggerated, showing prothorax (*T*₁, *Eps*₁, *Cx*₁), mesothorax (*T*₂, *Eps*₂, *Epm*₂, *S*₂, *Cx*₂), metathorax (*T*₃, *Pl*₃, *pl*₃, *Cx*₃) and propodeum or first abdominal segment (*IT*).

ized thoracic segment (fig. 4). The three segments are perfectly distinct, and the first abdominal segment, while it may be clearly separated from the rest of the abdomen, is not fused into the thorax so as to appear to be a part of it. If, now, we examine representatives of several families intermediate between the sawflies and

the bees, the line of specialization that has produced the bee thorax becomes perfectly evident. The principal features in these modifications are the following:

- (1) The lateral and ventral parts of the prothorax (figs. 20 and 21. *Eps*₁ and *S*₁) are suspended loosely in a large membranous area which is continuous anteriorly as the neck. They thus form a sort of suspensorium for the front legs, which appears detached from the rest of the thorax.
- (2) The protergum (*T*₁) is solidly attached to the anterior edge of the mesothorax and its lateral parts extend downward till they meet on the venter behind the prosternum (figs. 20 and 21).
- (3) The postnotum (post-scutellum) of the mesothorax (figs. 22, *PN*; 23 A. *PN*₂) is entirely invaginated into the cavity of the thorax and is reduced to the form of two lateral arms of the large

internal mesophragma (*Pph*) which has no median tergal connection at all. (4) The metatergum (figs. 21 and 23 Λ , T_3) consists of a single narrow plate. (5) The metapleurum (fig. 21, Pl_3 and pl_3) shows no trace of a division into episternum and epimerum, but is divided into an upper (Pl_3) and a lower (pl_3) pleural plate. (6) The first abdominal tergum (fig. 21, *IT*) is solidly attached to the metathorax and forms an intimate part of the thoracic mass.

We shall now proceed with a more detailed account of the thorax, and the reader should occasionally turn back to figure 4 (p. 19) in order to keep clearly in mind the parts that make up a generalized thoracic segment.

The parts of the **prothorax** are so separated from each other that they appear to belong to different segments. The protergum (fig. 21, T_1) forms a collar completely encircling the front of the mesothorax. On each side a large lobe (*w*) projects posteriorly as far as the base of the front wing and constitutes a protective shield over the first thoracic spiracle. The tergum presents a median transverse groove, dividing it into an anterior and a posterior part, which parts may be called the scutum (fig. 23 Λ , T_1 , *Sct*) and scutellum (*Scl*). The propleurum (figs. 20, 21, Eps_1) consists of a large plate presenting both a lateral surface (fig. 21) and a ventral surface (fig. 20). On account of the position of the coxal articulation (fig. 21) this plate would seem to be the anterior pleural plate alone (see fig. 4), which is the episternum. In some Hymenoptera the epimerum is represented by a very small plate on the rear edge of the episternum. The anterior ends of the two episterna form knobs which loosely articulate with the occipital region of the head (figs. 11 B, 20, and 21). Lying just ventrad of each is a slender cervical sclerite (fig. 21, *mi*). The prosternum (S_1) is shown by figure 20. It carries a large entosternum (Fu_1), forming a bridge over the nervous system behind the prothoracic ganglion (fig. 52).

The **mesotergum**, as seen in its natural position (fig. 21, T_2), consists of a large anterior scutum (Scl_2) and of a smaller but very prominent posterior scutellum (Scl_2), separated by a very distinct suture (*v*). The scutellum has two latero-anterior areas partially separated from the median area by sutures. When the mesotergum is detached from the rest of the thorax (fig. 22) it is discovered that there is attached laterally to the scutellum a large posterior internal part, which does not show on the surface at all. This is the representative of the postscutellum (*Pscl*) and its phragma (*Pph*) constituting the postnotum (*PV*) of our diagrammatic segment (fig. 4). The proof of this, again, is to be derived from a study of the lower Hymenopteran families. In some of the horn-tails (Siricidæ) the postnotum or postscutellum is a prominent plate on the surface of the dorsum behind the scutellum. In *Sirex* (Siricidæ) this plate is sunken below

the general surface and mostly concealed between the mesothorax and the metathorax. In higher families such as the Pompilidae the postnotum of the mesotergum is entirely concealed by invagination, but it still carries a very large phragma. When, now, we come to the highest members of the order we find that the median part of the postnotum in the mesothorax is gone entirely and that it is represented only by the lateral arms (figs. 22, *PN*; 23 A, *PN*₂) carrying the large, purely internal postphragma (*Pph*).

The **mesopleurum** is large and consists principally of the episternum (fig. 21, *Eps*₂), which, however, is continuously fused with the mesosternum (figs. 20 and 21, *S*₂). The pleural suture (fig. 21, *PS*₂) is short and sinuous and does not reach more than half way from the wing process to the base of the middle leg. The epimerum is reduced to a small double plate lying above the episternum and posterior to the wing process (figs. 21, *Epm*₂, and 24 A, *Epm* and *Epm*). The

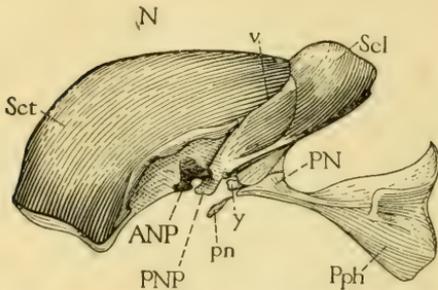


FIG. 22.—Lateral view of mesotergum of worker, removed from the rest of thorax to show large internal postscutellum (postnotum, *PN*) and its phragma (*Pph*) not visible normally in the bee from exterior.

pleural ridge (fig. 24 B, *PR*) is weak, but the wing process (*WP*) is well braced by a number of accessory internal ridges. One preparapterum (*2P*) and one postparapterum (*3P*) are present. Lying behind the postparapterum is another larger sclerite (fig. 24 A and B, *pn*), whose anterior end is articulated to the edge of the epimerum and whose posterior tapering end is loosely associated with the terminal arms

of the postnotum (fig. 22, *PN* and *pn*). This sclerite might be regarded as the fourth parapterum, but it is much more probably the representative of a small terminal bar of the postnotum present in other Hymenoptera, such as *Pepsis*, which connects this tergal plate with the epimerum, though in this genus it is not detached from the main postnotal sclerite.

Both the mesosternum (fig. 20, *S*₂) and the metasternum (*S*₃) contribute to the formation of a large entosternum (*En*₂₊₃), which forms a protecting bridge over the combined mesothoracic and metathoracic ganglia (fig. 52) and affords attachment for the ventral longitudinal muscles of the thorax (fig. 27, *lmcl*).

The **metathorax** consists of a very narrow series of plates (fig. 21, *T*₃, *Pl*₃, and *pl*₃) compressed between the mesothorax and the first abdominal tergum (*IT*). Its back plate is a single, narrow, transverse sclerite (figs. 21 and 23 A, *T*₃) widening on the sides, where it carries the wings by the two wing processes (fig. 23 A, *ANP* and *PNP*). The

ordinary tergal divisions seem to be entirely obliterated. The metapleurum consists of a dorsal plate (fig. 21, P_3) supporting the hind wing and of a ventral plate (p_3) carrying the hind leg. These two functions certainly identify these two plates as constituting together the metapleurum, but there is absolutely no trace of a division into an episternum and an epimerum. Once more, therefore, we have to go back to the generalized Hymenoptera to find out what has happened.

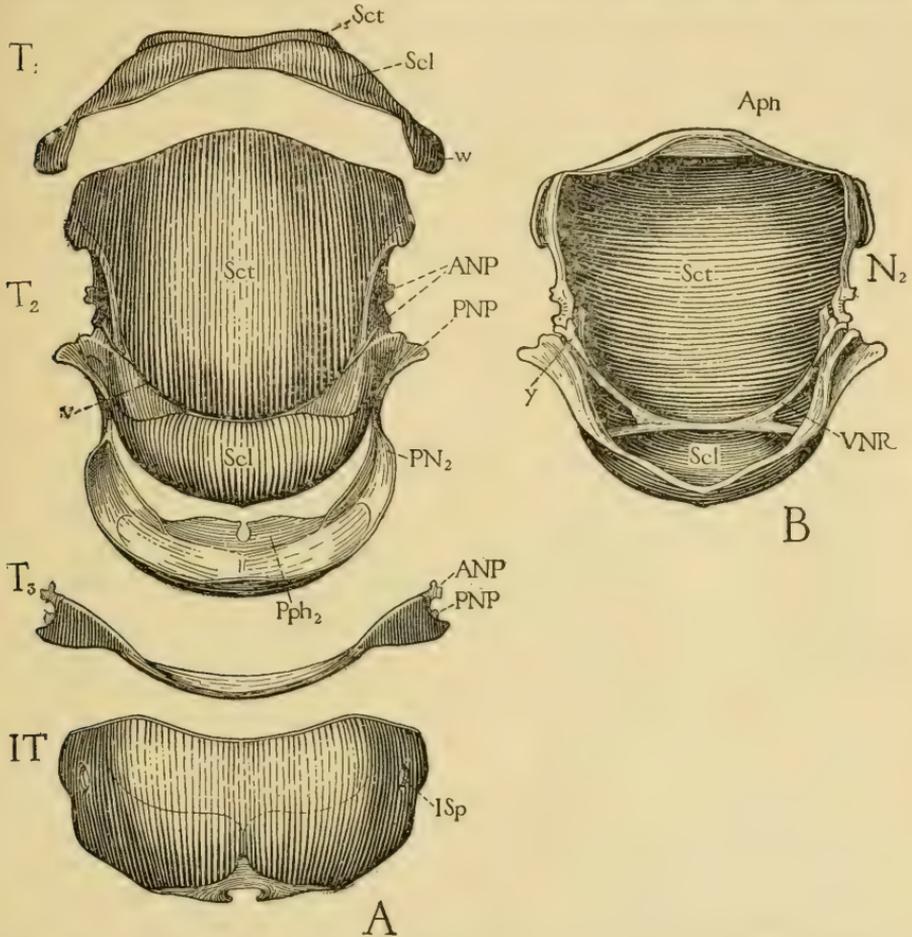


FIG. 23.—A, thoracic terga of worker separated from one another, showing protergum (T_1), mesotergum (T_2) and its internal postscutellum (postnotum PN_2) and phragma (Pph_2), metatergum (T_3) and propodeum or first abdominal tergum (IT); B, ventral view of principal or notal plate of mesotergum.

The answer is simple. *Sirex* has a typical metapleurum consisting of an episternum and epimerum separated by a complete pleural suture. In the higher forms this suture simply disappears, and consequently the pleurum shows no traces of its original component plates. The division into a wing-bearing and a leg-bearing plate is, therefore, a purely secondary one.

None of the Hymenoptera has separate trochantinal sclerites (see fig. 4, Tu), but, since the coxæ are articulated ventrally to knobs

(figs. 20 and 21, ε) apparently belonging to the sterna, it might be supposed that the trochantins have fused with the latter plates.

The posterior part of the thoracic mass (fig. 21) consists of the first abdominal tergum (*IT*), which fits into the deeply concave posterior edges of the metathorax and forms the peduncle (*Pd*) that carries the rest of the abdomen (fig. 32). It consists of a single large, strongly convex sclerite (figs. 21 and 23 A, *IT*) bearing the first abdominal spiracles laterally (*ISp*) and having its surface divided into several areas by incomplete sutures.

Many entomologists find it difficult to believe that this plate, which so apparently belongs to the thorax, is really derived from the abdomen. But the proof is forthcoming from a number of sources. In the first place, the thorax is complete without it and the abdomen is incomplete without it, the latter having otherwise only nine segments. Again, if the plate is reckoned as a part of the thorax we

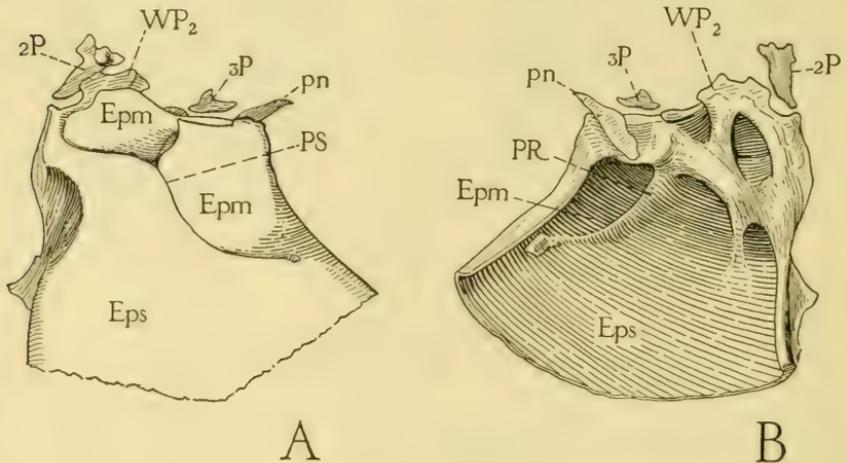


FIG. 24.—A, upper part of left mesopleurum of worker, external; B, inner view of same.

should have the anomaly of a thorax with three pairs of spiracles—there being the normal two on each side situated, as they always are, between the true thoracic segments. Furthermore, comparative anatomy shows us that in some of the sawflies (*Tenthredinidae*) the first abdominal tergum, while separated by a wide membranous space from the second, is not at all incorporated into the thorax. In a horn-tail such as *Sirex* (*Siricidae*) the entire first abdominal segment is fused to the posterior edge of the metathorax and is only loosely joined to the next abdominal segment by membrane. This insect affords, therefore, a most complete demonstration of the transference of this segment from the rest of the abdomen to the thorax. Finally, we have absolute proof of its abdominal origin based on a knowledge of development, for it has been shown by Packard from a study of the bumblebee that the first abdominal segment of the larva is transferred during the pupal metamorphosis to the thorax and forms the

part under discussion. We hence see that not only the first abdominal tergum but the entire segment has undergone transposition, though the ventral part has disappeared in all the higher families. This transferred part has been named both the *median segment* and the *propodeum* by writers who recognize it as belonging to the abdomen and not to the thorax.

The names current among systematists for the back plates of Hymenoptera afford an excellent example of the errors that entomologists may be led into through an ignorance of the comparative anatomy of insects. They recognize the protergum as such and then, knowing that there are yet two segments to be accounted for, they call the mesoscutum the "mesonotum," the mesoscutellum the "scutellum," the metatergum the "postscutellum" (being unaware that the true postscutellum is deeply concealed within the thorax), while the first abdominal tergum is called the metathorax. Such a nomenclature assigns both pairs of wings to the mesothorax. Too many systematists working in only one order of insects do not care whether their names are applied with anatomical consistency or not.

2. THE WINGS AND THEIR ARTICULATION.

In the study of insects the wings always form a most interesting subject because by them insects are endowed with that most coveted function—the power of flight. It has already been stated that the wings are not primary embryonic appendages, but are secondary outgrowths of the body wall from the second and third thoracic segments. Therefore it is most probable that the early progenitors of insects were wingless, yet for millions of years back in geological time they have possessed these organs in a pretty well developed condition.

Nearly all of the insect orders have some characteristic modification of the *wing-veins* and their branches. None of them, however, departs nearly so far from the normal type as do the Hymenoptera, even the lowest members of this group possessing a highly specialized venation. Before beginning a study of the Hymenopteran series which leads up to the bee the student should first turn back to figure 6 (p. 22) and again familiarize himself with the generalized condition of the veins and the articular elements of the wing. By comparing, now, with this diagram the basal parts of the wing of a sawfly (*Itycorsia discolor*, fig. 26 A) it will be easy to identify the parts of the latter. Vein *C* has two little nodules (*C'*, *C*) cut off from its basal end which lie free in the axillary membrane. Vein *Sc* articulates by an enlarged and contorted base (*Sc*) with the first axillary (*1A_x*), while vein *R* is continuous with the second (*2A_x*). The next two veins that come to the base and unite with each other are apparently not the media and cubitus but the first and third anals (*1A* and

3A), since they are associated with the third axillary (3Ax). In this species the subcosta (Sc) is entirely normal, but in the related horntail (*Sirex flavicornis*, fig. 26 B) the enlarged basal part of the subcosta is almost separated from the shaft of the vein, while the latter (fig. 25A, Sc) is short and weak. A study of the venation of this wing leads us to believe that the vein which arises from the radius a short distance from its base is the cubitus (Cu). Therefore the basal part

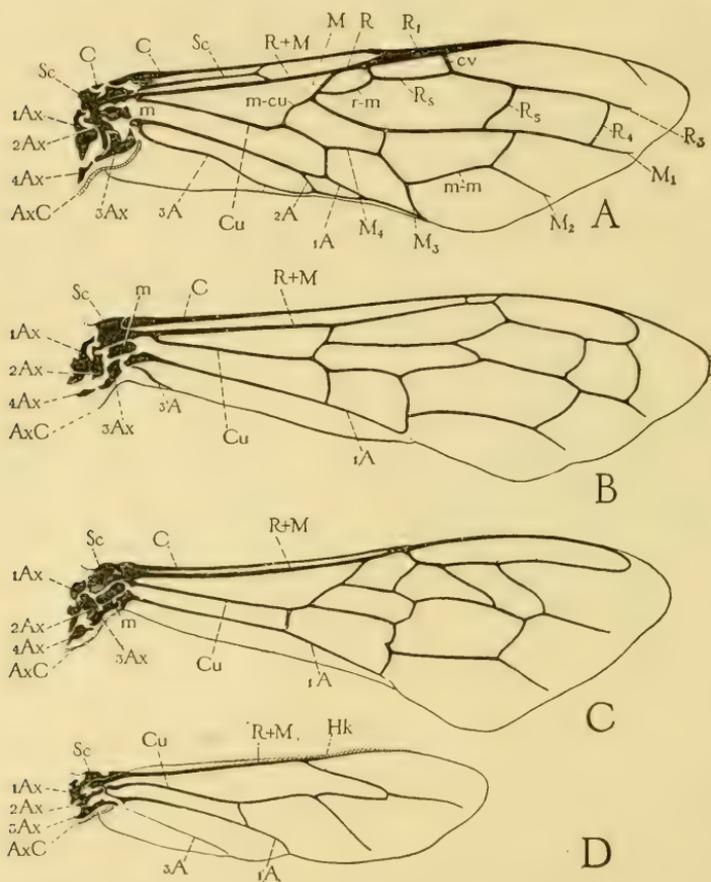


FIG. 25.—Wings of Hymenoptera and their basal articular sclerites (1Ax-4Ax): A, *Sirex flavicornis*, front wing; B, *Pepsis* sp., front wing; C, honey bee, front wing; D, honey bee, hind wing.

of the media is either gone or is fused with the radius. Since we discover its branches in the distal field of the wing, arising from the trunk of the radius, we conclude that the latter is the case. By this sort of reasoning we may arrive at the Comstock and Needham interpretation of the wing illustrated at A, fig. 25. From this it is evident that the branches of both the radius and the media have been bent back toward the posterior margin of the wing.

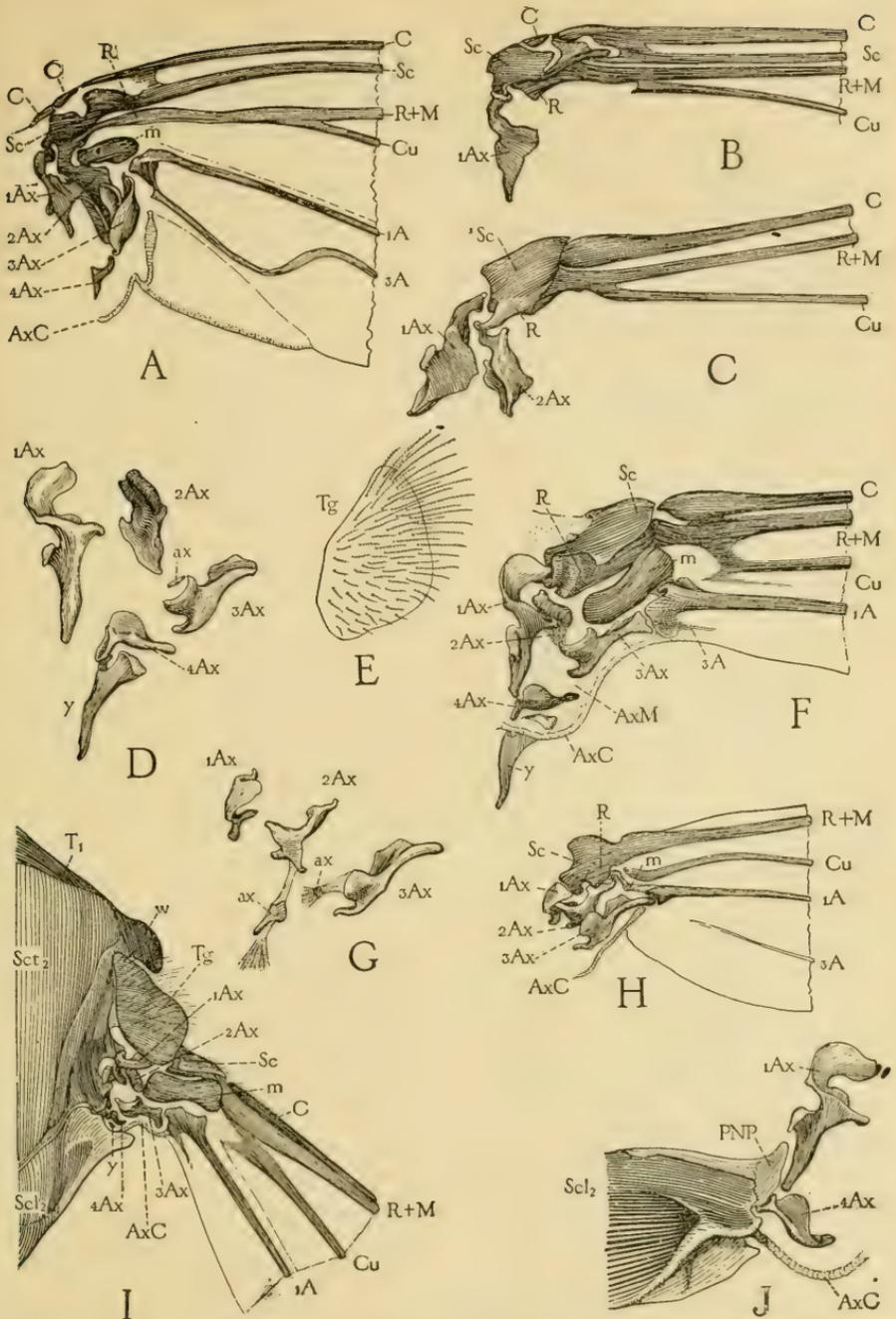


FIG. 26.—Basal elements of wings of Hymenoptera: A, base of front wing of a sawfly (*Itycorsia discolor*) showing comparatively generalized arrangement of veins and axillaries; B, bases of anterior veins of front wing of a horntail (*Sirex flavicornis*), showing detachment of base of subcostal vein (*Sc*) from its shaft; C, corresponding view of anterior veins in front wing of a tarantula-killer (*Pepsis* sp.), showing complete absence of shaft of subcosta, but presence of basal part (*Sc*) fused with base of radius (*R*); D, axillaries of anterior wing of honey bee worker; E, tegula of worker; F, base of anterior wing of worker showing absence of shaft of subcosta but presence of scale (*Sc*) derived from its base; G, axillaries of hind wing of worker, the fourth absent in bee; H, base of hind wing of worker, showing absence of costal and subcostal veins and fusion of bases of subcosta (*Sc*) and radius (*R*) into large humeral mass; I, attachment of front wing to scutum (*Sct*₂) and scutellum (*Scl*₂) of mesotergum; J, under view of end of mesoscutellum (*Scl*₂) showing attachment of both first (*1Ax*) and fourth axillaries (*4Ax*) to posterior wing process (*PNP*), an unusual connection for first axillary.

Taking this wing of *Sirex* as a foundation let us proceed a little higher and examine the wing of a Pompilid, such as *Pepsis* (figs. 26 C and 25 B). We observed that in *Sirex* (fig. 26 B) the basal part of vein *Sc* is almost separated from the distal shaft. In *Pepsis* (fig. 26 C) it is entirely a separate piece, to which is fused also the base of vein *R*. Moreover, the shaft of *Sc* has disappeared entirely (fig. 25, B). Thus there is at the humeral angle of the wing a large chitinous mass (fig. 26 C, *Sc* and *R*) representing the fused bases of both the subcosta and the radius, which is associated with both the first axillary (*1Ax*) and the second axillary (*2Ax*).

If now we proceed to a study of the front wing of the bee we find that its basal characters (fig. 26 F) are more similar to those of *Sirex* (B), while its venation (fig. 25 C) resembles more closely that of *Pepsis* (B). The subcostal scale at its base (fig. 26 F, *Sc*) is not fused with the base of the radius, but the distal part of the subcosta is gone (fig. 25 C), as in *Pepsis*. In the hind wing of the bee (fig. 26 H) the bases of the subcosta and radius are fused into one large humeral mass articulating with the first two axillaries (*1Ax* and *2Ax*). The third axillary (*3Ax*) is well developed but the fourth is absent. The venation (fig. 25 D) is reduced to a very simple condition, but to one just the opposite from primitive.

The details of the axillaries in the two wings are shown by figure 26 D and G. The fourth (*4Ax*) is well developed in the front wing (D) and has a large accessory sclerite (*y*) connected with it, upon which is inserted a long slender muscle (fig. 28, *cc*). A very small accessory sclerite (*ax*) occurs close to the muscle plate of the third axillary (*3Ax*). These are called "accessory" sclerites because they are of irregular occurrence in the wing bases of insects generally and are developed in connection with the muscle attachments. Similar ones occur in the hind wing (G, *ax*) in connection with the second (*2Ax*) and third axillaries (*3Ax*).

The front wing is attached to the posterior half of the side of the mesonotum. The anterior notal wing process is bilobed (figs. 22, 23 A, *T*₂, *ANP*) and is carried by the scutum, while the posterior process (*PNP*) is carried by the scutellum and is mostly hidden beneath the anterior wing process. The two wing processes, in fact, are so close together that the first axillary articulates not only with the first but also with the second (fig. 26 J). The axillary cord (fig. 26 F, *AxC*) arises from a lobe of the scutellum overlapped by the lateral margin (I and J, *AxC*). In the hind wing, where the fourth axillary is absent, the third articulates directly with the posterior notal wing process of the metatergum (fig. 23 A, *T*₃, *PNP*).

The base of the front wing is overlapped by a large scale (fig. 26, E and I, *Tg*) called the tegula. It is carried by the axillary mem-

brane, to which it is attached between the humeral angle of the wing base and the edge of the notum. The tegulae are present in most insects, generally on the base of each wing, but they usually have the form of small inconspicuous hairy pads, as shown in the diagram (fig. 6, *Tg*). In the flies, moths, butterflies, and Hymenoptera, however, the tegulae of the front wings develop into large conspicuous scales overlapping the humeral angles of the bases of these wings.

The motion of the wing in flight consists of both an up-and-down movement and a forward-and-backward movement, which two combined cause the tip of the wing to describe a figure-eight course if the insect is held stationary. Corresponding with these four movements are four sets of muscles. In the dragonflies nearly all of the wing muscles are inserted directly upon the base of the wing itself, but in other insects, excepting possibly the mayflies, the principal muscles are inserted upon the thoracic walls and move the wing secondarily. In the lower insects, such as the grasshoppers, crickets, stoneflies, net-winged flies, etc., the two wing-bearing segments are about equal in their development and each is provided with a full equipment of muscles. In these insects the wings work together by coordination of their muscles, although each pair constitutes a separate mechanism. In such insects, however, as the true flies and the wasps and bees the metathorax, as we have seen in the case of the bee, is greatly reduced, and what is left of it is solidly attached to the mesothorax. In the flies the hind wings are reduced to a pair of knobbed stalks having no function as organs of flight, while in the bees the hind wings, which are very small, are attached to the front wings by a series of hooklets on their anterior margins (fig. 25 D, *Hk*) which grasp a posterior marginal thickening of the front wings. Moreover, when we examine the interior of the bee's thorax we find that the muscles of the metathorax are greatly reduced or partly obliterated and that the great mesothoracic muscles serve for the movement of both wings, thus assuring a perfect synchrony in their action. Hence, it is clear that the union and consolidation of the thoracic segments in the higher insects is for the purpose of unifying the action of the wings.

The muscles of flight in the bee may be very easily studied by cutting the thorax of a drone into lateral halves. The cavity of the thorax is occupied almost entirely by three great masses of muscles. One of these is longitudinal, median, and dorsal (fig. 27, *LMcl*₂), extending from the mesoscutum (*Sc*₂) and the small prephragma (*Aph*) to the large mesothoracic postphragma (*Pph*₂). A small set of muscles (*LMcl*₃) then connects the posterior surface of this phragma with the lower edge of the propodeum (*IT*). On each side of the

anterior end of this great longitudinal muscle is a thick mass of dorso-ventral fibers (*VMcl*) extending from the lateral areas of the mesoscutum (*Sct*₂) to the lateral parts of the mesosternum (*S*₂). A contraction of the vertical muscles must depress the tergal parts, at the same time expanding the entire thorax in a longitudinal direction and stretching the longitudinal muscles. A contraction, then, of the latter muscles (*LMcl*) restores the shape of the thorax and elevates the tergal parts. Remembering, now, that the wings are

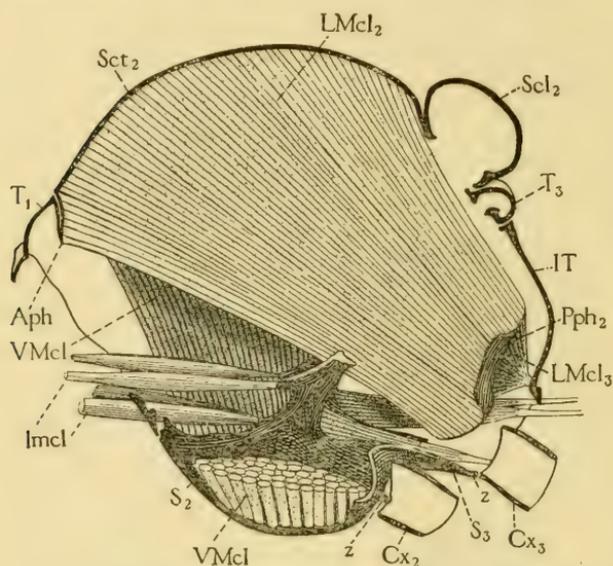


FIG. 27.—Median section through thorax of drone, showing longitudinal muscles (*LMcl*₂) of mesothorax going from mesotergal scutum (*Sct*₂) and small anterior phragma (*Aph*) to posterior phragma (*Pph*₂) of internal postscutellum (postnotum) of same segment, also showing vertical mesothoracic muscles (*VMcl*), and ventral longitudinal muscles (*lmcl*), and longitudinal muscles of metathorax (*LMcl*₃) going from postphragma of mesothorax (*Pph*₂) to posterior edge of propodeum or first abdominal tergum (*IT*). By alternate contraction of dorsal longitudinal muscles and vertical muscles, roof of thorax is elevated and depressed, causing wings to beat downward and upward respectively, being supported on fulcra formed by pleural wing processes (fig. 28, *WP*₂) of side walls of thorax.

themselves. The vertical muscles are the *elevators* and the longitudinal the *depressors*.

But besides being moved up and down the wings can also, as before stated, be extended and flexed, i. e., turned forward and backward in a horizontal plane upon the pleural wing process. The muscles which accomplish these movements lie against the inner face of the pleurum (fig. 28), and each wing is provided with a separate set. The extensor muscle (*PMcl*) is the most anterior and is inserted by a long neck upon the preparapterum (*2P*). The latter is closely

supported from below upon the pleural wing processes and that each is hinged to the back by the notal wing processes, it is clear that a depression of the dorsum of the thorax must elevate the wings and that an elevation of the dorsum depresses them—the pleural wing processes acting as the fulcra. Hence, the chief up-and-down movements of the wings are produced by these great thoracic muscles acting upon the shape of the thorax as a whole and not directly upon the wings

connected with the anterior part of the base of the wing so that a contraction of the muscle turns the wing forward and at the same time depresses its anterior margin. For this reason the parapterum and the extensor muscle have been called the *pronator apparatus*, and the muscle is known also as the *pronator muscle*. In some insects which fold the wings back against the body this muscle is a great deal larger than in the bee. The *flexor muscle* (*RMcl*) consists of three parts situated upon the anterior half of the pleurum and inserted upon the third axillary (*3Ax*) by long tendonlike necks. These muscles are antagonistic to the extensor and by their contraction pull the wing back toward the body.

The mechanism which produces the wing motion thus seems to be a very simple one and may be summarized as follows: Each wing rests and turns upon the wing process of the pleurum (figs. 24 and 28, *WP*) by means of the pivotal sclerite or second axillary in its base (figs. 26 F and 28, *2Ax*). It is hinged to the back by the first and fourth axillaries (fig. 26 F, *1Ax* and *4Ax*) which articulate with the anterior and posterior notal wing processes (fig. 23 A, *T₂*, *ANP* and *PNP*), respectively. The large vertical muscles (fig. 27, *VMcl*) of the thorax depress the tergum, which pulls down with it the base of the wing and hence elevates the distal part—

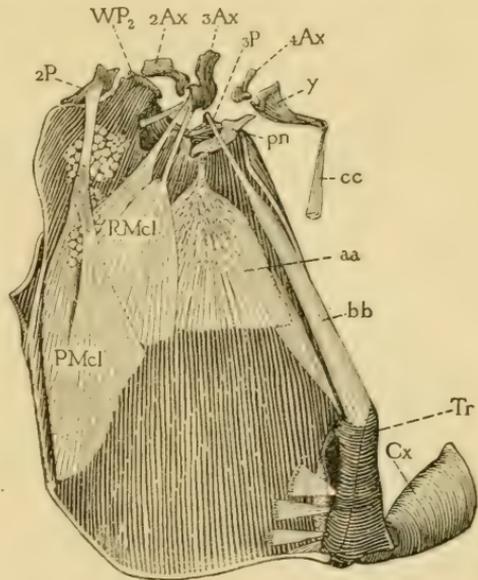


FIG. 28.—Internal view of right pleurum of mesothorax of drone, showing muscles inserted upon parapteral plates (*2P* and *3P*) and upon third axillary (*3Ax*). The wing rests upon wing process of pleurum (*WP₂*) by second axillary (*2Ax*); it is turned forward and downward by the pronator muscle (*PMcl*), inserted upon anterior parapterum (*2P*) which is attached to costal head of wing, and is turned back toward body by flexor muscle (*RMcl*) inserted upon third axillary (*3Ax*).

the fulcrum being the pleural wing process. The dorsal longitudinal muscle (*LMcl*) restores the shape of the thorax, elevates the tergum, and consequently depresses the wing. Extension and flexion of the wing are produced by special muscles (fig. 28, *PMcl* and *RMcl*) acting upon its base before and behind the pleural wing process, respectively.

Besides these muscles there are several others (fig. 28) associated with the wing whose functions are less evident. Most conspicuous of these is a muscle occupying the posterior half of the mesopleurum (*aa*) and inserted upon the outer end of the scutellum. This may

be simply accessory to the large vertical sterno-scutal muscle (fig. 27, *Ucl*). Another is a long slender muscle (*bb*) attached to the upper end of the mesocoxa and inserted upon the postparapterum (*βP*). This is sometimes termed the *cono-axillary muscle*. A third (*cc*) is inserted upon the tip of the accessory sclerite (*y*) of the fourth axillary and is attached to the lateral arm of the large entosternum of the mesothorax and metathorax.

3. THE LEGS.

The legs of the honey bee are highly modified for several special purposes besides that of walking, but they are so well known and have been so often described that it will not be necessary to devote much space to them here.

The **front legs** (fig. 29 A) have a structure formed by the adjoining ends of the tibia and the first tarsal joint, which is called, on account of its use, the *antenna cleaner*. It consists (fig. 29 C) of a semi-circular notch (*dd*) in the base of the first tarsal joint (*ITar*) provided with a comblike row of bristles. A specially modified, flat, movable spur (*cc*), shown in ventral view at B, is so situated on the end of the tibia that it closes over the notch when the tarsus is bent toward the tibia. By grasping an antenna between the notch and the spur and drawing it through the inclosure the bee is able to remove from this sensitive appendage any pollen or particles of dirt that may be adhering to it.

The **middle legs** (fig. 29 D) present no special modifications of any importance. It will be observed, however, that they, as well as the other legs (A and F), have the first joint of the tarsus (*ITar*) very greatly enlarged.

The **hind legs** of all three forms, the worker (F), the queen (E), and the drone (H), have both the tibia and the large basal segment of the tarsus very much flattened. In the queen and drone there seems to be no special use made of these parts, but in the worker each of these two segments is modified into a very important organ. The outer surface of the tibia (F, *Tb*) is fringed on each edge by a row of long curved hairs. These constitute a sort of basket (*cb*) in which the pollen collected from flowers is carried to the hive. The structures are known as the *pollen baskets*, or *corbicula*. The inner surface of the large, flat, basal segment of the tarsus (*ITar*) is provided with several rows of short stiff spines (G) forming a brush by means of which the bee gathers the pollen from its body, since it often becomes covered with this dust from the flowers it visits for the purpose of getting nectar. When a sufficient amount is accumulated on the brushes it is scraped off from each over the edge of the tibia of the opposite hind leg and is thus stored in the pollen baskets. Hence the worker often flies back to the hive with a great mass of

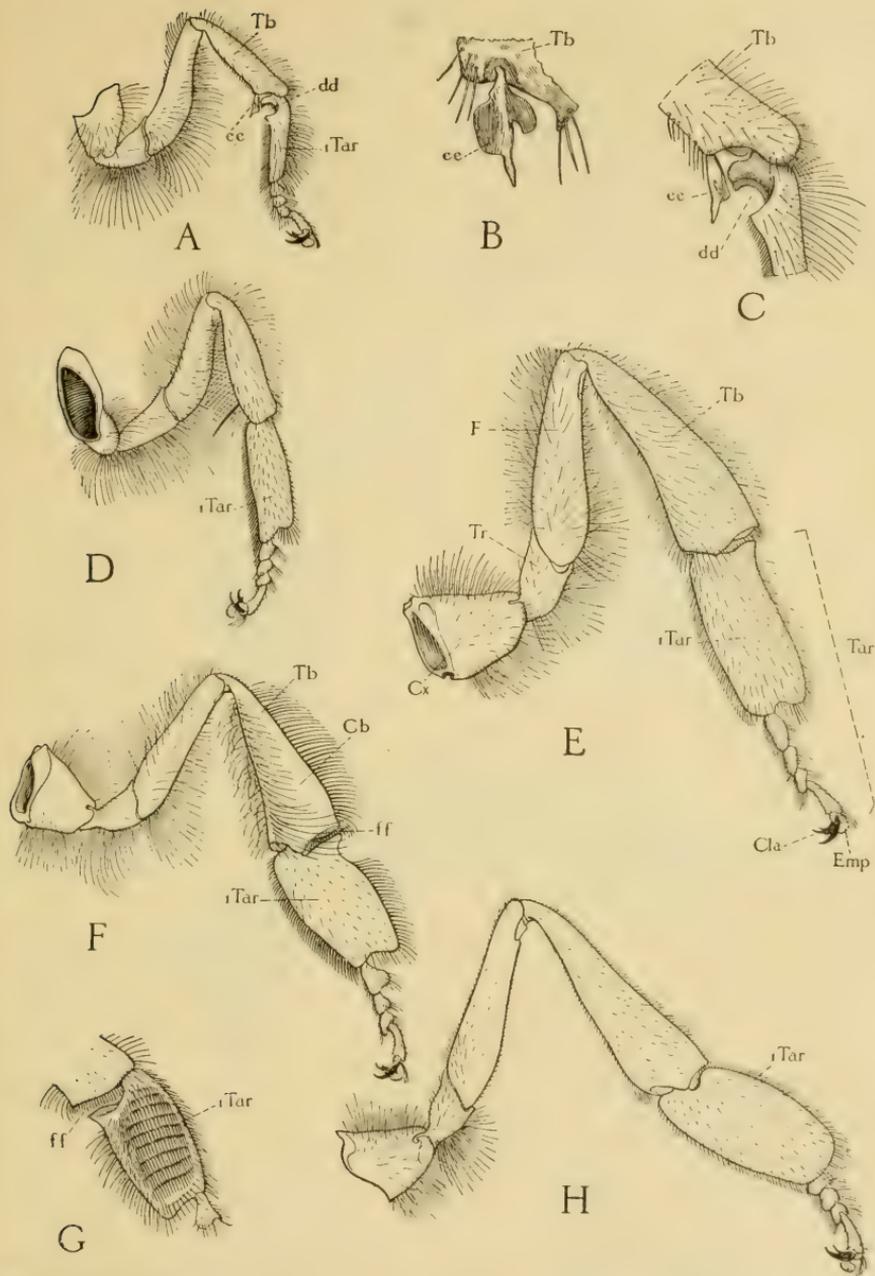


FIG. 29.—A, left front leg of worker, anterior view, showing position of notch (*dd*) of antenna cleaner on base of first tarsal joint (*iTar*) and of closing spine (*cc*) on end of tibia (*Tb*); B, spine of antenna cleaner (*cc*) in flat view; C, details of antenna cleaner; D, left middle leg of worker, anterior view; E, left hind leg of queen, anterior or outer view; F, left hind leg of worker, anterior or outer view, showing the pollen basket (*Cb*) on outer surface of tibia (*Tb*); G, inner view of first tarsal joint of hind leg of worker showing rows of pollen-gathering hairs and the so-called "wax shears" (*ff*); H, left hind leg of drone, anterior or outer view.

pollen adhering to each of its hind legs. The pollen baskets are also made use of for carrying propolis.

Between the ends of the hind tibia (*Tb*) and the first tarsal joint (*ITar*) is a sort of pincerlike cleft (*F* and *G*, #) guarded by a row of short spines on the tibial edge. This is popularly known as the "wax shears" and it is supposed to be used for picking the plates of wax out of the wax pockets of the abdominal segments. The writer, however, has watched bees take the wax from their abdomen and in these observations they always poked the wax plates loose

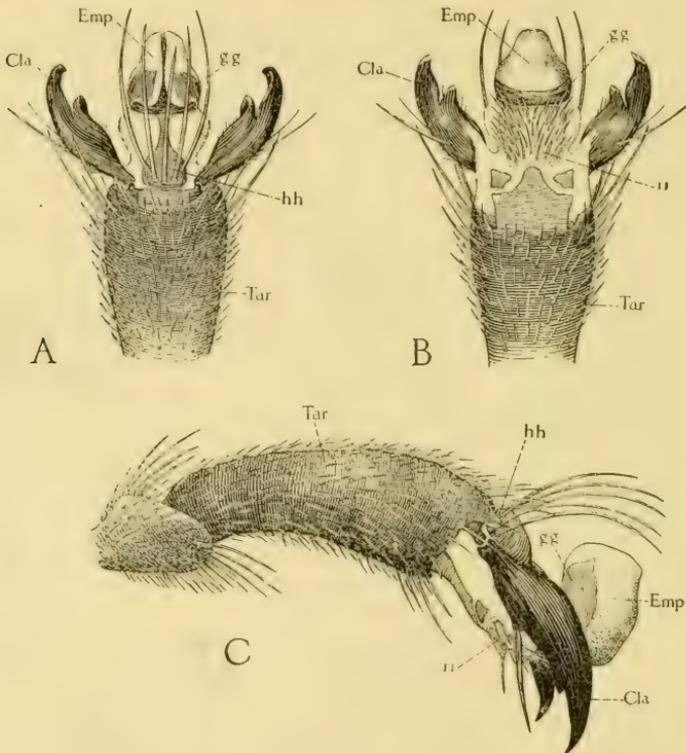


FIG. 30.—A, dorsal view of end of last tarsal joint of first foot (*Tar*), the claws (*Cla*), and empodium (*Emp*) of worker; B, ventral view of same; C, lateral view of same, showing empodium in ordinary position when not in use.

with the ordinary hairs or spines of the tibiae or tarsi and then by means of the feet passed them forward beneath the body to the mandibles.

The last tarsal joint of each leg bears a pair of claws (*E*, *Cla*) and a single median empodium (*Emp*). Each one of the claws is bilobed, consisting of a long tapering outer point and a smaller inner one (figs. 30 and 31). The claws of the worker (fig. 31 A) and the queen (B) are only slightly different in details of outline, although the claws of the queen are much greater in size than those of the

worker, but the drone's claws (C) are large and very strikingly different in shape from those of either the worker or the queen.

The empodium (fig. 30 A, B, and C, *Emp*) consists of a terminal lobe bent upward between the claws (C) and deeply cleft on its dorsal surface (A), and of a thick basal stalk whose walls contain a number of chitinous plates. One of these plates is dorsal (A and C, *hh*) and bears five very long, thick, curved hairs projecting posteriorly over the terminal lobe, while a ventral plate (B and C, *ii*) is provided with numerous short thick spines. A third plate (A, B, and C, *gg*) almost encircles the front of the terminal lobe, its upper ends reaching to the lips of the cleft.

When the bee walks on any ordinary surface it uses only its claws for maintaining a foothold, but when it finds itself on a smooth, slippery surface like glass the claws are of no avail and the empodia are provided for such emergencies as this. The terminal lobe is pressed down against the smooth surface and its lateral halves are flattened out and adhere by a sticky liquid excreted upon them by glands said to be situated in front of them. On the relaxation of the muscle that flattens the empodial lobes the latter spring back into their original position by the elasticity of the chitinous band (*gg*) in their walls.

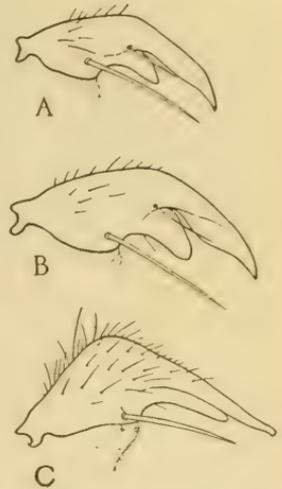


FIG. 31.—A, outer view of hind claw of worker; B, same of queen; C, same of drone.

V. THE ABDOMEN, WAX GLANDS, AND STING.

The abdomen of the worker and queen appears to consist of six segments (figs. 1, 32, 33, *II-VII*), but it must be remembered that, as has already been explained, the thoracic division of the body in the Hymenoptera includes one segment, the propodeum or median segment, which really belongs to the abdomen and is its true first segment according to the arrangement in all other insects. Hence, counting the propodeum (figs. 21 and 32, *IT*) as the first, we find seven exposed abdominal segments in the worker and queen and nine in the drone. Each one except the first consists of a tergum (*T*) and a sternum (*S*), the former reaching far down on the side of the segment, where it carries the spiracle (*Sp*) and overlaps the edge of the sternum. The two plates of the last or seventh segment in the worker and queen are separated by a cleft on each side, and if they are spread apart it is seen that the tip of the abdomen

incloses a cavity which lodges the sting and its accessory parts. The end of the abdomen of the male (fig. 56 D) is quite different from that of the female, while in it parts at least of nine segments are

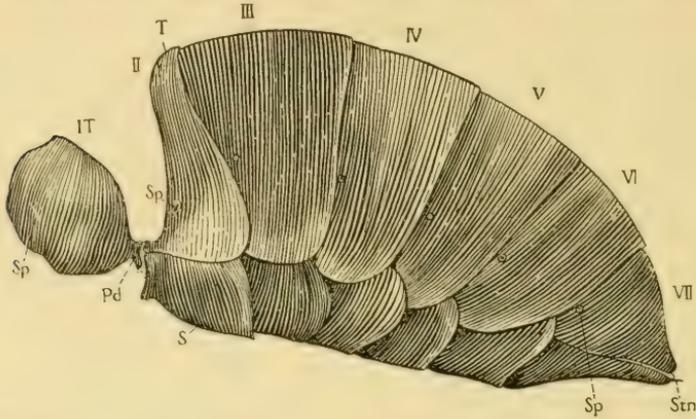


FIG. 32.—Lateral view of abdomen of worker, showing the propodeum (IT) as a part of the abdomen, of which it is the true first segment.

visible, the last is very much modified and is exposed only on the sides and below.

An internal view of the ventral plates and the lateral parts of the

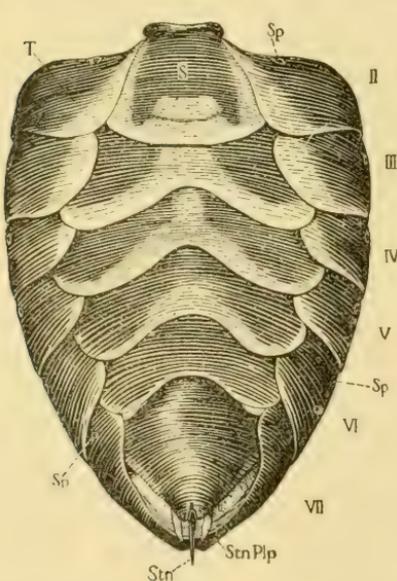


FIG. 33.—Ventral view of abdomen of worker, showing tip of sting (Stn) and palpuslike appendages (StnPlp) projecting from sting chamber within seventh segment (VII).

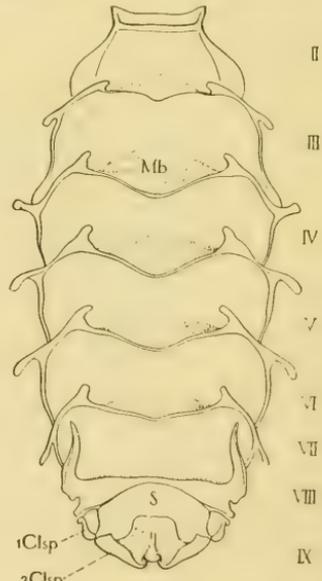


FIG. 34.—Dorsal view of abdominal sterna of drone, showing clasp appendages (1Clsp and 2Clsp) of ninth segment.

terga in the worker is shown by figure 20, while a corresponding view of the male sterna is shown by figure 34. It will be seen that each sternum is very widely underlapped (viewed from above) by the

one next in front of it and that the intersegmental membrane (*Mb*) is reflected from the middle of the dorsal surface of each to the anterior edge of the following sternum. By removing an individual plate (fig. 35 A) this is more easily shown. It is also clearly seen that the transverse line of attachment of the membrane (*Mb*) divides the sternum into a posterior part (*Rd*), which is merely a prolonged reduplication underlapping the following sternum, and into an anterior part underlapped by the preceding sternum. The posterior half is, hence, purely external while the anterior half forms the true ventral wall of the segment, its dorsal face being internal and its ventral face external. The anterior part is also very smooth and shiny and somewhat bilobed and for this reason it is sometimes called the "mirrors." Its edge is bounded by a thickened ridge giving off a short apodeme (*Ap*) on each side. The mirrors of the last four sterna are also, and more appropriately, called the wax plates because the wax is formed by a layer of cells lying over them. It accumulates on the ventral side in the pocket between the wax plates and the posterior underlapping prolongation of the preceding sternum. Wax is formed only on the last four visible segments, i. e., on segments IV-VII, inclusive.

In studying any part of the body wall of an insect it must always be borne in mind that the chitin is originally simply an external cuticular layer of a true cellular skin or epidermis (erroneously called "hypodermis" in insects), but that in the adult stage the latter almost everywhere disappears as a distinct epithelium. Thus the chitin comes to be itself practically the entire body wall, the cell layer being reduced to a very inconspicuous membrane. However, in certain places the epithelium may be developed for special purposes. This is the case with that over the wax plates which forms a thick layer of cells that secrete the wax and constitute the so-called *wax glands*. The wax is first secreted in a liquid condition and is extruded through minute pores in the wax plates of the sterna, hardening on their under surfaces into the little plates of solid wax with which every bee keeper is acquainted.

The **secretion of the wax** has been studied by Dreyling (1903), who made histological sections through the glands at different times in the life of the bee. He found that in young, freshly emerged workers the epidermis of the wax plates consists of a simple layer of ordinary epithelial cells. As the activities of the bee increase, however, these cells elongate while clear spaces appear between them and, when the highest development is reached, the epithelium consists of a thick layer of very long cells with liquid wax stored in the spaces between them. In old age most of the cells become small again and in those bees that live over the winter the epithelium degenerates to a simple sheet of nucleated plasma showing no cell boundaries. It is thus evident that the secretion of wax is best performed during the prime

of life, which in bees is at about 17 days of age or before, and that old bees can only gather honey and pollen. Bees do not normally secrete wax while performing the other more ordinary duties of their life. When comb is needed a large number of young bees or bees that have not passed their prime hang together in vertical sheets or festoons within the hive and are fed an abundance of honey. After about twenty-four hours they begin to construct comb. During this time the wax is excreted through the wax plates and accumulates in

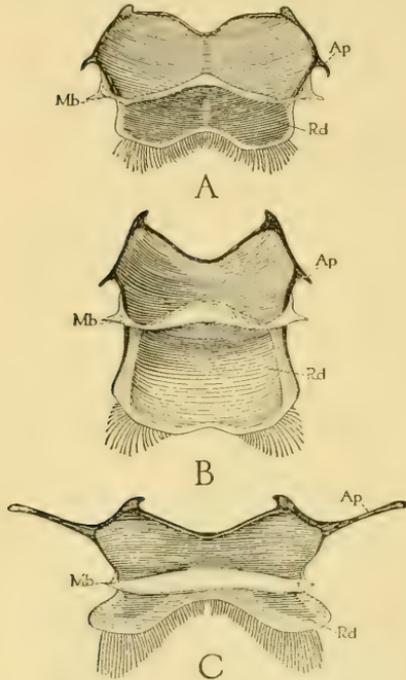


FIG. 35.—Dorsal surface of sixth abdominal sternum: A, worker; B, queen; C, drone; showing division of plate by line of attachment of intersegmental membrane (*Mb*) into anterior part with polished internal surface, in worker bearing wax glands, and into large posterior external part (*Rd*) underlapping anterior half of succeeding sternum.

the external wax pockets below. It is poked out of these pockets by means of the spines on the feet and is passed forward beneath the body to the mandibles. By means of these organs it is manipulated into little pellets and modeled into the comb. Dreyling describes the pores of the wax plates as excessively fine, vertical, parallel canals only visible in very thin sections and under the highest power of the microscope.

Corresponding abdominal sterna present quite different shapes in the three forms of the bee (fig. 35 A, B, and C). In the queen (B) the sterna are much longer than in the worker (A), while in the drone (C) they are shorter and have very long lateral apodemes (*Ap*).

The last three abdominal segments—the eighth, ninth, and tenth—are very different in the two sexes on account of their modification in each to accommodate the external organs of reproduction and egg laying. In the female these segments are entirely concealed within the seventh, but, in the male, parts of both the eighth and ninth segments are visible externally.

The seventh segment of the drone (counting the propodeum as the first) is the last normal segment, i. e., the last one having a complete tergum and sternum resembling those of the anterior part of the abdomen (fig. 56 D, *VIIIT* and *VIIIS*). Behind the seventh tergum and partly concealed within it is the eighth tergum (*VIIIT*) carrying the last abdominal spiracles (*Sp*). The eighth sternum is

almost entirely concealed within the seventh. It is very narrow below, but is expanded at the upper parts of its sides (*VIIIS*), where it is partly visible below the eighth tergum and behind the seventh sternum. The dorsal part of the ninth segment is membranous except for a small apodeme-bearing plate on each side hidden within the eighth tergum. The ninth sternum, on the other hand, is a well-developed semicircular band (*IXS*) forming the ventral and ventrolateral parts of the ninth segment. It bears on each side two conspicuous lobes—one a small, darkly chitinized, dorsal plate (*1Clsp*) carrying a large bunch of long hairs, the other a large, thin, ventral plate (*2Clsp*). Between these four appendicular lobes is ordinarily a deep cavity, which is the invaginated penis (fig. 56 E), but in figure D this organ is shown partly evaginated (*Pen*). While the penis is really an external organ, the details of its structure will be described later in connection with the internal organs of reproduction. The tenth segment is entirely lacking in segmental form. The anal opening is situated in a transverse membrane beneath the eighth tergum (*VIIIT*), and below it is a thin chitinous plate, which may belong to the tenth segment.

In many insects the modification of the terminal segments of the males in connection with the function of copulation is much greater than in the bee. The ninth segment often forms a conspicuous enlargement called the *hypopygium*, which is usually provided with variously developed clasping organs in the form of appendicular plates and hooks.

The development of the external genital parts of the drone has been described by both Michaelis (1900) and Zander (1900). A small depression first appears on the under surface of the ninth segment of the larva shortly after hatching. Soon two little processes grow backward from the anterior wall of this pouch and divide each into two. The part of the larval sternum in front of the pouch becomes the ninth sternum of the adult, while the two processes on each side form the upper and lower appendicular lobes (the *valva externa* and the *valva interna* of Zander). The penis at first consists of two little processes which arise between the valvæ internæ, but is eventually formed mostly from a deep invagination that grows forward between them. These four processes arising on the ventral side of the ninth segment of the male larva are certainly very suggestive of the similar ones that are formed in the same way on the same segment of the female and which develop into the second and third gonapophyses of the sting. If they are the same morphologically we must homologize the two clasping lobes of the ninth sternum in the male with the two gonapophyses of this segment in the female. Zander (1900) argues against such a conclusion on the ground that the genital pouch is situated near the anterior edge of the segment in the female and

posteriorly in the male, while the parts in the two sexes develop later in an absolutely different manner. These arguments, however, do not seem very forcible—in the earliest stages the processes certainly look alike in the two sexes.

The **sting** of the bee is situated in the sting cavity at the end of the abdomen, from which it can be quickly protruded when occasion demands. This sting chamber contains also the reduced and modified sclerites of the eighth, ninth, and tenth abdominal segments. In fact, the sting chamber is formed by an infolding of these three segments into the seventh. It is consequently not a part of the true interior of the body or body cavity which contains the viscera, but is simply a sunken and inclosed part of the exterior, in the same sense that the oven of a stove is not a part of the real inside of the stove. Consequently the parts of the sting, though normally hidden from view, are really external structures.

A very gentle pull on the tip of the sting is sufficient to remove it from its chamber, but a sting thus extracted brings along with it the ninth and tenth segments, most of the eighth segment, the poison glands, and the terminal part of the alimentary canal. This is due to the fact that the inclosed segments are attached to the surrounding parts by very delicate membranes. For the same reason they so easily tear from the living bee as the latter hurriedly leaves its victim after stinging. The worker thus inflicts a temporary wound and pain at the cost of its own life. Undoubtedly, however, nature regards the damage to the enemy as of more importance to the bee community as a whole than the loss of one or a dozen of its members. The entire stinging apparatus with a bag of poison attached is thus left sticking in the wound while the muscles, which keep on working automatically, continue to drive the sting in deeper and deeper and at the same time pump in more poison. Such a provision certainly produces much more effective results than would a bee giving a thrust here and another there with its sting and then rapidly flying away to escape from danger.

The sting itself, when extracted from its chamber, is seen to consist of a straight tapering shaft with its tip directed posteriorly and its base swollen into a bulblike enlargement. In superficial appearance the shaft appears to be solid, although we shall presently show that it is not, but the bulb is clearly hollow and is open below by a distinct median cleft. Several plates of definite shape and arrangement always remain attached to the sting and overlap its base. The entire apparatus, including the base of the large poison sac, is shown somewhat diagrammatically in side view by figure 36. The bulb of the sting (*ShB*) is connected with the lateral plates by two arms which curve outward and upward from its base. (Only the left side is shown in the figure.) Between these arms the two poison glands

(*PsnSc* and *BGl*) open into the anterior end of the bulb. From the posterior ends of the plates two whitish fingerlike processes (*StnPlp*) project backward. When the sting is retracted these lie at the sides of the shaft (figs. 33 and 37), but in figure 36 the sting is shown in a partly protracted position. These appendages, often called the sting palpi, undoubtedly contain sense organs of some sort by means of which the bee can tell when her abdomen is in contact with the object upon which she desires to use her sting.

A close examination of the sting shows that it is a much more complicated structure than it at first sight appears to be. The shaft, for example, is not a simple, solid, tapering, spearlike rod, but is a hollow organ made of three pieces which surround a central canal. One of these pieces is dorsal (fig. 36, *ShS*) and is the true prolongation of the bulb (*ShB*), while the other two (*Lct*) are ventral and slide lengthwise on tracklike ridges of the dorsal piece. Moreover, each basal arm of the sting is double, consisting of a dorsal or posterior piece (*ShA*), which is likewise a prolongation of the bulb, and a ventral or anterior piece (*Lct*), which is continuous with the ventral rod of the shaft on the same side. Hence the sting may be analyzed into three elements, which

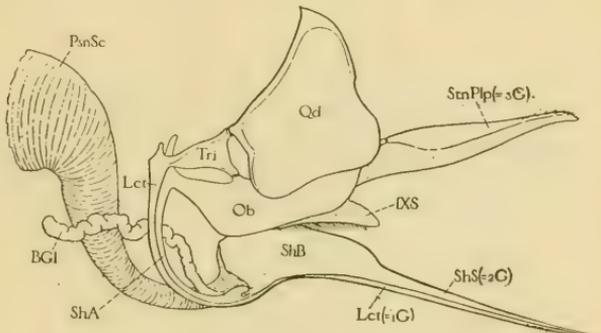


FIG. 36.—Semidiagrammatic view of left side of sting of worker, accessory plates (*Tri*, *Ob*, *Qd*), sting palpus (*StnPlp*), alkaline poison gland (*BGl*), and base of large poison sac (*PsnSc*) of acid gland.

are characterized as follows: The dorsal piece, known as the *sheath*, consists of a prominent basal swelling or *bulb* (*ShB*) containing a large cavity, of a terminal tapering *shaft* (*ShS*), and of two curved *basal arms* (*ShA*). The ventral part consists of two long slender rods, called the *lancets* or *darts* (*Lct*), which slide freely upon two tracks on the ventral edges of the sheath and diverge upon continuations of these tracks along the basal arms of the latter (*ShA*). The bulb is hollow, containing a large cavity formed by invagination from below, where it is open to the exterior by a lengthwise cleft. This cavity continues also through the entire length of the shaft of the sting as a channel inclosed between the dorsal sheath and the latero-ventral lancets. This channel, as will be explained later, is the *poison canal* of the sting.

Each arm of the sheath (*ShA*) is supported at its end farthest from the bulb by an *oblong plate* (fig. 36, *Ob*), which normally over-

laps the side of the bulb, and which carries distally the *palpi* of the sting (*StnPlp*). Each lancet is attached at its base to a *triangular plate* (*Tri*) which lies latero-dorsad to the base of the oblong plate and articulates with a knob on the dorsal edge of the latter by its ventral posterior angle. By its dorsal posterior angle the triangular plate is articulated to a much larger *quadrate plate* (*Qd*) which overlaps the distal half of the oblong plate. A thick membranous lobe (*LVS*), concave below, where it is thickly set with long hairs, overlaps the bulb of the sting and is attached on each side to the edges of the oblong plates. All of these parts are shown flattened out in ventral view by

figure 37.

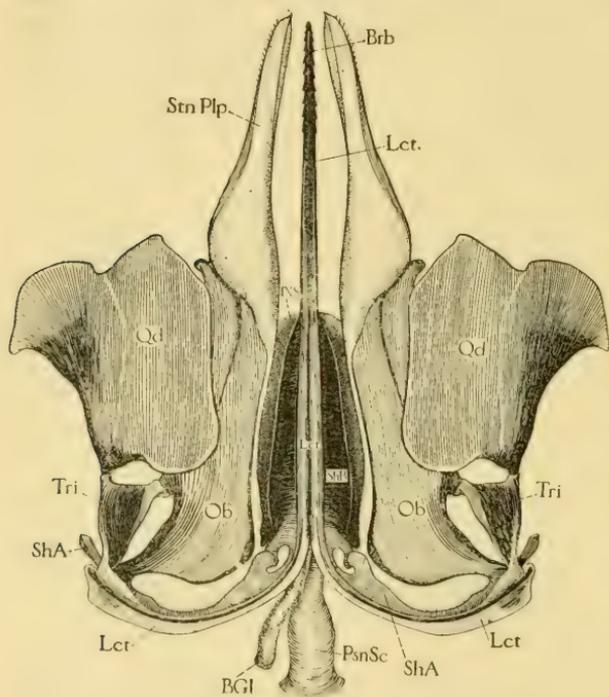


FIG. 37.—Ventral view of sting of worker and accessory parts, flattened out.

The presence of the two basal arms of the sheath might suggest that this part is to be regarded as made up of fused lateral halves. In this case we should have six appendicular elements, viz, the two lancets, the two halves of the sheath, and the two palpuslike organs. If now we turn back to figure 8, showing the component parts of the ovipositor of a longhorned grasshopper, we can not fail to be struck at

once by the great similarity between this organ and the sting of the bee (fig. 36). The first gonapophyses (*1G*) of the ovipositor are identical with the lancets (*Lct*) of the sting, and their sliding connection, by means of longitudinal tracks, with the second gonapophyses (*2G*) suggests at once that the latter represent the sheath of the sting (*ShS*). The identity is still more strongly suggested when we observe the small bulb (*ShB*) formed by the fused bases of these gonapophyses. The third gonapophyses (*3G*), which inclose between them the other parts of the ovipositor, represent the palpi of the sting (*StnPlp*). If, finally, we study the development of the parts of the sting we are convinced that this similarity between the sting and an ovipositor means something more than an accidental resemblance

between two different organs—in fact we can not doubt that the sting is simply an ovipositor which, being no longer needed for egg-laying purposes, has been modified into a poison-injecting apparatus. Zander (1899, 1900) and others have shown that the sting of the bee arises from six little abdominal processes of the larva, two of which arise on the eighth segment and four on the ninth. Those of the first pair develop into the lancets, those of the middle pair on the ninth segment fuse to form the sheath, while those of the outer pair become the palpi. The ovipositor, it will be remembered, develops in the lower insects from two pairs of processes arising on the eighth and ninth abdominal sterna, the second pair of which very soon splits into four processes. The simultaneous appearance of six on the bee larva is simply an example of the hurrying process or acceleration that the embryos and young of most higher forms exhibit in their development.

It is only the higher members of the Hymenoptera, such as the wasps and the bees and their close relatives, that possess a true sting. The females of the lower members have ovipositors which closely resemble those of such insects as the katydids, crickets, and cicadas, but which, at the same time, are unquestionably the same as the sting of the stinging Hymenoptera. It is said that the queen bee makes use of her sting in placing her eggs in the cells, but both the wasps and the bees deposit their eggs in cells or cavities that are large enough to admit the entire abdomen, and so they have but little use for an egg-placing instrument. But the females of the katydids and related forms like *Conocephalus* (fig. 8) use their ovipositors for making a slit in the bark of a twig and for pushing their eggs into this cavity. The cicada and the sawfly do the same thing, while the parasitic Hymenoptera often have extremely long and slender piercing ovipositors for inserting their eggs into the living bodies of other insects.

An examination of the sting in place within the sting chamber, as shown by figure 41, will suggest what the accessory plates represent in other less modified insects. It has already been explained that the last external segment of the female abdomen (fig. 32, VII) is the seventh. Within the dorsal part of the sting chamber is a slight suggestion of the eighth tergum (fig. 41, VIII), which laterally is chitinized as a conspicuous plate bearing the last or eighth abdominal spiracle (*Sp*). The triangular plate (*Tri*), as Zander has shown by a study of its development, is a remnant of the eighth sternum, and the fact that it carries the lancet (*Lct*) shows that even in the adult this appendage belongs to the eighth segment. The quadrate plate (*Qd*), since it is overlapped by the spiracle plates of the eighth tergum, might appear to belong to the eighth sternum, but Zander has shown that, by its development, it is a part of the ninth tergum. In many other adult Hymenoptera, moreover, the quadrate plates are undoubtedly tergal,

for they are sometimes connected by a bridge behind the eighth tergum. The oblong plate (*Ob*) and its stalk represent the ninth sternum, and since it carries both the arm of the sheath (*Sh.1*) and the palpus (*StnPl*) it still maintains its original relationships to the gonapophyses. The membranous lobe arising from between the oblong plates and overlapping the bulb of the sting (figs. 36 and 37, *IXS*) must belong to the median part of the ninth sternum.

The tenth segment (fig. 41, *X*) consists of a short, thick tube having the anus (*An*) at its tip. It takes no part in the formation of the sting, but is entirely inclosed in the dorsal part of the sting chamber beneath the seventh tergum.

In the accessory plates of the bee's sting we have a most excellent illustration of how the parts of a segment may become modified to meet the requirements of a special function, and also an example of how nature is ever reluctant to create any new organ, preferring rather to make over some already existing structure into something that will serve a new purpose.

There are four glands connected with the sting, two of which are known to secrete the poison, which is forced through the canal between the sheath and the lancets and ejected into the wound made by the latter. It is this poison that causes the pain and inflammation in the wound from a bee's sting, which would never result from a mere puncture. The other two glands have been described as "lubricating glands," being supposed to secrete a liquid which keeps the parts of the sting mechanism free from friction. They lie within the body cavity, one on each side against the upper edge of the quadrate plate, where they are easily seen in an extracted sting, each being a small oblong or ovate whitish cellular mass. Transverse microtome sections through this region show that each of these glands opens into a pouch of the membrane between the quadrate plate and the spiracle-bearing plate of the eighth tergum. Each gland cell communicates with this pouch by a delicate individual duct. The secretion of the glands is thus poured upon the outer surfaces of the quadrate plates and might easily run down upon the bases of the lancets and the arms of the sheath, but, for all that, the notion that it is lubricative in function is probably entirely conjectural.

The large, conspicuous poison sac (figs. 36, 37, 41, and 57, *PsnSc*) that opens by a narrow neck into the anterior end of the bulb of the sting is well known to everyone at all acquainted with bees. The poison which it contains comes from the delicate branched thread attached to its anterior end (fig. 57), a minute tube which, if traced forward a short distance from the sac, will be seen to divide into two branches, which are long and much coiled and convoluted, each terminating finally in a small oval enlargement (*AGI*). These terminal swellings are generally regarded as the true glands and the tubes

(*AGD*) as their ducts, but the epithelium of the tubes appears to be of a secretory nature also, and, if it is not, it is hard to see any reason for their great length. It also does not look probable that the two little end bodies could form all the poison that fills the comparatively enormous sac.

The walls of the poison sac (fig. 38) are lined by a thick coat of laminated chitin (*Int*) thrown into numerous high folds. In the neck part of the sac the folds are arranged very regularly in a transverse direction and form interrupted chitinous rings, holding the neck rigidly open. The epithelium (*Epth*) contains nuclei (*Nu*), but the cell boundaries are very slightly marked. There is a distinct basement membrane (*BM*), forming a tunica propria externally, but there are no muscle fibers of any sort present except a few which are inserted upon the sac from some of the surrounding organs and which apparently act as suspensoria.

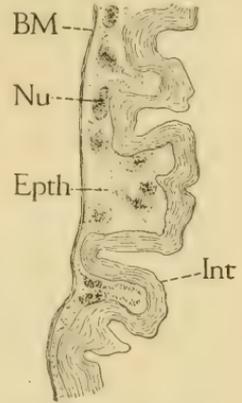


FIG. 38.—Section of small piece of wall of poison sac of sting.

The poison found in the sac has an acid reaction and is supposed to consist principally of formic acid. Hence its gland is known as the *acid gland* (*AGl*) of the sting.

The other sting gland is a short, very inconspicuous, and slightly convoluted whitish tube (figs. 36, 37, 41, and 57, *BGl*) opening directly into the base of the bulb ventrad to the opening of the poison sac. Its walls consist of a thick epithelium of distinct cells (fig. 39, *Epth*) lined with a thin chitinous intima (*Int*) and surrounded by a distinct basement membrane (*BM*), but, as in the other gland, there are no muscles present. The secretion of this gland is said to be alkaline and the gland is therefore known as the *alkaline gland* (*BGl*) of the sting.

Experiments made by Carlet (1890) show that it is only the mixture of the products from the two poison glands that is fully effective in stinging properties. Carlet's experiments were made upon houseflies and blowflies. He shows (1) that flies stung by a bee die almost instantly. (2) flies artificially inoculated with the secre-

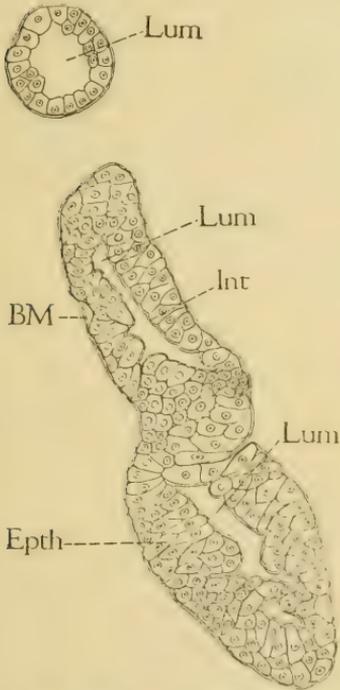


FIG. 39.—Sections of alkaline gland of sting.

tion of either gland alone do not die for a long time even in spite of the necessary mutilation, while (3) successive inoculations of the same fly first from one gland and then from the other produce death in a much shorter time than when inoculated from one gland alone—presumably as soon as the two liquids mix within the body.

The two secretions, one acid and the other alkaline, are poured together into the base of the sting bulb and mix within the cavity of the latter. The resulting poison is then driven through the channel in the shaft to near the tip of the latter, where it makes its exit into the wound. Since the large poison sac is not muscular, the poison is not forced through the sting by it, as is often supposed. A glance at figure 57 (see p. 135) will show that the accessory plates of the sting support several very compact sets of muscles on their inner faces. These muscles so act during the process of stinging that the triangular plates (figs. 36 and 37, *Tri*) turn upon their hinge-joint articulations with the oblong plates (*Ob*). By this motion of the triangular plates the attached lancets (*Lct*) are moved back and forth along the tracks on the lower edges of the sheath and its arms (*ShA*). Each of these tracks consists of a ridge with a constricted base which dovetails into a correspondingly shaped groove on the dorsal surface of the lancet. This structure, as seen in cross sections through the shaft and bulb of the sting, is shown by fig. 40 A, B, and C. The lancets are thus held firmly in place, while at the same time they may slide back and forth with perfect freedom. The figures show also that all three parts of the sting are hollow, each containing a prolongation (*bc*) of the body cavity. Between them, however, is inclosed another cavity through which the poison flows. This is the *poison canal* (*PsnC*). In the bulb (fig. 40 C) the body cavity is reduced to a narrow cleft (*bc*) by the great size of the invaginated poison canal (*PsnC*).

It will now be most convenient to describe the apparatus by means of which the poison is ejected from the sting. As before pointed out, the large poison sac can have no functions in this connection because its walls are entirely devoid of muscle fibers. On the other hand, there is an actual pumping apparatus situated within the bulb. This consists of two pouchlike lobes, having their concavities directed posteriorly, attached to the upper edges of the lancets (fig. 40 D and G, *Vlv*) on the anterior ends of the parts of the latter which slide within the lower edges of the bulb chamber. The lobes lie side by side within the bulb (fig. 40 C, *Vlv*), when the lancets are in the same position, and each has an accessory lamina against its own inner wall. When the lancets are pushed backward the walls of the lobes flare apart against the poison contained in the bulb and drive this liquid before them into the channel of the shaft, while at the same time they suck more poison into the front of the bulb from the glands. When,

or the other hand, the lancets are retracted the pouches collapse so that they may be drawn back through the poison-filled bulb without resistance, but they are ready for action again as soon as the movement of the lancets is reversed. The whole apparatus thus constitutes an actual force pump in which the lobes on the lancets alternately act as a piston and as valves. The lancets need not work together; in fact, they more often perhaps work alternately, the lobes being of such a size as to be effective either when acting together or separately.

The reader acquainted with other works on the anatomy of the bee, such as those of Cheshire (1886), Cook (1904), Cowan (1904), and Arnhart (1906), will see often repeated the statement that the poison leaves the sting both by a ventral opening between the lancets near their tips and by several lateral pores near the ends of the lancets opening from the poison canal upon

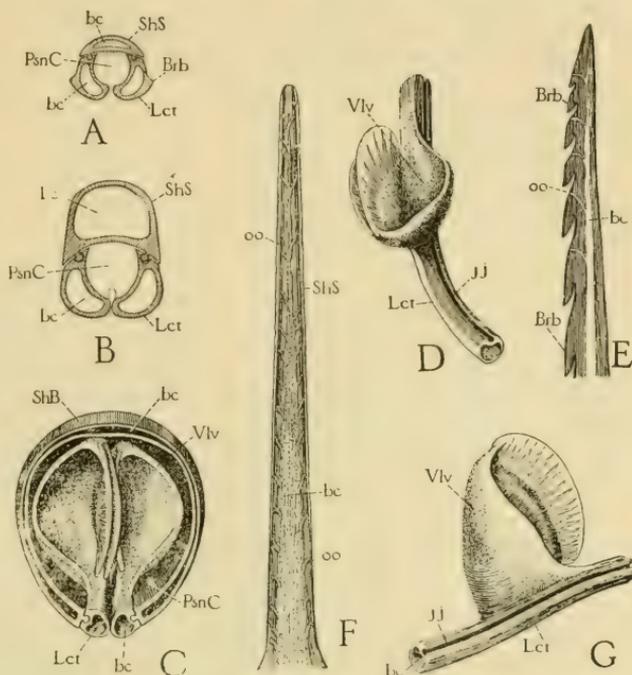


FIG. 40.—Details of sting of worker: A, section through tip of sting showing lancets (*Lct*) and shaft of sheath (*ShS*) surrounding central poison canal (*PsnC*), and each containing a prolongation of the body-cavity (*bc*); B, section of same near base of bulb; C, section of sting through basal bulb, showing poison canal as large invaginated cavity (*PsnC*) in bulb of sheath (*ShB*) containing the two valves (*Vlv*) of lancets (*Lct*); D, part of left lancet carrying valve (*Vlv*), dorsal view; E, tip of lancet showing pores opening on bases of barbs (*oo*) coming from body-cavity (*bc*) of lancet—not from poison canal; F, dorsal view of shaft of sheath showing lateral series of pores (*oo*) from prolongation of body-cavity (*bc*); G, lateral view of left valve and part of lancet.

the bases of the barbs. The writer, however, has never been able to observe the exit of the poison from any such lateral pores, while, on the other hand, it is very easy to watch it exude from between the lancets on the ventral side of the sting near the tip. If an excited bee is held beneath a microscope and the tip of the sting observed, the poison will be seen to accumulate in little drops near the tip on the ventral side. If, also, the bulb of an extracted sting

be squeezed gently between a pair of forceps the poison will be seen to emerge in the same way. In fact, it can be actually squirted out by a sudden compression when the bulb is well filled with poison, but there is never any evidence of its escape through the sides.

An examination of the end of each lancet does reveal a number of oblique pores (fig. 40 E, *oo*) which have been figured by other writers, and they certainly open on the bases of the barbs as described, but their inner ends apparently communicate with the body cavity (*bc*) of the lancet instead of passing clear through the lancet and opening into the poison canal. Furthermore, a paired series of exactly similar pores extends the entire length of the shaft of the sheath (fig. 40 F, *oo*), opening on its dorsal surface from the body cavity (*bc*). No one could possibly claim that the poison emerges

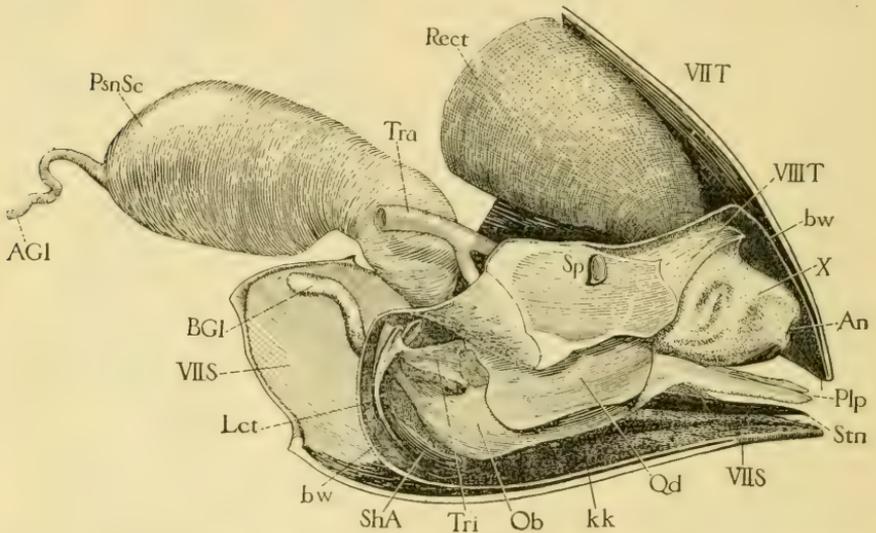


FIG. 41.—Tip of abdomen of worker with left side removed, showing right halves of seventh tergum (VIIIT) and sternum (VIIS), containing the sting chamber (*kk*) cut open along the line *bw*, exposing the eighth tergum (VIII T), the rudimentary tenth segment (*X*) carrying the anus (*An*), and the sting and accessory parts shown by fig. 36.

also through these pores, which, very curiously, do not appear to have been described before, although they are even more conspicuous as well as more numerous than those of the lancets. The writer has not been successful in preparing histological sections of the sting which show these pores, but they probably constitute the ducts of some kind of subcuticular glands.

A cross-section through the sting a short distance in front of its tip shows that the lancets are here separated by a narrow cleft (fig. 40 A), while elsewhere (B and C) they are contiguous. This cleft between the ends of the lancets forms the exit for the poison from the channel.

The sting of the queen is much longer than that of the worker and is more solidly attached within the sting chamber. Its shaft is

strongly decurved beyond the bulb. The lancets have fewer and smaller barbs than those of the worker, but the two poison glands are well developed (fig. 57, *1Gl* and *BGl*), while the poison sac (*PsnSc*) is especially large.

A number of minute unicellular glands open upon the intersegmental membrane between the seventh and eighth terga of the abdomen. These are sometimes called the glands of Nassanoff, after their discoverer. Nassanoff suggested that they are sweat glands, while Zoubareff thought that they form small drops of liquid said to be excreted by bees during flight derived from the excess of water in the newly collected nectar. Their function, however, has been much more carefully investigated by Sladen (1902), who found that they are scent organs producing a strong odor even when the part of the back to which they are attached is removed from the rest of the abdomen. He furthermore identified this smell as the same that bees give off when a lot of them are shaken from a frame on the ground close to the front of the hive. Under such circumstances also, as in natural swarming or during the first flights in the spring or after a period of bad weather, bees are well known to produce a peculiar sound called the "joyful hum." Sladen observed that this was produced, in the case of bees shaken before the hive, by those individuals who first found the hive entrance, then by those next to them, until very soon all the others were informed of the location of the entrance and proceeded to make their way in. Also, when a swarm loses sight of its queen, those that find her first set up this "joyful hum" and immediately the rest of the swarm is attracted to the spot. In the springtime the young bees seem to be guided in their flights by this same hum of the old ones. Sladen, however, observing the odor emitted at the same time, thinks that this and not the sound is the real means of information, the sound being simply incidental to the special movement of the wings produced for the purpose of blowing the odor away from the body. He argues that we have no evidence of an acute sense of hearing in bees, while it is well known that they possess a delicate sense of smell located on the antennæ. This argument certainly seems reasonable, and we may at least accept Sladen's theory as the best explanation of the function of the glands of Nassanoff.

VI. THE ALIMENTARY CANAL AND ITS GLANDS.

1. THE GENERAL PHYSIOLOGY OF DIGESTION, ASSIMILATION, AND EXCRETION.

It is no exaggeration to say that eating is the most important thing that any animal does and that its alimentary canal is the most important organ it possesses. The entire system suffers when there is a deficiency in the food supply or an impairment in the digestive apparatus. Every other function is either subservient to or dependent upon that which furnishes nourishment to the cells. The senses of sight, smell, and taste are all more or less concerned in the acquisition of food. The muscular system enables the animal to hunt for it, to dig for it, to climb for it, or to chase living prey either on the ground, in the water, or in the air, and to kill, tear, and chew it when obtained. The blood is the servant of the stomach, for its entire function in insects is to carry the products of digestion to the body cells. The heart furnishes the motor power of the blood. The respiratory function is accessory to that of digestion, inasmuch as it furnishes the oxygen which unites with the waste materials ejected from the cells and renders them capable of being removed from the blood. This removal is accomplished partly by the respiratory system itself and partly by special excretory organs. Thus we see that the sense organs and the muscular system are the agents that cooperate in obtaining the raw food, the digestive tract is the kitchen of the body in which the food is prepared for use, the blood is the waiter that distributes it, while the respiratory and excretory systems are the refuse gatherers that remove waste products. The nervous system holds the controlling power over all these organs. It regulates them in the performance of their duties and coordinates their actions so that they all work together. It makes a unified organism out of what would otherwise be simply a complex mass of variously specialized cells.

The reproductive function alone contributes nothing to the individual. In fact, the production of spermatozoa by the male and of eggs by the female and the nourishing of the embryo and the young create a demand upon all the other organs for material which is separated from the individual that produces it. But this is what the organism exists for; this is its reason for being. At least this is what it amounts to in the case of the individual, though from a wider philosophical standpoint the real truth is probably just the reverse, viz, any species exists because its individuals reproduce themselves.

The writer has already made frequent use of the word "cell," assuming that the reader is familiar with the meaning of this word as used in anatomy and physiology. The entire body of an animal or plant is made up of *cells* or their products. The word, however, is misleading, for a cell is not a small sac or empty space, as was at

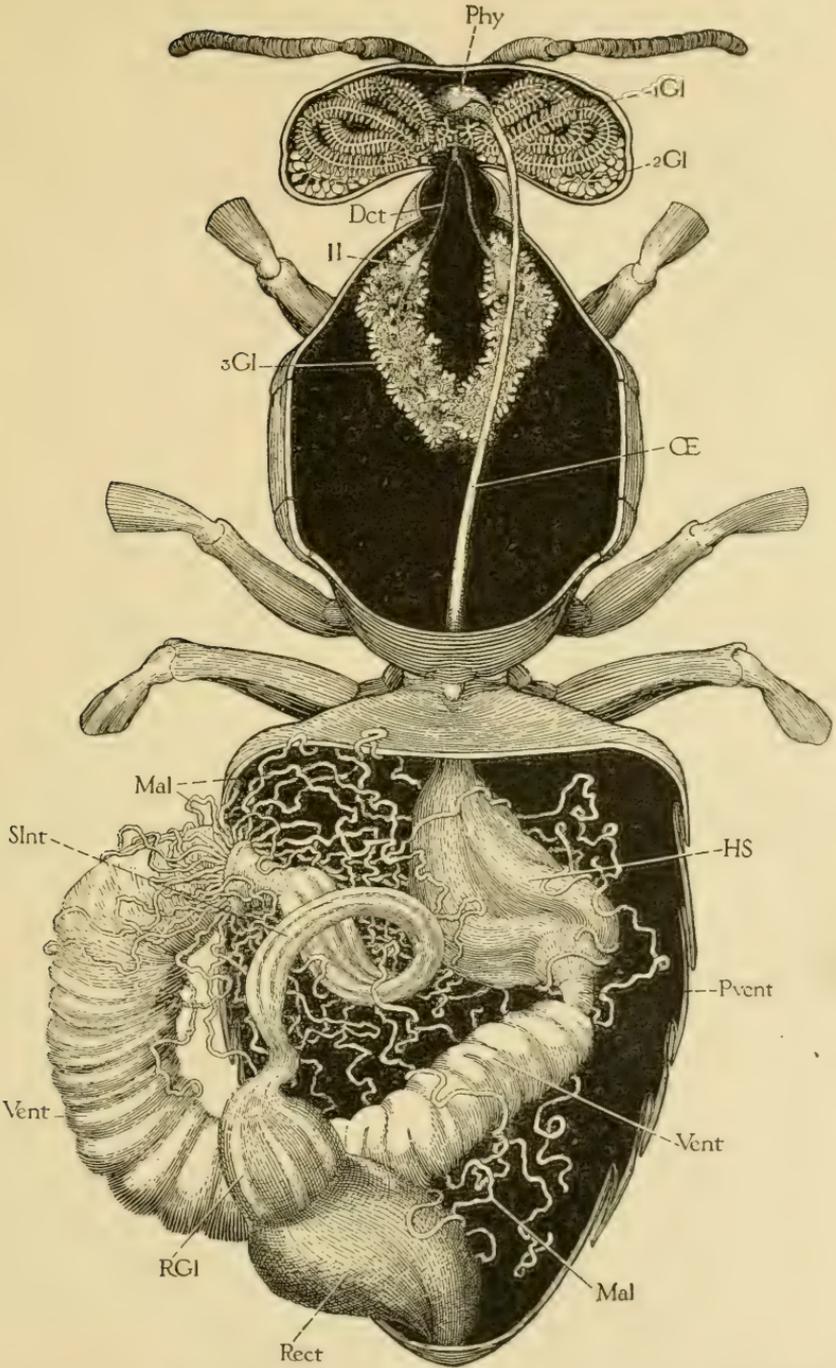


FIG. 42.—Alimentary canal of worker (*Phy-Rect*), together with pharyngeal glands (*1Gl*), and salivary glands of head (*2Gl*) and of thorax (*3Gl*), as seen by cutting body open from above and pulling the ventriculus (*Vent*) out to left.

first supposed from the study of plants, but is a little protoplasmic body or corpuscle, visible only under the microscope, surrounded by a membranous cell wall and containing a small internal body called the nucleus. The different cells of the body are specialized in groups to do some one particular thing—the salivary cells secrete saliva, the muscle cells contract, the excretory cells pick out waste substances from the blood, and so on. But this specialization does not signify that each cell does not perform its own vital processes in addition to its speciality. The fact that it remains alive and works means that the complex chemical components of its body substance or *protoplasm* are constantly being reduced to simpler compounds which are expelled, while new protoplasm is built up from the supply of food material brought by the blood. This double process of destruction and reconstruction is known as *metabolism*, while its two phases, the breaking-down process and the building-up process, are known as *katabolism* and *anabolism*, respectively.

Now, while all the cells of the body must have nourishment, none of them, except those of the alimentary canal, is capable of utilizing the raw food materials that an animal obtains in a state of nature. These materials must therefore be changed into some other form in order that they may be *assimilated* by the cells. This change is called *digestion*.

The single cell composing the body of a Protozoan, living free in nature, digests its own food and then assimilates the products of its own digestion. But, of the cells constituting the body of any multicellular animal, only those of the alimentary canal are capable of digesting *raw* foodstuffs, and, moreover, as digestion is the speciality of these cells, they have also to digest the food for all the other cells of the body.

The two most important changes that must be brought about in the natural food by digestion are those which make it soluble in the blood and which render it capable of passing through animal tissues. In the first place, the food must diffuse through the walls of the alimentary canal as a liquid which mixes with the blood, for there are no pores or openings of any sort from the alimentary canal into the body cavity; and in the second place, it must pass through the walls of the cells themselves. The digestive changes result chiefly in a breaking down of the complex molecules of the raw food materials into more simple chemical substances. These are taken up by the cells and reconstructed into complex protoplasmic molecules which can not escape through the cell membrane until they are again broken down into simpler forms.

The waste products of the cells consist principally of carbon, hydrogen, and nitrogen. These are converted by the oxygen supplied by the respiratory system into carbon dioxide, water, and compounds of

urea. The first, being a gas, mixes with the air in the tracheal tubes and so reaches the exterior during exhalation. Much of the water is also given off through the tracheal system in the form of vapor which exhales from the spiracles, but, since insects are covered by their hard chitinous shell, it is probable that they do not "sweat." The compounds of urea, and probably also some water, are separated from the blood by the excretory glands, called Malpighian tubules in insects, which empty their products back into the alimentary canal, whence they are discharged with the feces from the intestine.

Digestion is brought about by substances called *enzymes* which are contained in the various liquids mixed with the food in the alimentary canal. These liquids are secreted by the salivary glands and by the cellular walls of the stomach.

2. THE SALIVARY GLANDS.

The opening of the salivary duct on the base of the proboscis has already been described (see pp. 49-51). The true salivary glands, or those corresponding with the salivary glands of other insects, are arranged in two pairs, one situated within the head (figs. 19 and 42, *2Gl*) and the other within the thorax (fig. 42, *3Gl*). The four ducts unite into one median tube, which enters the base of the labium (fig. 19, *SalD*) and opens upon the upper surface of the ligula (fig. 15 F, and fig. 16, *SalDO*). The large and conspicuous glands lying within the anterior and upper parts of the head and opening into the pharynx will be described later in connection with this organ. They are special pharyngeal glands in no way homologous with the salivary glands of other insects, and are by many supposed to secrete the brood food instead of a digestive liquid like saliva.

The salivary glands of the head (*System No. 2* of Cheshire, *post-cerebral glands* of Bordas) lie against the posterior walls of the cranium. In the worker each consists of a loosely arranged mass of pear-shaped follicles or acini whose individual ducts unite irregularly with one another and eventually form a common duct on each side (figs. 19, 42, and 43 F, *2Gl*). Their two ducts unite with the median duct from the thoracic glands just before the bases of the mesocephalic pillars (fig. 19). In the drone these glands have a quite different appearance from those of the female, each consisting of a compact mass of very small follicles connected by minute ducts and flattened against the posterior walls of the head (fig. 43 B and C, *2Gl*). A large lobe of this gland in the drone extends forward on each side against the face, between the compound eye and the clypeus (fig. 10 C, *2Gl*), thus occupying the position of the large mandibular gland in the worker (A, *1MdGl*) and in the queen (B, *1MdGl*). There is also a prominent triangular mass of glandular cells in the drone situated just above the ocelli (fig. 10 C, *2Gl*) which has been

described by Bordas (1895) as a separate gland opening by two ducts into the œsophagus just behind the pharynx. The writer, however, has been utterly unable to discover any such ducts, though two suspensorial ligaments of the anterior end of the œsophagus are attached to the wall of the head at the posterior ends of these glands (fig. 11 B, *g*) and might easily be mistaken for ducts. These "post-ocellar glands" of Bordas, moreover, appear to be simply detached lobes of the postcerebral glands. They are prominent also in the queen (fig. 10 B, *2Gl*) and are represented by a few follicles in the worker.

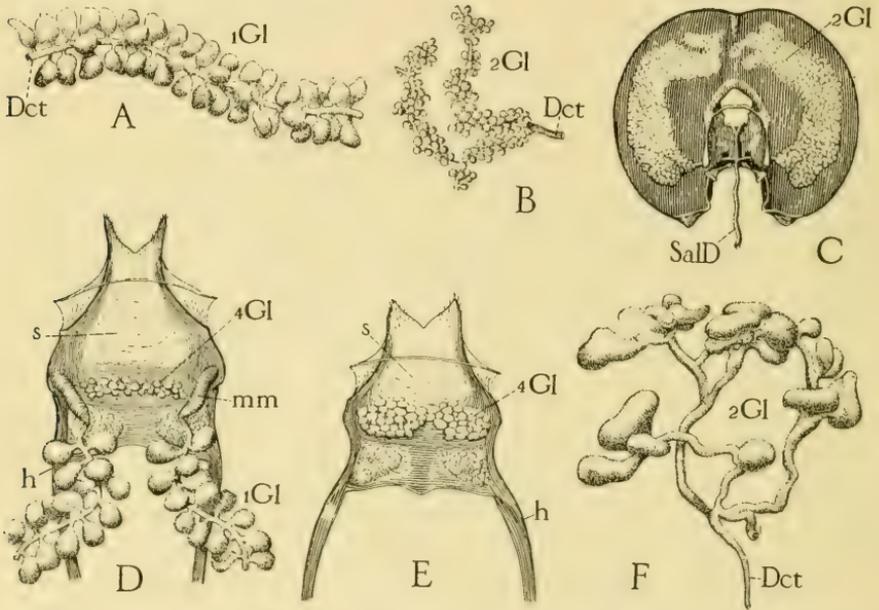


FIG. 43.—A, small piece of large lateral pharyngeal glands in head of worker; B, piece of postcerebral salivary glands in head of drone; C, postcerebral glands (*2Gl*) in normal position against posterior wall of head in drone; D, pharyngeal plate (*s*) of worker, ventral view, showing bases of lateral pharyngeal glands (*1Gl*) and their receptacula (*mm*), and median ventral pharyngeal gland (*4Gl*); E, corresponding view of pharyngeal plate of drone, showing entire absence of lateral pharyngeal glands, and greater development of small median glands (*4Gl*); F, part of postcerebral gland of worker.

Bordas describes the follicles of the postcerebral glands in the worker as hollow sacs, each having a large lumen lined with a chitinous intima. Their secretion, he says, is a thin viscid liquid, pale yellow in color and having a slightly alkaline reaction. According to Schiemenz (1883) each gland is developed as an outgrowth from the common duct of the thoracic glands.

The salivary glands of the thorax in the bee (*System No. 3* of Cheshire, *thoracic salivary glands* of Bordas) are the ones that correspond with the ordinary salivary glands of other insects. They are described by Schiemenz (1883) as being formed inside of the

outer covering (tunica propria) of the first part of the larval silk glands. But it is of common occurrence in insects that the salivary glands are temporarily specialized as silk-producing organs in the larva. In the adult worker these glands lie in the ventral part of the anterior half of the thorax (fig. 42, 377). The two are widely separated anteriorly, but their posterior ends are contiguous. Each consists of a mass of small, many-branched, glandular tubes opening into several collecting ducts which empty into a sac near the anterior end of the gland (*II*). From each of these reservoirs, then, a duct (*Dct*) runs forward and fuses with the one from the opposite side just within the foramen magnum of the head. The common duct thus formed turns downward within the head, receiving the two ducts of the postcerebral salivary glands and then enters the base of the mentum (figs. 19 and 43 C, *SalD*), to open as already described on the upper side of the ligula at the root of the glossa and between the bases of the two paraglossæ (fig. 15 F and 16, *SalDO*). The secretion of the thoracic glands is said also to be weakly alkaline. Therefore the entire salivary fluid poured out upon the labium is alkaline, and it must be designed to act especially upon the food taken through the proboscis. This action, furthermore, on account of the location of the salivary opening, may take place before the food enters the mouth.

The food of the bee consists normally of pollen, nectar, and honey. The first is eaten entirely with the mandibles, while the other two are taken through the proboscis. The pollen is to the diet of the bee what meat is to ours; that is to say, it contains the *proteid* or nitrogen-containing ingredient of the food which is necessary to the support of any animal, and also substances comparable with fat, called in general *hydrocarbons*. The nectar and honey consist principally of grape sugar, fruit sugar, and cane sugar, which belong to the class of chemical substances known as *carbohydrates*. Now, all of these foodstuffs, except the grape and fruit sugars, have to be changed chemically by the digestive process before they can be absorbed into the blood. The pollen, which contains the proteids and hydrocarbons of the food, is taken directly into the mouth by means of the mandibles and apparently is not digested until it reaches the small intestine, and therefore it would seem that it is the cane sugar which must be affected by the saliva. The change, or inversion, as it is called, of cane sugar, which has a very large molecule ($C_{12}H_{22}O_{11}$), consists of its reduction to grape and fruit sugars which have smaller molecules ($C_6H_{12}O_6$). Starch ($C_6H_{10}O_5$) must also be reduced to simpler and more soluble compounds before it is capable of absorption. Its inversion is effected in us partly by the saliva, but starch appears to form a very inconsiderable element in the bee's diet.

3. THE ALIMENTARY CANAL.

The alimentary canal is a tube which extends through the entire length of the body and, on account of being more or less coiled, it is generally considerably longer than the length of the body in insects. It has no openings of any sort into the body cavity. The internal organs are packed closely about it, and the interstices are filled with the blood, there being no special arteries or veins in insects. The amount of space occupied by the alimentary canal varies according to the amount of food it contains, and for this reason it seldom looks exactly alike in any two individuals examined.

The part of the canal immediately following the mouth forms an enlargement (fig. 42, *Phy*) called the *pharynx*. Succeeding this is a slender tube which leaves the head by the foramen magnum above the small transverse tentorial bar and traverses the entire length of the thorax. This is the *œsophagus* (*Æ*). In the anterior part of the abdomen the *œsophagus* expands into a large thin-walled sac which is ordinarily called the *crop* or *ingluvies*, but which, in the bee, is known as the *honey stomach* (*HSt*). Behind this is a short, narrow, necklike division, with rigid walls constituting the *pro-ventriculus* (*Prent*). Then comes a large U-shaped part, with thick, spongy-looking walls containing numerous annular constrictions. This is the *ventriculus* (*Vent*), or stomach, of the bee, frequently referred to as the "chyle stomach." Following the ventriculus is a short, narrow, coiled *small intestine* (*SInt*) having a circle of about one hundred long, greatly coiled, blind, threadlike tubes opening into its anterior end. These latter are called the *Malpighian tubules* (*Mal*). Functionally they do not belong to the digestive tract, since they are excretory organs, corresponding with the nephridia of other invertebrates and with the kidneys of vertebrates. Following the small intestine is the *large intestine*, or *rectum* (*Rect*), which is often distended by its contents into a great sac occupying a large part of the abdominal cavity. Six whitish bands on its anterior end are called the *rectal glands* (*RGl*). The rectum opens to the exterior through the anus, which is situated, as already described, at the end of the rudimentary tenth or last segment of the abdomen (fig. 41, *An*).

After this brief general survey of the parts of the alimentary canal, we shall proceed with the description of each in detail, and at the same time give what is known of the rôle each plays in the process of digestion. What is known, however, about digestion in the bee, or in any insect, for that matter, really amounts to nothing, but the views of various writers on the subject must be discussed briefly, in order to show how little has actually been demonstrated.

The *pharynx* (figs. 11 B, 19, and 42, *Phy*) lies in the anterior part of the head close behind the clypeus, extending from the mouth

dorsally to above the antennæ, where it turns posteriorly and contracts into the much narrower œsophagus (\mathcal{E}). Attached to its walls are numerous suspensorial muscles, whose contraction must expand the pharyngeal cavity, while the latter may be contracted by the sheet of muscles surrounding its walls. In this way the pharynx is undoubtedly able to perform a sucking action, by means of which the liquid foods are taken into the mouth. Its lateral walls are strengthened by two long, chitinous rods (figs. 11 B and 19, h), which arise from a median anterior plate in its floor (fig. 19, s). The anterior end of this plate is prolonged into two free, tapering lobes which hang down over the lower rim of the mouth. The plate, in the worker, and the bases of the rods are shown in ventral view, removed from the pharyngeal wall, in figure 43 D. Near where the rods join the plate are two long, chitinous pockets (mm), opening above, which receive the ducts of the two large glands ($1Gl$) lying within the anterior part of the head. Between these two pockets is a transverse row of cells ($1/2Gl$), which have been described by Bordas (1895) as the "sublingual glands," but this name is not appropriate in insects, for, while the gland in question may be suggestive of the sublingual salivary gland of vertebrates, it does not lie beneath the tongue or lingua of the bee. Although the pharyngeal plate lies upon the floor of the true mouth, it is not, as already explained (p. 44), the equivalent of what is properly called the tongue, lingua, or hypopharynx in other insects—this organ being absent in most Hymenoptera. The only suggestion the writer can make, however, is to call this group of cells the *ventral* or *median ventral pharyngeal gland* in distinction to the large lateral glands. A comparative view of the pharyngeal plate and its accessory parts in the drone is given in figure 43 E. The plate itself (s) is shorter than in the worker, and its anterior lobes are smaller. The lateral glands and their receptacula are entirely absent, but the median glands ($1/2Gl$) are much larger than those of the worker. Bordas says that each acinus of the latter glands in both the worker and the drone is provided with a fine, sinuous canaliculus, and that these tiny ducts open separately in two bundles on the lateral parts of the pharyngeal plate. The lateral glands are present in the queen, but are very small and rudimentary.

Especial interest attaches to the large lateral pharyngeal glands of the worker (*System No. 1* of Cheshire, the *supracerebral glands* of Bordas), because they are regarded by many as the source of the brood food and the so-called "royal jelly," which is fed to the larvæ and to the adult queens and drones by the workers. Each consists of a long coiled string of small ovate follicles attached to one median duct (fig. 43 A) and the two are intricately packed into the anterior and upper parts of the head (figs. 10 A, 19, and 42, $1Gl$). Each

acinus consists of a solid mass of several small cells, which are penetrated by a large number of fine, chitinous ducts, arising in the neck of the acinus from the common duct of the gland. These follicular ducts can be very clearly shown by treating a part of the gland with weak caustic potash, which dissolves the protoplasm of the cells and brings out the bunch of ductules very clearly.

The fact that these glands are entirely absent in the drone and at best rudimentary in the queen shows that they must in some way be connected with the special functions of the worker. Schiemenz (1883) and Cheshire (1886) have shown that their development in the different species of bees is in proportion to the social specialization. They vary from a group of cells opening by separate ducts upon the pharyngeal plate to the highly developed condition they present in the honey bee. The writer questions, however, whether these authors did not mistake the median pharyngeal glands of these lower genera of bees for rudimentary representatives of the lateral glands. Bordas states that the former occur in all Hymenoptera, but Schiemenz and Cheshire did not seem to recognize them. The bumblebees (*Bombus*) have them almost as well developed as the honey bee (*Apis*), especially the large females. In the genus *Psithyrus* they are similar to those of *Bombus* but are smaller, while in such genera as *Andrena* and *Anthophora* they are rudimentary or consist of a few scattered cells. Both Schiemenz and Cheshire have thus argued strongly that these glands of the pharynx are the organs that produce the brood food. On the other hand, Schönfeld (1886) has made an equally strong plea in favor of the ventriculus as the producer of this important material. He believes that the brood food, especially royal jelly, is regurgitated chyle. Both Schönfeld and Cook (1904) fed bees in a hive some honey containing powdered charcoal and later found this in the brood food in the comb cells, thus apparently confirming its ventricular origin. However, the charcoal that got into the cells might have come from the mouth, the oesophagus, or the honey stomach. It, of course, could not have gone through the stomach walls and entered the pharyngeal glands, as proved by Dr. J. A. Nelson, of this Bureau, from microtome sections of bees fed on lampblack. The arguments, then, in favor of the stomach and the pharyngeal glands seem equally strong, and perhaps the truth is, as occurs in so many such cases, that both sides are right—that the brood food is a mixture of chyle from the stomach and of secretion from the pharyngeal glands.

Arnhart (1906) seems to adopt the position that the brood food is chyle which has been acidified by the addition of an acid from the glands. He states that the acid reaction of the royal jelly is due to the presence of three-fourths of 1 per cent of tartaric acid. The contents of the ventriculus, on the other hand, and for that matter

of all the parts of the alimentary canal, are alkaline. Hence, it seems very logical to suppose that if the brood food comes from the stomach, its acid constituent is furnished by the glands in the head. But the difference between the brood food found in the cells and the contents of the ventriculus is so great that it would seem as if a very substantial addition of something more than a mere preservative acid must be made to the latter.

The brood food given to the queen larvæ, known as royal jelly, is a gummy paste of a milky-white color when fresh, but when taken out of the cell it soon acquires a darker tone with a yellowish tint. Under the microscope it appears to be a homogeneous, very minutely granular mass. It is very acrid and pungent to the taste, and must be strongly acid. Samples examined by the writer taken from cells containing queen larvæ two and four days old contained a number of fresh undigested pollen grains but no bits of hairs such as occur in the stomach.

The possible ventricular origin of a part of the brood food and its regurgitation will be further discussed when we treat of the stomach (page 98). The writer does not advocate any personal view regarding the origin of this larval food—the fact is, there is not enough known about it to enable one to formulate any opinion worth while. We know only that the whitish paste comes out of the mouths of the workers, but we *know* nothing of where it is made or of how it is made. Hence we can but await the evidence of further investigation.

The brood food is fed to the larvæ by the workers and is produced in greatest abundance by the younger individuals. The larvæ of the queens are said to receive nothing but pure royal jelly throughout their entire developmental period, while the larvæ of the drones and the workers are given the pure product only during the first three days of their life. From the beginning of the fourth day on, honey is said to be mixed with the diet of the drones and workers and, in the case of the former, undigested pollen also. Moreover, the adult queens and the drones receive a certain amount of prepared food throughout their lives; if they do not get it they become weak. While they can feed themselves with honey they apparently can not eat pollen, and consequently are not able to obtain the proteid element of diet unless fed this in a predigested condition by the workers. During egg-laying activity the queen especially demands this food, and by furnishing or withholding it the workers probably have the power of stimulating or inhibiting her production of eggs. Arnhart (1906) says that the workers feed it to weak or starved members of their own class, the material being accumulated upon the upper surface of the mentum of one bee whence it is sucked up through the proboscis by the other. All of these statements, however, concerning the feeding of the brood and the differences in the diet need to be verified. They

are based chiefly on the work of Planta, published in 1888. Cheshire (1886) states that the stomachs of queens contain a substance which is "microscopically indistinguishable from the so-called royal jelly," scarcely a pollen grain being discoverable in it. If this is so, it would seem to prove that the queen is fed this substance by the worker, for the stomach of the latter is invariably filled with a dark-brown slime

containing a varying amount of pollen and in no way resembling royal jelly. Cheshire further says that before impregnation the stomachs of the queens always contain pollen, the royal jelly being found in them two or three days after impregnation, when all traces of pollen have disappeared.

The narrow œsophagus (fig. 42, *Æ*) is a simple tube with a thick chitinous lining and muscular walls. The epithelium (fig. 45) is very rudimentary, its cell boundaries being lost and its nuclei (*Nu*) appearing as if imbedded in the lower layers of the thick transparent

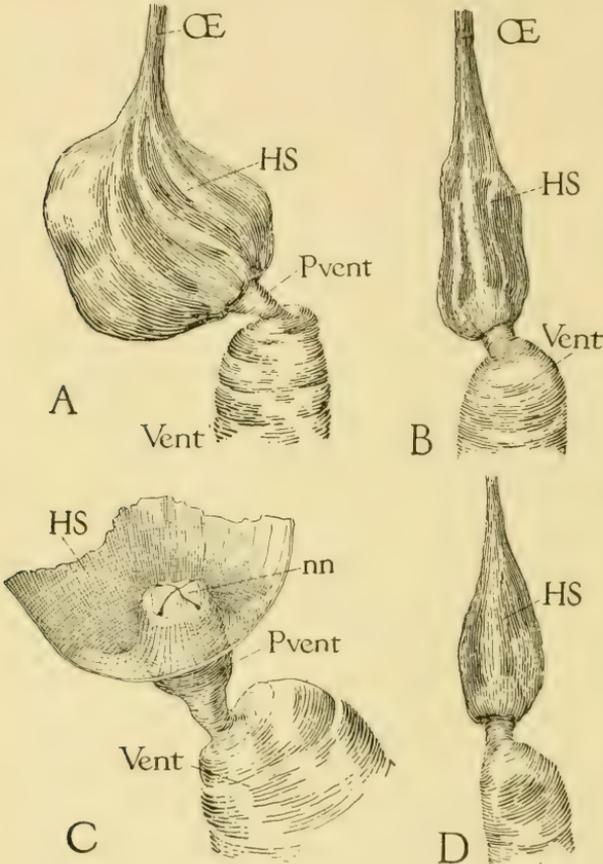


FIG. 44.—A, honey stomach (*HS*) of worker with posterior end of œsophagus (*Æ*), proventriculus (*Pvent*), and anterior end of ventriculus (*Vent*); B, same of queen; C, honey stomach (*HS*) of worker mostly cut away exposing the stomach-mouth (*nn*) of proventriculus (*Pvent*) leading into ventriculus (*Vent*); D, honey stomach of drone.

intima (*Int*). The muscles are disposed in an outer layer of transverse fibers (*TMcI*) and an inner layer of longitudinal ones (*LMcI*).

The honey stomach (fig. 42, *HS*) is simply an enlargement of the posterior end of the œsophagus lying within the anterior part of the abdominal cavity. It is best developed in the worker (fig. 44 A), but is present also in the queen (B) and in the drone (D). The organ should perhaps have been named the nectar stomach, for its

principal function in the bee is to hold the nectar as it is collected from the flowers and to allow the worker to accumulate a considerable quantity of this liquid before going back to the hive. Hence, since the honey stomach is a sac with very distensible walls, its apparent size varies greatly. When empty it is a small flabby pouch, but when full it is an enormous balloon-shaped bag with thin tense walls. The histological structure of the honey stomach (fig. 45, *HS*) is exactly the same as that of the œsophagus. The numerous high folds into which its epithelium (*Epth*) is thrown permit the enormous expansion of which the sac is capable. When a worker with its honey stomach filled with nectar reaches the hive, the nectar is either stored directly in a cell or is given up first to some other worker, who places it in a cell.

It would appear that all the food swallowed by a bee must go first into the honey stomach, and since the bee's diet consists of pollen and honey as well as nectar, one would suppose that in regurgitating the latter the bee would also disgorge the pollen it might have recently eaten. Honey which is made from the regurgitated nectar does indeed contain some pollen, but most of the pollen eaten by the bee is undoubtedly retained in the stomach as food. The apparatus by means of which the pollen is supposed to be separated from the nectar belongs to the following division of the alimentary canal, but it is not known that the worker takes nectar, and pollen for food, into its honey stomach at the same time.

The *proventriculus* (figs. 42 and 44, *Pvent*) forms the necklike stalk between the honey stomach (*HS*) and the true stomach or ventriculus (*Vcut*), but a very important part of it also projects up into the honey stomach (fig. 44 C). If the honey stomach be slit open, a short, thick, cylindrical object will be seen invaginated into its posterior end and having an X-shaped opening at its summit (fig. 44 C, *m*). This opening is the mouth of the proventriculus, and its four triangular lips, which are thick and strong, mark four longitudinal ridges of the proventricular tube. This structure is commonly known as the "stomach-mouth" and is supposed to be an apparatus designed especially to enable the worker to pick out pollen grains from the honey stomach and swallow them on down into the true stomach or ventriculus, while the nectar is left to be stored in the hive. Cheshire says: "While the little gatherer is flying from flower to flower her stomach-mouth is busy separating pollen from nectar." This notion is so prevalent among bee writers in general that it passes for a known truth. Yet it has really never been shown that the worker eats pollen while she is gathering nectar. Probably no more pollen is ever mixed with the nectar in the honey stomach than is found in the honey itself. Furthermore, under normal conditions pollen never accumulates in the honey stomach, even when the bee

is not collecting nectar—or, at least, the writer has not observed it—while, finally, both the proventriculus and its mouth are just as well developed in the queens and drones as in the workers, though neither of the former are known to eat pollen, and they certainly do not gather nectar.

If the honey stomach be cut open in a freshly killed bee, the proventricular mouth may be seen still in action. The four lips spasmodically open wide apart with a quivering motion and then tightly roll together and sink into the end of the proventricular lumen. This, of course, suggests their picking pollen out of the nectar, but it is probably simply the ordinary process by means of which the proventriculus passes any of the food in the honey stomach on to the ventriculus. Nearly all insects have some such proventricular apparatus, which simply takes the stored food from the crop as it is needed by the stomach. In some insects it forms apparently a straining apparatus, which prevents coarse, indigestible fragments from entering the stomach, while in some the proventriculus may be a triturating organ comparable with a bird's gizzard. Bees, however, do not crush the pollen either in their mandibles or in the proventriculus, for it occurs in perfect condition in the ventriculus.

Hence, before the current notion that the "stomach-mouth" is for the special purpose of taking pollen out of the nectar in the honey stomach can be accepted it must be first demonstrated that the workers eat pollen while the honey stomach contains nectar to be stored in the cells, i. e., any more than is disgorged along with the nectar; and, secondly, a reason must be shown why the queens and drones should have a "stomach-mouth" as well developed as that of the worker. In the meantime it appears most logical to regard the proventricular mouth as simply the ordinary apparatus, possessed by insects in general, by means of which all of the food is passed from the crop to the stomach.

A longitudinal section through the honey stomach, the proventriculus, and the anterior end of the ventriculus is shown in figure 45, which is made from a queen. The proventriculus does not differ from that of a worker, but the honey stomach is smaller and not so much turned to one side (cf. fig. 44 A and B). The two muscle layers of the œsophagus continue down over the walls of the honey stomach (*TMcI* and *LMcI*). The outer layer of transverse fibers, however, ceases at the posterior end of this organ, while the longitudinal fibers continue posteriorly over the proventriculus and the ventriculus as an external layer (*LMcI*). A new layer of internal transverse fibers begins on the proventricular walls and extends backward on the ventriculus (*TMcI*) beneath the longitudinals. Hence the muscles on the œsophagus and crop are in reverse order from those of the proventriculus and ventriculus. The proventriculus is deeply in-

vaginated into the posterior end of the honey stomach. Each lobe of its mouth forms a thick triangular ridge on the walls of its lumen, in which lies a special mass of longitudinal muscle fibers (*LMcl*). The epithelium of the lumen is lined by a thick, smooth, chitinous intima (*Int*), while the lobes of the mouth (*nn*) are provided with bristles pointing inward and backward into the mouth opening.

The posterior opening of the proventriculus into the ventriculus is guarded by a long tubular fold of its epithelium (fig. 45, *PventVlv*), the *proventricular valve*. This would appear to constitute an effective check against the escape of any food back into the proventriculus. It looks like one of those traps which induces an animal to enter by a tapering funnel but whose exit is so small that the captive can not find it from the other side. Yet Schönfeld has elaborately described experiments by means of which he induced the ventriculus to discharge its contents through the proventriculus into the honey stomach and even into the end of the œsophagus. He says that he did this by gently tapping on the honey stomach and the ventriculus at the same time. The experiment

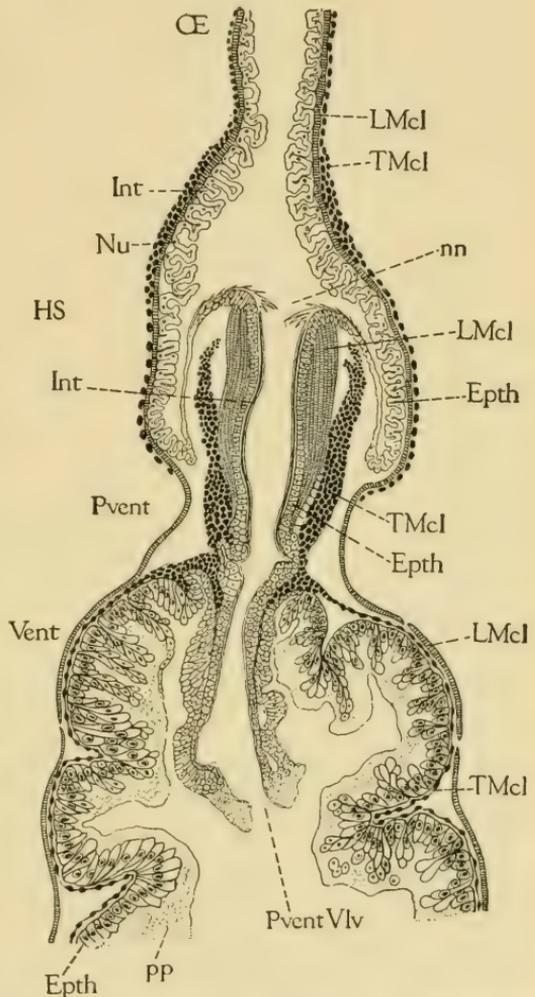


FIG. 45.—Longitudinal median section of base of œsophagus (*CE*), honey stomach (*HS*), proventriculus (*Pvent*) and ventriculus (*Vent*) of a queen.

was repeated many times with unvarying results and Schönfeld describes so minutely what happened that we can not disbelieve his statements. From these experiments he argues that the larval food-stuff is prepared in the stomach and regurgitated through the proventriculus directly into the œsophagus by a contraction of the honey stomach which brings the stomach-mouth against the base of the œsoph-

agus. We shall have to postpone a further discussion of this subject to page 99, after the ventriculus and its contents have been described.

The *ventriculus* (fig. 42, *Vent*) is the largest part of the alimentary canal in the bee and is bent into a U-shaped loop of which the posterior arm is dorsal. It is cylindrical and does not vary so much in shape and diameter according to its contents as do the other parts of the canal, although the numerous transverse constrictions which give it a segmented appearance are not at all constant. When examined under alcohol the ventriculus has an opaque whitish appearance, but in the natural condition—that is, as seen when examined in a freshly killed or asphyxiated bee—it is of a dark-brown color with lighter rings corresponding to the constrictions. The latter represent internal folds where the walls are really thicker than elsewhere, the color being due to the contents which naturally show more plainly through the thin parts.

The contents of the ventriculus invariably consist of a dark brown mucilaginous slime and generally also of a varying amount of pollen. The latter is most abundant in the posterior arm of the ventricular loop and is often densely packed in its rear extremity, while the anterior arm may be almost entirely free from it. The pollen in the ventriculus is always fresh-looking, the native color showing distinctly through the enveloping slime while most of the grains yet retain all of their contents. The writer has examined many samples of pollen from the stomachs of workers and, in all, the great mass of it showed no evidence of digestion, the color being fresh and the contents perfect—only a few had the latter shrunken and seldom was an empty shell observed. On the other hand, the pollen contained in the small intestine has invariably lost its bright color, the contents of the majority of the grains are more or less shrunken, while a number of empty shells are to be found. That in the rectum, finally, consists in large part of empty shells or of grains having the contents greatly shrunken and apparently mostly dissolved out, although a few perfect and bright-colored grains are always present, looking as if entirely unaffected by the digestive liquids. From these observations the writer would conclude that the digestion of pollen takes place principally in the intestine. In all parts of the alimentary tract there occur numerous bits of feathered bee-hairs, but these seem to be especially numerous in the ventriculus.

We are now in a position to discuss the possibility of the **production of the brood food** in the stomach. Schönfeld (1886), as has already been stated, argues that this substance is regurgitated "chyle" from the ventriculus. Arnhart (1906) adopts this view and elaborates considerably upon the chemical process by means of which the transformation of "chyle" into this larval food is effected through the addition of tartaric acid from the pharyngeal glands of the head.

The ventricular contents do become slightly milky when treated with a solution of tartaric acid, but they are not changed into anything at all resembling royal jelly. Moreover, a transformation of the brown slimy contents of the ventriculus into the white gummy paste on which the larvæ are fed does not seem possible without the addition of much other material. In fact the added material must make up the conspicuous part of the larval foodstuff and, from a purely argumentative standpoint, it would not seem necessary to assume that it contains any "chyle" at all. Again, if it were not for Schönfeld's experiments one could not easily believe that the food could be disgorged through the proventricular valve. The conspicuous action of the proventricular mouth is a swallowing motion, and the writer has not been able to induce the ventriculus to disgorge its contents through it in the way that Schönfeld describes, although perhaps sufficient care was not observed in exposing the organs. Cheshire states that the proventricular tube (fig. 45, *PventVlv*) in the ventriculus "rather makes regurgitation improbable than impossible," while he argues that the down-pointing bristles of the stomach-mouth would further interfere with this process. Cowan adopts the view of Dufour and Schönfeld that the brood food is of ventricular origin, and says in this connection: "Although saliva from the glands (especially System I) is probably added to the food, this can not, from its great variability, be entirely a secretion, as stated by Schiemenz. The work of Doctor Planta, we think, conclusively proves that the food is not a secretion, and that the nurses have the power of altering its constituents as may be required for the different bees." If the variation of the food is under the control of the workers producing it, it does indeed look impossible that it should be produced entirely by glands. Cowan illustrates by a diagram how regurgitation through the proventriculus may be possible in spite of the proventricular tube projecting into the ventriculus. Since this tube is simply a cylindrical fold its walls, as shown in figure 45, *PventVlv*, consist of two layers, and Cowan says that "when the bee wishes to drive the chyle food from the chyle-stomach (*Vent*) into the cells it forces the stomach-mouth (*mn*) up to the œsophagus (*Æ*) and the prolongation (*PventVlv*) unfolds, extending the chyle-stomach to the œsophagus, making a direct communication through which the food is forced by compression of the chyle-stomach by its muscles." The honey-stomach of the worker is much larger than that of the queen, shown by figure 45, in which there is not enough space for the unfolding of the proventricular tube. This mechanism suggested by Cowan looks simple and conclusive in a diagram, but when one attempts to unfold the proventricular tube by grasping the stomach-mouth in a pair of fine forceps and pulling the top of the proventriculus upward it is found that, while the tube *can* be entirely straightened out, doing

so involves the tearing of all the fine muscle fibers and tracheal branches uniting the honey-stomach to the upper end of the ventriculus (fig. 45). If, then, the organ itself can not be made to work according to this scheme, it might be supposed that the inner wall of the proventriculus and the tube are evaginated through the stomach-mouth (*mn*), but the walls of the former certainly appear to be entirely too rigid to permit of any such performance as this. Finally, it is not clear how *any* eversion of the tube could be produced by the proventricular muscles as they exist.

The various facts and arguments bearing on the origin of the brood food may be summarized as follows:

1. The brood food itself is a milky-white, finely granular, and gummy paste having a strong acid reaction said to be due to the presence of tartaric acid.

2. The pharyngeal glands of the head are developed in proportion to the social specialization of the various species of bees; they are always largest in those individuals that feed the brood, and they reach their highest development in the workers of the honey bee. From this it would seem that they are accessory to some special function of the worker.

3. The contents of the stomach in the workers consist of a dark brown, slimy, or mucilaginous substance in no way resembling the brood food, even when acidulated with tartaric acid. Pollen is present in varying quantity, mostly in the posterior end of the stomach, and shows little or no evidence of digestion. Since the brood food is highly nutritious, it must contain an abundance of nitrogenous food material which is derived only from pollen in the bee's diet. Therefore it is not clear how the stomach contents can alone form brood food.

4. The constituents of the food given to the different larvæ, at different stages in their growth, and to the adult queens and drones show a constant variation apparently regulated by the workers producing it. A variation of this sort can not be explained if it is assumed that the brood food is produced by the glands alone.

5. Powdered charcoal fed to a hive of bees appears after a short time in the brood food in the cells, and this has been urged as proof that the latter is regurgitated "chyle." But it is certainly entirely possible that the charcoal found in the food might have come only from the honey stomach or even from the œsophagus or mouth.

6. We have Schönfeld's word for the statement that a regurgitation of the stomach contents may be artificially induced by irritation of the honey stomach and ventriculus in a freshly dissected bee, but all explanations offered to show how this is mechanically possible in spite of the proventricular valve are unsatisfactory when the actual anatomical structure is taken into consideration.

The only conclusion, then, that we are really warranted in drawing concerning the origin of the royal jelly or of any of the larval food paste is that we do not know anything about it. Cheshire is probably responsible for the widespread opinion that it is formed by the pharyngeal glands, though Schiemenz (1883) published a large paper containing this theory three years before Cheshire's book was printed. The "chyle" theory, which also has many advocates, originated with Dufour but was principally elaborated by Schönfeld. Arnhart would derive the brood food from both the stomach and the glands. But we are still absolutely in the dark, since we lack definite and conclusive information. A satisfactory study of the subject would involve the chemical investigation of very minute quantities of substances, and it may be a long time before any interested person is found capable of undertaking a work of this sort. The writer of the present paper is professedly preparing an account only of the structure of the organs, but is doing this with the hope that it may furnish a basis for some future investigator who shall have time to devote himself to a study of the chemistry and physiology of the digestive organs and their glands.

In vertebrate animals the digestive secretion of the stomach is acid and its enzymes bring about especially the digestion of proteids. The resulting acid mixture is called *chyme*. In the intestine the contents are flooded with various alkaline liquids whose enzymes then take up the digestion of the other food elements. The final prepared product, which is absorbed by the lacteals, is called *chyle*. These names have been applied to the contents of the alimentary canal in insects—especially by Arnhart (1906), who speaks of the material undergoing digestion as "chyme" and the completed products as "chyle." But absolutely nothing is known of the digestive process in insects beyond the fact established by Plateau (1874) that the contents of all parts of the alimentary tract are alkaline during digestive activity and either neutral or weakly alkaline at other times. Hence, if we make use of these words in insect physiology, it must be with the understanding that no chemical significance is implied. The ventriculus is very commonly called the "chyle stomach" but there is probably no reason for calling it a "chyle stomach" any more than a "chyme stomach," and likewise there is no reason for supposing that the intestine does not contain chyle—in fact, it almost certainly does. The word "chyle" may be used with entire propriety in insect physiology to signify the completed products of digestion, but to designate a part of the alimentary tract as the "chyle stomach" is applying the term without an adequate basis of facts.

The contents of the ventriculus are surrounded by several concentric layers of thin filmy membrane which form an interior tube extending the entire length of the stomach and reaching down into the

anterior end of the intestine. This tube can be very easily seen by carefully cutting open the outer walls of the ventriculus, but it is best demonstrated by transverse microtome sections of a specimen prepared for histological purposes. Such a section is shown by figure 46 A. A small amount of solid food matter (*qq*) is seen in the center of the specimen, surrounding which are numerous irregular concentric rings of membrane (*Pmb*), some adhering to each other in places, others entirely free, most of them structureless, but others partly cellular. These are known as the *peritrophic membranes* (*Pmb*). They keep the solid contents of the stomach away from the epithelial walls, from which, as will be presently explained, they are given off from time to time.

The walls of the ventriculus (fig. 46 A) are thick and consist of numerous cells (*Epth*) apparently very irregularly arranged. On their inner surfaces is a thin intima (*Int*) and on their outer surfaces a still finer basement membrane (*BM*). Outside of the last are two layers of muscles, the external layer consisting of longitudinal fibers (*LMcl*) and the inner of transverse ones (*TMcl*). Numerous annular depressions of the walls form internal folds (fig. 45), but any part of the ventricular wall can be stretched out into a flat sheet, which is then seen to be full of little pits, giving the whole a screenlike appearance. Sections show that the pits result from circular invaginations of the basement membrane (fig. 46 B, *BM*), and that at the bottom of these pockets the cells are very small and convergent, while those on their lips are very large. Figure 46 B is a very perfect example of this structure of the epithelium, which is usually more or less obscured, as in figure 46 A, by a great proliferation of small cells from the lips of the cups—and then a large section seldom gives a symmetrical view of all the parts. The cups are all filled to overflowing by a gelatinous mass (*pp*) which fuses over their edges into a continuous coating beneath the intima over the entire inner surface of the epithelium. This mass appears to be formed mostly by the cells at the bottoms of the cups, for the outermost of these (fig. 46 B, *rr*) often insensibly fade into it.

Figure 46 E shows an opposite condition of the epithelial cells. Here the lip cells of the cups appear to be very actively dividing, and proliferating a great number of small cells (*Enz*) which float off into the gelatinous covering. These discharged cellules are all nucleated, but their protoplasm does not stain in preparations and consequently they appear clear and transparent as compared with the cells they apparently come from. The writer has not been able to find any of these cells actually in the process of division, but a comparison of figures B and E (which are camera lucida drawings and not diagrams) would certainly suggest that the condition of the cells in E has resulted from a very active division of the cells of the walls and

lips of the cups, which are quiescent in B. Comparing this with what is known to take place in other insects during digestion, there is every reason for believing that the proliferated cellules are filled with the digestive secretion, and that E represents a stage immedi-

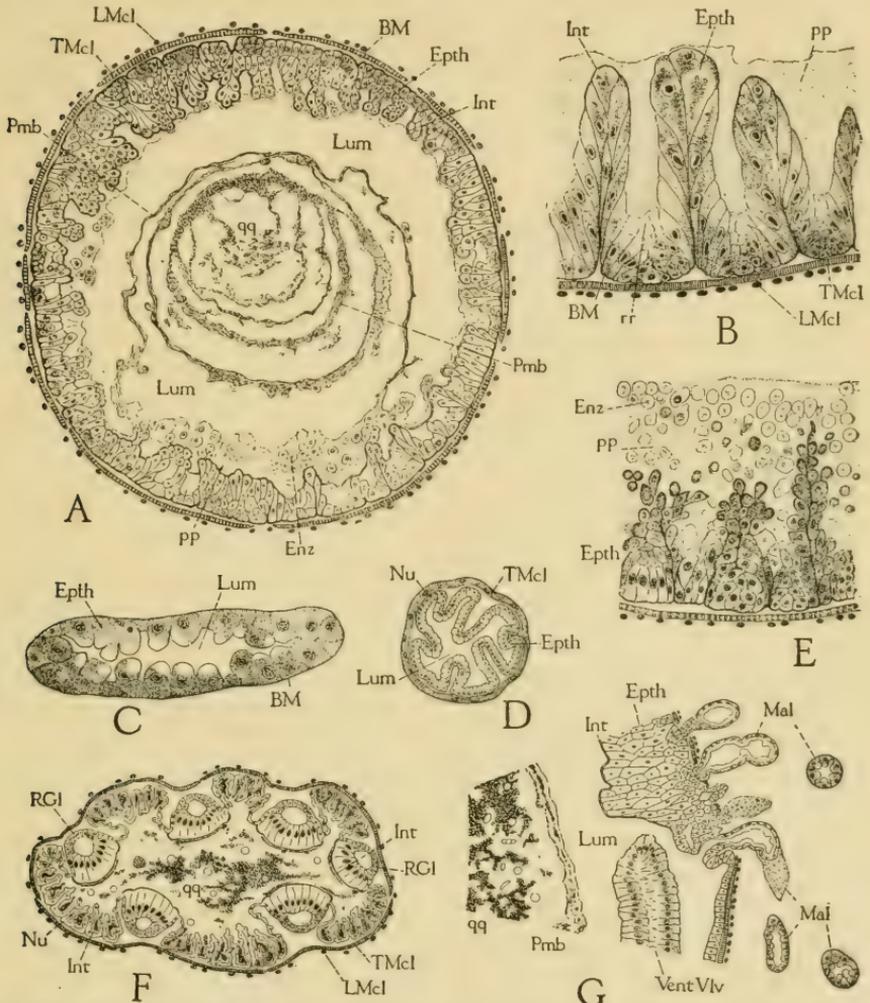


FIG. 46.—Histological details of alimentary canal of worker: A, cross section of ventriculus showing peritrophic membranes (*Pmb*); B, section of wall of ventriculus showing epithelial cups with cells in resting condition and covered by gelatinous mass (*pp*); C, section of Malpighian tubule; D, cross section of small intestine; E, section of ventricular epithelium after formation of numerous small digestive or enzyme cells (*Enz*) given off into gelatinous matrix (*pp*); F, section of anterior end of rectum through rectal glands (*RGl*); G, part of slightly oblique section through posterior end of ventriculus and anterior end of small intestine, showing openings of Malpighian tubules (*Mal*) into the latter.

ately subsequent to one of greatest secretive activity, in which there is a large number of little cells (*Enz*) highly charged with the enzyme-containing digestive juices imbedded in a gelatinous matrix covering the inner surface of the epithelium. This matrix next

separates itself from the ends of the remaining epithelial cells, which at the same time secrete a new intima over their inner surfaces. The lower part of figure 46 A shows this indisputably. The whole thing, then, finally contracts about the food and, as the digestive cellules give up their contents, shrivels and shrinks and becomes a peritrophic membrane. In figure A the outermost peritrophic layer is still in both conditions—its dorsal part is shrunken to a thin membranous form, while its lower part is gelatinous and filled with secretion cellules, though it is separated from the epithelium by a new intima and is detached at intervals from the latter. Beneath the new intima, furthermore, is seen at places the formation of a new gelatinous mass. Some of the inner peritrophic layers shown in A also retain remnants of cells.

Figure 46 A is drawn from a specimen which is typical of all in several series of sections through the ventriculus. The peritrophic layer partly adhering to the epithelium is no artifact, because the same condition may often be directly observed in dissections of fresh specimens. In the opposite end of the series from which the specimen was selected this layer is entirely free from the epithelium.

The peritrophic membrane has been described in some insects as being a prolongation from the intima of the proventriculus, the ventriculus itself being supposed never to secrete an intima. It is perfectly conceivable that the anterior end of the membranes might be generated by the outer cellular layer of the proventricular funnel and remain attached to it after the rest of it had become free from the ventricular wall, and thus give the appearance of belonging to the proventriculus. The writer, however, has several sets of longitudinal sections through these parts in the bee, but none of them nor any dissections made show such a condition.

Absorption is commonly supposed to take place largely in the ventriculus. If so, the food must pass through the several peritrophic membranes and then through the thick epithelium. It is entirely possible that it may do so, but the pollen contained in the ventriculus, as already stated, shows little or no evidence yet of digestion and does not begin to do so until it reaches the small intestine. On the other hand, the dark mucilaginous slime of the ventriculus does not appear in any quantity in the much drier contents of the small intestine. Therefore it may be supposed that this slime contains the sugar elements of the food and that the latter are principally digested in, and absorbed from, the ventriculus. The absorption of the proteids and hydrocarbons must take place in the intestine and rectum since these food elements in the bee's diet are derived only from the pollen. However, these conclusions are purely tentative, being based on the writer's observation of the contents of the different parts of the alimentary tract, which, while fairly extensive and continued through

most of a year, are confessedly not nearly adequate to serve as a basis for conclusive statements on the digestive process. They are sufficient, however, to show the utter lack of a basis in facts for many other opinions on this subject.

Cheshire (1886) describes two kinds of cells in the ventricular epithelium, "one secreting a digestive fluid (gastric juice) from the surrounding blood into the stomach, so that the pollen grains may be made fit for assimilation by a transformation not unlike that liquefying gluten in our own case; the other absorbing the nutrition as prepared and giving it up to the blood." Though Cheshire refers to his figures to show these two kinds of cells, he does not point out which are which—in fact, he does not even designate two different kinds in his drawings nor even represent two kinds.

The **small intestine** (fig. 42, *SInt*) forms a loop upon itself and constitutes a narrow tube connecting the stomach (*Vent*) with the large intestine or rectum (*Rect*). Its anterior end is somewhat enlarged and carries the circle of malpighian tubules (*Mal*). Its epithelium (fig. 46 D, *Epth*) is very simple and is thrown into six longitudinal folds that project into its lumen. On the outside is a thick sheath of transverse muscle fibers (*TMcl*) with distinct nuclei (*Nu*). The latter are designated by Cheshire (1886) as "longitudinal muscles" (see his figure 14 D), but this is a very evident mistake—the small intestine has no longitudinal muscles at all. It is evident that the folds of the epithelium permit the ordinarily narrow tube to expand very considerably when necessary to allow the passage of a large amount of food. The contents of the small intestine are usually drier than those of the ventriculus, consisting principally of masses of partly digested pollen, that is to say, the contents of the grains are partly dissolved out—presumably signifying that they are undergoing digestion. There is usually only a small amount of the brown slime present such as fills the ventriculus.

The **Malpighian tubules** (fig. 42, *Mal*) are wrapped and coiled about one another and about the viscera of the abdominal cavity. There are about 100 of them in the honey bee and they all open separately into the anterior end of the intestine. Each is a very long thread-like tube consisting of a single layer of epithelial cells provided with a very delicate basement membrane and intima (fig. 46 C). The ends of many of the cells are clear and bulge into the lumen. Figure 46 G shows a section through the junction of the ventriculus and the intestine where the tubules open by narrow necks penetrating the epithelium. The wall of the ventriculus forms a short double-layered fold (*VentFlv*) projecting backward into the anterior end of the intestine, behind which are the orifices of the Malpighian tubules. The section from which figure G was drawn is cut somewhat obliquely and takes in this fold only on one side.

The Malpighian tubules are regarded as excretory in function and are supposed to remove from the blood the nitrogenous waste products resulting from metabolism. Minute crystals of urates are often to be found in them and they probably perform the work of the kidneys in vertebrate animals.

The large intestine (fig. 42, *Rect*), called the rectum in insects, is an enormous sac which may lie limp and flabby in the rear part of the body or it may be so immensely distended by the amount of its solid and liquid contents as to occupy a large part of the abdominal cavity. The recognizable elements of the material within it consist mostly of the empty shells of pollen grains or of grains having their contents greatly shrunken and distorted—presumably as a result of the absorption of the protoplasm, although a considerable number are usually present which are only slightly digested, while there are always to be observed a few perfect and fresh-looking grains showing no evidence at all of digestion. The rest of the indefinite mass of solid rectal material consists of some unrecognizable, finely triturated substance, probably derived in part from fragments of the peritrophic membranes. There are always present a few bits of feathered bee hairs.

The epithelium of the rectum is, like that of the œsophagus, rudimentary, being distinguishable only by the nuclei (fig. 46 F, *Nu*) remaining in the outer layer of the thick transparent intima (*Int*). Outside of this is an external layer of longitudinal muscle fibers (*LMcl*) and an inner layer of transverse fibers (*TMcl*). The intima (*Int*) is thrown into numerous folds whose edges converge, forming pocketlike grooves between them in which are lodged small masses of the rectal contents. This is very suggestive that absorption takes place in this part of the alimentary tract, although it is not commonly supposed to do so, but if the pollen is not fully digested until it reaches the rectum, how can it be absorbed by the anterior part of the alimentary canal?

The so-called rectal glands (fig. 42, *RGl*) consist of six hollow epithelial tubes (fig. 46 F, *RGl*) and are the only parts of the rectal epithelium in which the cells are well developed. The cells on the outside of each "gland" are small, but the inner ones are very large and are covered by a thick layer of dark chitin (*Int*). The lumen is intercellular and does not communicate with that of the rectum. When the rectum is distended the "glands" bulge out on the surface as six short opaque ridges (fig. 42, *RGl*), but when it is empty they sink into the walls as in figure 46 F. Nothing is known of the function of these organs, and their glandular nature is entirely conjectural. If they are glands, it is not clear why the intima should be so especially dense on their inner faces.

VII. THE CIRCULATORY SYSTEM.

The liquid medium that distributes the digested food from the alimentary canal to the cells of the body tissues is called the *blood*, and the contractile organ that keeps the blood in motion is the *heart*. In vertebrate animals the blood is contained entirely within tubes called arteries and veins, but in insects and most other invertebrate animals the blood simply fills the empty spaces between the viscera of the body-cavity, which spaces may, however, constitute definite channels or *sinuses*, and may even be shut in by special membranes. Besides carrying and distributing the digested food that is absorbed into it in solution, the blood of animals generally has also to distribute oxygen to the tissue cells and carry off their waste products. Oxygen is obtained from the air and, like any other gas, is soluble in liquids. Hence it is present in the blood not in the form of small bubbles of gas but in solution, just as it is in all water exposed to the air. The respiratory system (see page 116) is simply a special contrivance for bringing air into close proximity to the blood so that its gases may diffuse into the latter, but many soft-bodied animals like earthworms absorb air directly through the skin. Vertebrate animals have a substance in their blood called hemoglobin which is contained in the red corpuscles and has a great capacity for absorbing oxygen. It, therefore, enables the blood to carry much more of this gas than could be dissolved simply in its plasma. Invertebrate animals do not need so much oxygen as vertebrates, and, therefore, most of them can get along with that which dissolves in the colorless blood plasma without the special aid of hemoglobin. Most insects, however, being excessively active creatures, must have a rapid metabolism in their cell tissues, and consequently they need much oxygen to consume the product of this metabolism, but they belong to the class of animals without red blood and, hence, nature has provided them with another means of obtaining a special supply of air, namely, a set of air-tubes branching minutely over nearly all the internal organs, the tissues, and even most of the cells in the body. (See "The Respiratory System," page 112, for discussion of oxidation and removal of waste products.)

The blood of insects is usually a colorless liquid containing opaque granular cells or corpuscles floating in it. There are no special blood vessels, but there are very definite channels between the muscles and viscera through which the blood flows, while conspicuous membranes stretched across the dorsal and ventral walls of the abdomen (fig. 1, *DDph* and *VDph*) inclose special dorsal and ventral sinuses which play an important part in the circulation. These membranes, called *diaphragms*, are rhythmically contractile, and contribute much to

maintaining the circulation of the blood. The heart (fig. 1, *Ht*) is located in the dorsal sinus, which latter is therefore often called the *pericardial chamber*. The pulsations of the diaphragms are produced by fine muscle fibers lying in their walls. These are usually arranged in a number of fan-shaped bunches on each side radiating from the edges of the diaphragm (fig. 47, *DphMcl*) toward the middle, where most of them are continuous with the fibers from the opposite side. It used to be supposed that those of the dorsal diaphragm produced the expansion of the heart, and they were for this reason called the "wing muscles of the heart," but the latter organ is now known to be a muscular tube and to contract and expand by its own

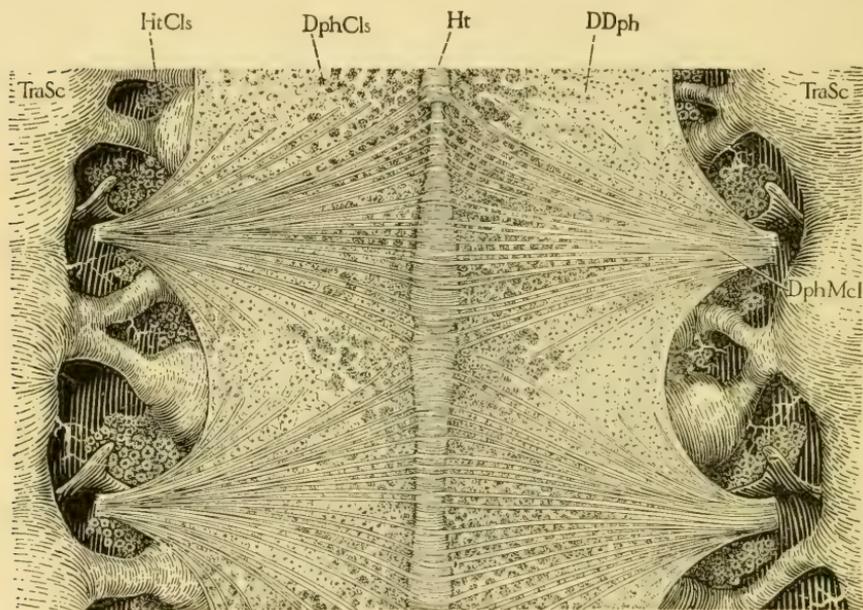


FIG. 47.—Dorsal diaphragm of drone, from one segment and adjoining parts of two neighboring segments, showing median heart (*Ht*) as seen through transparent diaphragm (*DDph*), fan-shaped bunches of diaphragm muscles (*DphMcl*), and lateral tracheal sac (*TraSe*) giving off sac-bearing trunks into pericardial chamber above diaphragm.

power. In some insects the muscles of the dorsal diaphragm form a meshwork of fine fibers surrounding numerous large and small holes in the membrane, which probably permit the entrance of blood into the sinus above, but in most species the diaphragm is imperforate and the blood enters the pericardial chamber above its scalloped edges (figs. 1 and 47).

The heart of insects in general is a long narrow tube (fig. 1, *Ht*) situated in the dorsal sinus or pericardial chamber of the abdomen along the midline of the body. It is swollen toward the middle of each segment into a *heart chamber* (*ht*) which presents a vertical slitlike opening or *ostium* (*Ost*) on each side. Theoretically, in

generalized insects, there should be a chamber to each segment, but the heart is variously shortened from both ends so that the chambers are always fewer than the segments. The posterior end of the heart is closed, but its anterior end is produced into a long narrow tube called the *aorta* (fig. 1, *Ao*) which extends through the thorax and opens by a few simple branches into the cavity of the head.

The heart of the bee (fig. 1, *Ht*) consists of only four chambers (*1ht-4ht*) lying in the third, fourth, fifth, and sixth segments of the abdomen. In the front of this part of the body it bends downward and forms a large convoluted loop (*i*) of about 18 folds where it passes through the abdominal constriction. All of this convoluted part really belongs to the abdomen, since it lies in the propodeal part of the apparent thorax, which is the true first abdominal segment. The aorta (*Ao*) extends forward from here as a very fine tube making a large arch between the muscles of the thorax and then enters the back of the head. According to Pissarew (1898) the convolutions of the anterior end of the heart are peculiar to the honey bee, being absent in its nearest relatives such as *Bombus* and *Megachile*. The heart walls, as before stated, are muscular and produce a rhythmical contraction of the tube whose pulsations follow each other from behind forward. Thus the contained blood is driven out of the anterior end of the aorta into the head, where it bathes the brain and the other organs of this region, and then flows backward, percolating through the spaces between the organs of the thorax.

From the thorax it enters the cavity of the ventral sinus—not the general abdominal cavity, at least in the bee—and is pumped backward by the pulsations of the ventral diaphragm and dorsally over the inner walls of the thorax and through definite channels about all the viscera, finally collecting in the dorsal sinus where it again enters the heart through the lateral ostia. The lips of the ostia are provided with small membranous lobes which project inward and constitute valves that prevent the expulsion of the blood. A similar valve is placed at the anterior end of each chamber of the heart to prevent a possible backward flow.

In the bee, both the dorsal and the ventral diaphragms are well developed, the former (fig. 1, *DDph*) extending from the third abdominal segment to the seventh, inclusive, while the latter (*VDph*) extends from the abdominal constriction to the eighth segment. The ventral diaphragm is much more muscular than the dorsal and its pulsations, which are very strong, follow each other from before backward. They may easily be observed by removing the top of the abdomen from an asphyxiated bee. The ventral sinus is very ample, inclosing the nerve cord of the abdomen, and receives into its anterior end the blood channels of the thorax, so that the latter

communicate with the general cavity of the abdomen only through the ventral sinus.

The dorsal diaphragm (fig. 1, *DDph*) ends by a free transverse edge near the front of the third abdominal segment. A part of it is shown by figure 47 extending across one segment and the adjoining parts of two others. The fan-shaped bunches of muscle fibers (*DphMcl*) are seen radiating from the anterior edges of the terga toward the midline, where they are mostly continuous with those from the opposite side, only a few of the anterior and posterior ones ending free in the membrane of the diaphragm. The latter is imperforate, but its edges are deeply scalloped between the points where the muscles are attached, allowing free entrance to the blood from the intervisceral channels of the abdomen. The dorsal surface of the diaphragm is covered by a network of cells (figs. 47 and 48, *DphCls*) arranged in flat branching and fusing bands. These cells

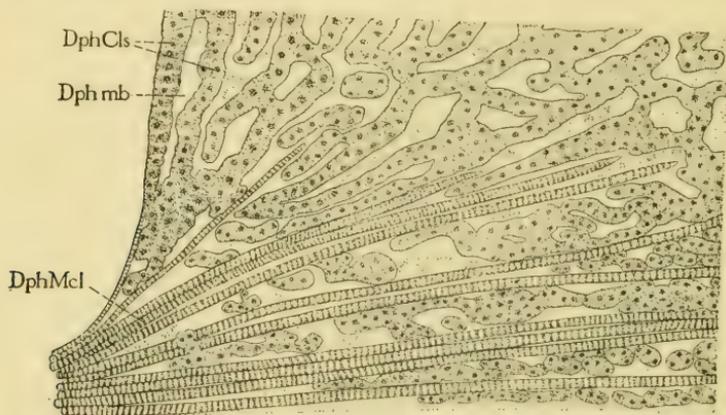


FIG. 48.—Small part of dorsal diaphragm of drone, showing bands of flat diaphragm cells (*DphCls*), the diaphragm membrane itself (*Dphmb*), and the muscle fibers (*DphMcl*).

may be called the *diaphragm cells* to distinguish them from the pericardial cells to be described later.

The abdominal circulation is very easy to observe in a living bee. The best way to demonstrate it is to pin an asphyxiated bee to a block of cork or paraffin and remove the top of the abdomen by making an incision with a small pair of scissors clear around it. Gently pull the alimentary canal to one side so as to expose the ventral diaphragm, which will be observed pulsating strongly backward. Next cut a small hole in the top of the thorax and insert into it a drop of some stain in a water solution (the writer used carmalum). Almost immediately this will appear in the ventral sinus of the abdomen, in which it is pumped backward by the diaphragm, and from which it goes upward through invisible channels between the air sacs and the alimentary canal and especially up

wide channels against the lateral walls of each segment. It does not run out free into the abdominal cavity, however, unless through a rent, nor does it enter the latter from the thorax except by way of the ventral sinus. The dorsal circulation of course can not be observed in this specimen because the back is removed. Therefore, take another bee and fasten it in the same manner, but make simply a shallow median slit along the back, thus exposing the dorsal sinus and the heart from above. Now insert a drop of stain into the thorax as before. After about two minutes this will appear in perceptible amount in the dorsal sinus, very much diluted, to be sure, with the blood, but there will be enough to give white blotting paper a distinct red tint. In a short time the heart becomes filled with the stained blood and appears as a red tube along the median line.

The dorsal sinus contains not only the heart but also two pairs of pericardial air sacs in each segment. These are seen entering the

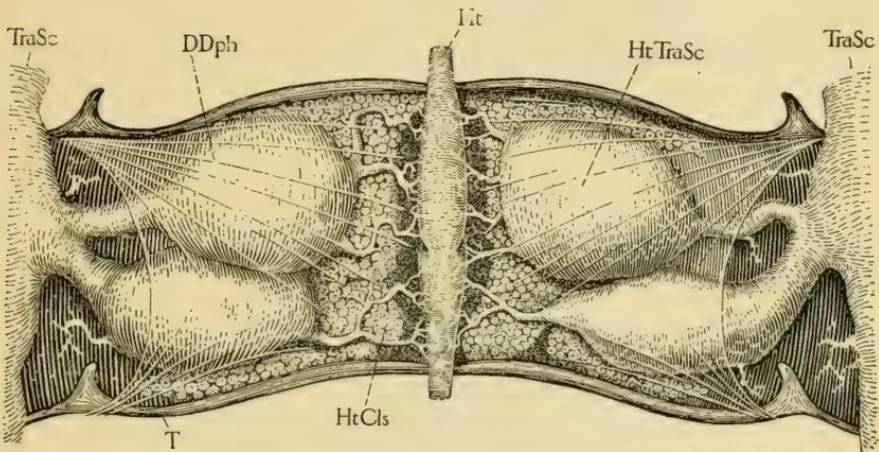


FIG. 49.—Pericardial chamber of one segment in worker, seen from below looking through transparent dorsal diaphragm (*DDph*), showing median heart (*Ht*), lateral pericardial air sacs (*HtTraSc*) given off from large lateral sacs (*TraSc*), and the padding of pericardial cells (*HtCls*) against inner surface of tergum (*T*).

sinus from the large lateral air sacs of the abdomen (*TraSc*) in figure 1 and also in figure 47. In the latter the heart (*Ht*) is seen along the median line as it shows through the diaphragm. Figure 49 gives a view of the pericardial sinus as seen from below, in one segment, by focusing through the transparent diaphragm (*DDph*). In the middle lies a chamber of the heart (*Ht*) with the slitlike ostium on each side. Laterally are the four pericardial air sacs (*HtTraSc*) giving off branches that ramify profusely upon the heart. Above the heart and the air sacs is a thick bed of large granular cells (*HtCls*) which make a soft padding between the hard tergal wall and the delicate organs of the sinus. These are called the *pericardial cells*. They may have some physiological function, as has often been supposed, but if so no one has decided what it is.

VIII. THE RESPIRATORY SYSTEM.

The lives of all animals depend upon a constant distribution of free oxygen gas throughout their bodies. This oxygen, continually inhaled and exhaled, is not used in the formation of tissues, it does not become a part of the living protoplasm of the animal—it is the physiological scavenger that eats up certain waste products of metabolism which are deadly to the system unless constantly removed or changed into less harmful compounds. The action of oxygen upon these waste substances within the body is comparable with ordinary combustion in that it results in the formation of carbon dioxide gas and water and in the generation of heat. Since the air, which is composed of both oxygen and nitrogen, is the source of the oxygen supply, the ordinary breathing processes involve an inhalation also of nitrogen gas, and the tissues become permeated with it as well as with oxygen. The nitrogen of the air, however, is not known to serve any physiological purpose in the body, its presence being simply unavoidably incidental to the inhalation of oxygen. While oxygen and nitrogen are two most important food elements, the tissues of animals can not make use of either in the gaseous condition, but must be supplied with substances containing these elements in combination with others in the form of solid and liquid food stuffs taken into the alimentary canal. Hence, air is not a food, and the respiratory system is to be regarded as chiefly excretory in function.

The means by which different animals receive oxygen into their systems are various. All aquatic breathers of course use that which is naturally dissolved in water. Many of the lower animals absorb air directly through their skins and into their tissues, while the carbon dioxide escapes the same way. Others that live in the water and whose bodies are covered by an impervious skin or shell have thin-walled, hollow, branching appendages, called *gills*, through which the blood circulates freely and through whose walls the necessary exchange of gases takes place. Land animals very commonly have some sort of an invagination from the exterior which allows the air to enter thin-walled tubes or cavities and be absorbed into the blood. Land vertebrates have a tube opening from the back of the mouth whose inner end branches profusely and forms a pair of organs called the lungs, through which the blood circulates freely in delicate tubes that allow the transfer of gases. Insects, finally, have a system of internal air tubes, called *tracheæ*, opening to the exterior by a number of small orifices, called *spiracles*, situated along the sides of the thorax and abdomen, which give off branches that ramify minutely to all parts of the organism, thus virtually making a lung of the entire body. The tracheæ are thin tubes made of flat epithelial

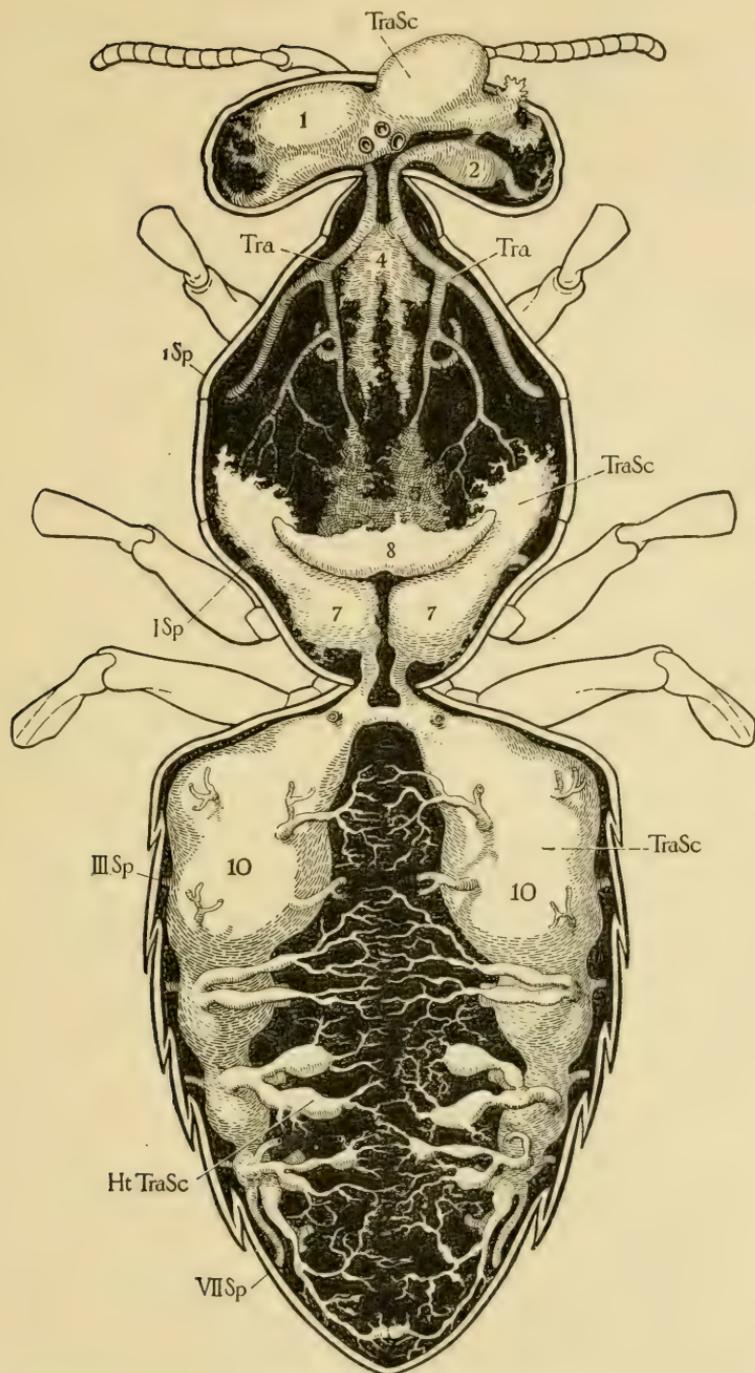


FIG. 50.—Tracheal system of worker as seen from above, one anterior pair of abdominal sacs (fig. 1, 9) removed and transverse ventral commissures of abdomen not shown.

cells lined with a delicate layer of chitin. The latter, however, is strengthened by circular thickenings which give the appearance of an internal spiral thread, but a closer examination shows that each thickening makes only a few turns and that several lie in parallel bands. This structure is for the purpose of maintaining an open passageway for the air through the very thin-walled tubes. The tracheæ branch into fine capillaries and these terminate in excessively delicate end-tubes. In some cases it is easy to see that a great number of capillary branches surround the cells of a tissue, if they do not actually enter the cell walls, but in others it can not be shown that the tracheæ really penetrate below the surface of a mass of cells.

Gases in solution, like solids, pass freely back and forth through moist animal membranes, going in the direction of the least pressure of each particular gas. By this simple method the gases go back and forth through the walls of the gills, lungs, or air tubes and permeate the tissues themselves. Vertebrate animals, as already explained, have a red substance in the blood called hemoglobin which has a very great oxygen-absorbing power and which greatly increases the oxygen-carrying power of the blood, but still a certain amount of oxygen is carried in solution by the liquid or plasma of the blood. Now, the blood of insects has none of this hemoglobin and all the oxygen it can carry is that which dissolves in its plasma, but, on account of the extensive ramification of the air tubes, it is not necessary for the blood to distribute the oxygen to the organs. It is usually stated that the blood in insects does not carry oxygen at all, except for its own use, but it would seem physically impossible that the gases should not diffuse out of the fine terminal air-tubes into the blood when they do so in all other cases. If the blood of a crab or crayfish is capable of carrying enough oxygen in solution to supply the wants of the body, there is no reason why that of an insect, which has much better facilities for obtaining air, should not do the same. Furthermore, we can not suppose that the products of katabolism have to accumulate about the end tracheæ in order to be oxidized. They are produced wherever metabolism is going on, which is everywhere in the living cell substance, and, hence, the latter must be permeated with oxygen in solution, which must also be in the blood along with the carbon dioxid formed. The carbon dioxid diffuses back into the end tracheæ from the blood. Therefore, while the great extent of the tracheal system in insects relieves the blood of the work of distributing the oxygen, the blood must nevertheless serve as an intermediary medium for both the oxygen and the carbon dioxid between the fine terminal tracheal branches and the cells.

It has sometimes been suggested that certain large cells called *anocytes*, found especially in connection with the tracheal system,

function as intermediaries between the tracheae and the cells, but Koschevnikov (1900) has shown that these cells appear to be temporary storehouses for waste products from the tissues—presumably uric acid compounds which have been already oxidized. Even the fat-body has been regarded as a sort of lung in which oxidation takes place, but there is no evidence to support this theory, although, for that matter, there is little evidence in favor of any theory in insect physiology.

The process of metabolism, or the vital activity of the cells themselves, results in a breaking down of the complex and highly unstable protoplasmic molecules into chemical substances of much simpler construction, and it is these by-products of metabolism that are attacked by the oxygen in the blood furnished by the respiratory system. Protoplasm consists principally of the elements carbon, oxygen, hydrogen, and nitrogen, and the oxidation process results, as before stated, in the formation of carbon dioxid (CO_2) and water (H_2O), while the residuary products are mostly organic compounds of nitrogen related to uric acid ($\text{C}_5\text{H}_4\text{N}_4\text{O}_3$) and urea (CON_2H_2). The carbon dioxid is a soluble gas which diffuses into the end tubes of the tracheae and is exhaled. A part of the water at least is given off with the "breath" in the form of water vapor, for drops of it can be collected by inclosing bees or any insects in a tube for a short time. The nitrogen compounds and probably a part of the water are dissolved in the blood and removed by the Malpighian tubules, which are the kidneys of insects.

Besides this oxidation of waste products, which allows the process of metabolism to go on unhindered, the inhaled oxygen serves also another purpose, namely, that of maintaining the body heat. Although insects are usually classed as "cold-blooded" animals, they nevertheless maintain a temperature which is always higher than that of the surrounding air and is often a number of degrees above it. It is well known that the temperature of a beehive during the brood-rearing season is almost as high as that of the human body, and that even during winter it remains at nearly 80°F .; but this is, of course, due to the accumulation and condensation of the warmth from the bodies of a great many bees, and is much higher than the temperature of any bee outside of the hive. In our own bodies certain substances are consumed by oxidation in the blood simply to produce the necessary heat energy for maintaining metabolism, and hence it seems reasonable to suppose that the same thing takes place in insects, although of course to a much less degree.

There are generally ten pairs of spiracles or breathing apertures in insects, two being situated on the sides of the thorax between the segments, but probably belonging to the mesothorax and the

metathorax (although the first is often regarded as prothoracic), while the other eight are situated on the sides of the first eight abdominal segments—in the bee on the lateral parts of the terga (figs. 32 and 33, *Sp*). The breathing apertures are usually provided with a closing apparatus of some sort consisting of the swollen lips of slitlike spiracles, of a small lid, or of a flexible and collapsible chitinous ring, each with special ocluser muscles attached. In the bee a chitinous band surrounds the tracheal tube opening at each spiracle, a short distance from the aperture, and has two opposite loops projecting on the same side, connected by a muscle whose contraction approximates the two halves of the band so as to close the lumen of the trachea.^a It is supposed that after an inhalation the spiracles are closed momentarily, so that the first force of the expiratory contraction of the abdomen is exerted against the air shut in the tracheæ, with the result of driving it into the extreme tips of the latter—the spiracles then opening, the rest of the contraction is expended in exhalation.

The internal tracheal system consists, among insects generally, of a large tracheal trunk lying along each side of the body, connected by short tubes with the spiracles and by transverse commissures with each other, while they give off segmental branches into the body cavity which ramify minutely upon the organs and tissues. In the thorax specially large tubes are given off on each side to the legs and to the bases of the wings, while in the head others go to the eyes, antennæ, and mouth parts. The whole body is thus virtually a lung with ten pairs of openings along the sides.

The tracheal system of the bee (figs. 1, 50, and 51) is best developed in the abdomen, where the longitudinal trunks are enlarged into two enormous lateral air sacs (*TraSc*), which are of greatest diameter in the anterior end of the abdomen. They are segmentally connected by large transverse ventral commissures (fig. 51, *TraCom*), most of which are themselves distended into small air sacs. Dorsally the lateral sacs give off in each segment a large tube which divides into two sacculated branches (figs. 49 and 50, *III TraSc*) that enter the pericardial chamber and supply the heart and pericardial cells with tracheæ. In the thorax a large sac lies on each side of the propodeum (figs. 1 and 50, 7), which bears a short tube opening to the first abdominal spiracle (figs. 21 and 50, *ISp*). Above these sacs is a narrow transverse median one (figs. 1 and 50, 8) occupying the large cavity of the turgid mesoscutellum (fig. 21, *ScI₂*). In the ventral part of the thorax there is a large median posterior sac (figs. 1, 50, and 51, 5)

^a For a detailed description of the spiracles in the bee and their ocluser apparatus see Djathchenko (1906).

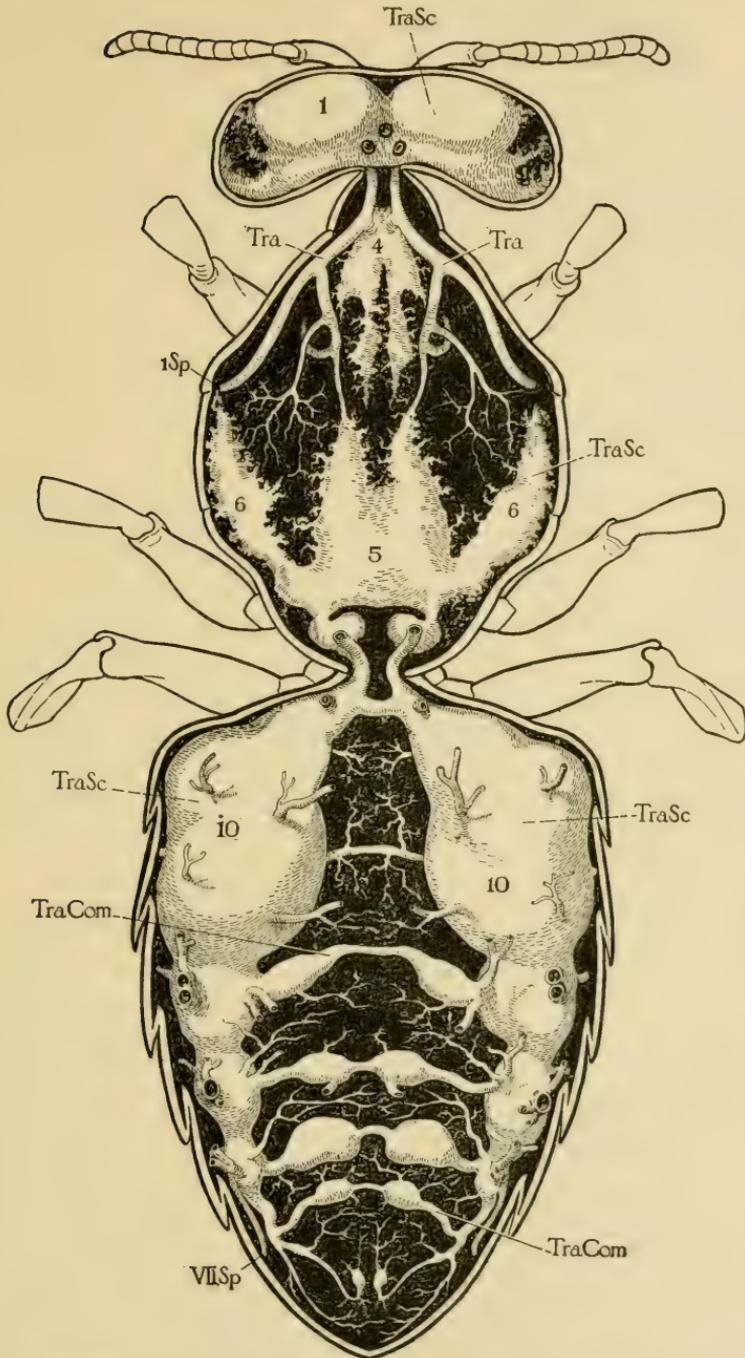


FIG. 51.—Tracheal system of worker showing lateral and ventral parts as seen from above, with dorsal sacs and trunks removed in both thorax and abdomen.

which gives off trunks to the middle and hind legs and a large sac on each side (fig. 51, *G* and *G'*) to the ventro-lateral walls of the thorax. Two large strong tubes (figs. 1, 50, and 51, *Tra*)—the only trachea in the bee's body well developed as tubes—extend backward from the head through the neck and prothorax to the first thoracic spiracles (figs. 50 and 51, *ISp*). Each of these gives off a branch which divides into the trachea for the first leg and into another that connects with the posterior ventral thoracic sac (*S*). An anterior median thoracic sac (*A*) is connected with the two large anterior tubes near where these enter the neck. In the head are a number of large sacs which are situated above the brain (see figs. 1, 50, and 51, *I*), about the bases of the eyes and optic lobes (see figs. 1 and 50, *2*), and above the bases of the mandibles (see fig. 1, *3*).

Nearly all of the trachea in the bee's body are excessively delicate and their walls mostly lack the spiral thickening that ordinarily holds a tracheal tube open. They are consequently very distensible and, when inflated, they show as opaque glistening white vessels, which, however, when empty, are extremely difficult or actually impossible to see. The smaller branches are so numerous and flabby in the thorax and the legs (fig. 1, *LTra*) that they appear to form everywhere meshworks or sheets of tiny glistening air-cavities imbedded between the muscle fibers. Only the large trunks in the anterior part of the thorax have the normal tracheal appearance.

The body of the bee is thus most abundantly aerated, probably more so than that of any other insect. The numerous large and small sacs form great storehouses of air—tanks containing reserve supplies of oxygen. They are not present for the purpose of lightening the weight of the body, because inflation with air does not decrease the weight of any object surrounded by air.

The respiratory movements are limited to the abdomen in the bee on account of the solidity of the thorax. They vary a great deal according to the activity of the individual. While sitting quietly at the entrance of the hive or walking slowly about, bees usually exhibit almost no respiratory motion, only a very slight vibratory trembling of the abdomen being noticeable. Others that are walking hurriedly about lengthen and shorten the abdomen very perceptibly, the motion being specially pronounced at the tip. A bee that has just alighted after flying exhibits still more pronounced abdominal movements, not only a contraction and expansion but an up-and-down motion as well. When a bee is becoming asphyxiated in a killing bottle the extension and contraction of the abdomen is most pronounced, although much slower than in the ordinary breathing movements.

The muscles of the abdomen that produce respiration have been described by Carlet (1884), who distinguishes seven different sets of

them as follows: There are two dorsal sets: (1) The *internal dorsal*, going from the anterior edge of one tergum to the anterior edge of the next following tergum, and (2) the *external dorsal*, going from the lateral edge of one tergum to the corresponding edge of the following tergum. Both of these are expiratory, since their contractions bring the two segments together. On the sides are three sets: (3) The *external oblique*, going from the anterior edge of each tergum to the side of the corresponding sternum; (4) the *internal oblique*, crossing under the last from the anterior edge of each tergum to the side of the preceding sternum. These two sets are likewise expiratory, because their contractions approximate the terga and sterna. The third set of lateral muscles is (5) the *transverse*, lying between the overlapping surfaces of each tergum and its corresponding sternum and being, therefore, inspiratory, because the contraction separates the terga and sterna. Finally, there are two sets of ventral muscles: (6) The *external ventrals* and the *internal ventrals*, forming a letter *M* between the anterior edge of each sternum and the one following, and (7) the *intercentral*, situated between the overlapping surfaces of consecutive sterna and causing their separation by contraction. These last are therefore also inspiratory.

It would thus seem that the abdomen is much better equipped with expiratory than with inspiratory muscles. Perhaps the expansion is partly due to elasticity, and perhaps, also, it is true that the abdomen contracts upon the full tracheæ and air sacs, before the spiracles open to allow exhalation, in order to drive the air into the farthest recesses and terminal tubes of the tracheal system, which necessitates an extra contractive force.

IX. THE FAT BODY AND THE CENOCYTES.

The fat tissue of insects is not miscellaneously distributed through the tissues, imbedded beneath the skin and packed between the muscles, but is disposed in sheets and strands within the body cavity, especially in the abdomen, or forms a definite mass, the *fat body*. The fat cells are large and extensively vacuolated with clear globules of fatty oils. In some insects the fat bodies have a brilliant yellow, golden, or orange color. Associated with the fat cells are other much larger and often gigantic cells, called *anocytes*, attaining the largest size of all the cells in the body except the eggs. They were first discovered in segmental clusters attached to the tracheæ near the spiracles, but they are now known also to be scattered through the depths of the body cavity, where they occur imbedded especially between the fat cells. The term "anocyte" signi-

fies merely that those cells first observed by Wielowiejski, who gave them this name, were slightly wine-colored.

Both the fat cells and the *œnocytes* of the honey bee have been specially studied by Koschevnikov (1900), who gives the history of the **fat body** as follows: In the larva it consists of gigantic lobes, the cells of which are in general all alike and so closely packed in 30 or more layers that, in the younger stages, most of them assume angular forms. Many of them are binucleate, and the protoplasm is strongly vacuolated except for a small area about the nuclei. In the full-grown larvæ the fat cells become globular and filled with a number of round granules, which, during the early part of the pupal stage, are set free by a dissolution of the cell walls and float free in the body cavity. In pupæ a little older, having even but a very thin chitinous covering, the adult fat body is fully formed, and yet neither the disappearance of the larval granules and nuclei nor the formation of new adult fat cells is to be observed. It seems that the granules of the larval fat cells, set free at the beginning of histolysis, are reassembled about the nuclei to form the fat cells of the adult. In the very young imago the cells of the fat body are very distinct, and each possesses a considerable amount of protoplasm, with enormous vacuoles which press upon all sides of the nucleus. In old bees the vacuolation is much reduced and may even be entirely lacking, while the cells become filled with a solid granular plasma. Old workers examined in the fall show the fat cells united into *syncytia* or masses in which the cell boundaries are lost, although the nuclei remain distinct. A queen does not appear to form these *syncytia* in old age.

The function of the fat body is still unsettled, but we do not know of any reason why it should not be comparable physiologically with the fat of vertebrate animals and constitute a reserve supply of materials which can be used both as food and as a source of heat oxidation. It has already been stated (p. 115) that insects maintain several degrees of body temperature. Some entomologists have supposed that the fat body gives rise to the corpuscles of the blood, others have believed it to be an excretory organ because concretions of uric-acid salts are often found associated with its cells, while still others have regarded it as the seat of the combustion of waste products by the tracheal oxygen.

The *œnocytes* of the bee are described by Koschevnikov (1900) as enormous cells imbedded in the fat bodies. He says that those of the larva persist into the pupal stage where they undergo dissolution and disappear, while new imaginal *œnocytes* are formed from proliferations of the ectodermal epithelium. The new ones are at

first small and increase about five times in diameter before reaching their adult proportions. The fat cells and the cenoctes, although closely associated with each other, are easily distinguishable by their size and by their reaction in life to staining solutions. Koschevnikov fed some bees honey or sugar sirup containing sesquichlorate of iron and then, after a few hours, removed the fat body, washed it in ferrocyanide of potassium, and placed it in alcohol acidulated with hydrochloric acid. He found a precipitate of Berlin blue in the fat cells while the cenoctes remained perfectly colorless. Thus he showed conclusively that the two classes of cells are physiologically different in life, although, he says, if a piece of dissected fat body be placed in the staining solution the color diffuses alike throughout all the cells.

The cenoctes have a golden brown pigmentation but no differentiated contents in young workers and queens. In old workers, toward the end of the summer, yellow granules begin to appear in them. During winter and especially in early spring the cenoctes of the workers contain a great number of these granules, but they are present in greatest quantity in queens several years old, while in the latter the fat cells also contain similar granules. Although Koschevnikov admits that the chemistry of these granules is entirely unknown, he thinks that they are undoubtedly excretory substances, that the waste products of metabolism are first taken up by the cenoctes and then delivered to the blood, and that the accumulation of the granules in the cells during old age means the loss of power to discharge them, which brings on the decline in the life activity of the bee. If this is so, then the cenoctes are, as he states, excretory organs without ducts—cells which serve as depositories for waste products.

According to this theory of Koschevnikov, the cenoctes might be likened in function to the liver of vertebrate animals, which, according to the present views of physiologists, is the seat of the splitting up of the immediate nitrogenous products of katabolism, discharged into the blood from the tissues, into those final compounds of nitrogen excreted by the kidneys.

Wheeler^a also describes the fat cells and cenoctes of insects as perfectly distinct in their origins, the fat cells arising from the mesoderm, which is the embryonic cell layer between that which forms the outer body wall and that which forms the embryonic alimentary canal, while the cenoctes are derived from internal proliferations of ectodermal cells.

^a Concerning the Blood Tissue of Insects. *Psyche*, VI, 1892, pp. 216-220, 233-236, 253-258, Pl. VII.

X. THE NERVOUS SYSTEM AND THE EYES.

We have learned so far that the bee is a complex animal made up of a large number of tissues and organs all definitely interrelated, and we speak of these tissues and organs as performing their own special functions. Yet, in itself, a mass of cells, even though a living mass, is incapable of doing anything—it is inert unless stimulated into action. The legs would not move, the heart would not beat, the glands would not secrete, the respiratory movements would not be produced, and the animal would cease to live were it not for a vital force that incites them all into activity. This force is generated by certain cells of the nervous system and is sent out to the other organs along the nerve cords, but we know nothing more about it than simply that it exists in living animals and is dependent upon the maintenance of the nerve cells.

Now, in order that an animal may be “alive,” it is not only necessary that the muscles should be made to contract, the glands to secrete, and all the other organs induced to perform their individual rôles, but it is equally important that they should all work together and accomplish definite results. The muscles must perform harmonious movements to produce walking, flying, breathing, or swallowing, the heart must beat in proper rhythm, the glands must secrete their juices at the right time and in needed amounts. Hence, the functions both of *stimulation* and *coordination* devolve upon the nervous system. The nerve-cells generate a force which, delivered through the nerve-fibers to the various organs, irritates the tissues into activity, but, at the same time, the cells send out this force in such a methodical manner that the activities produced in the different organs are definitely correlated and cooperate in maintaining the necessary condition for the life of the cells.

The nervous system, however, is more than simply the source of these physical and chemical processes that constitute the visible phenomena of life, for it is also the seat of all sense perceptions and, in the higher animals, of consciousness. We do not know, however, that insects possess consciousness—that they are actually aware of their own existence, and we therefore do not know that they have conscious sense perceptions. We do know that they are affected by external objects—by light, heat, taste, odor, pressure, and perhaps sound acting upon specially sensitized cells of the ectoderm called sense organs, but we do not know that the reaction of the individual is anything more than the exhibition of a very highly developed reflex nervous system. It is most probable that bees do all that they do—make the comb, store up honey and pollen, feed the young, attend to the wants of the queen, and so on—without knowing why, and we have no evidence that they are even conscious of the fact that they do

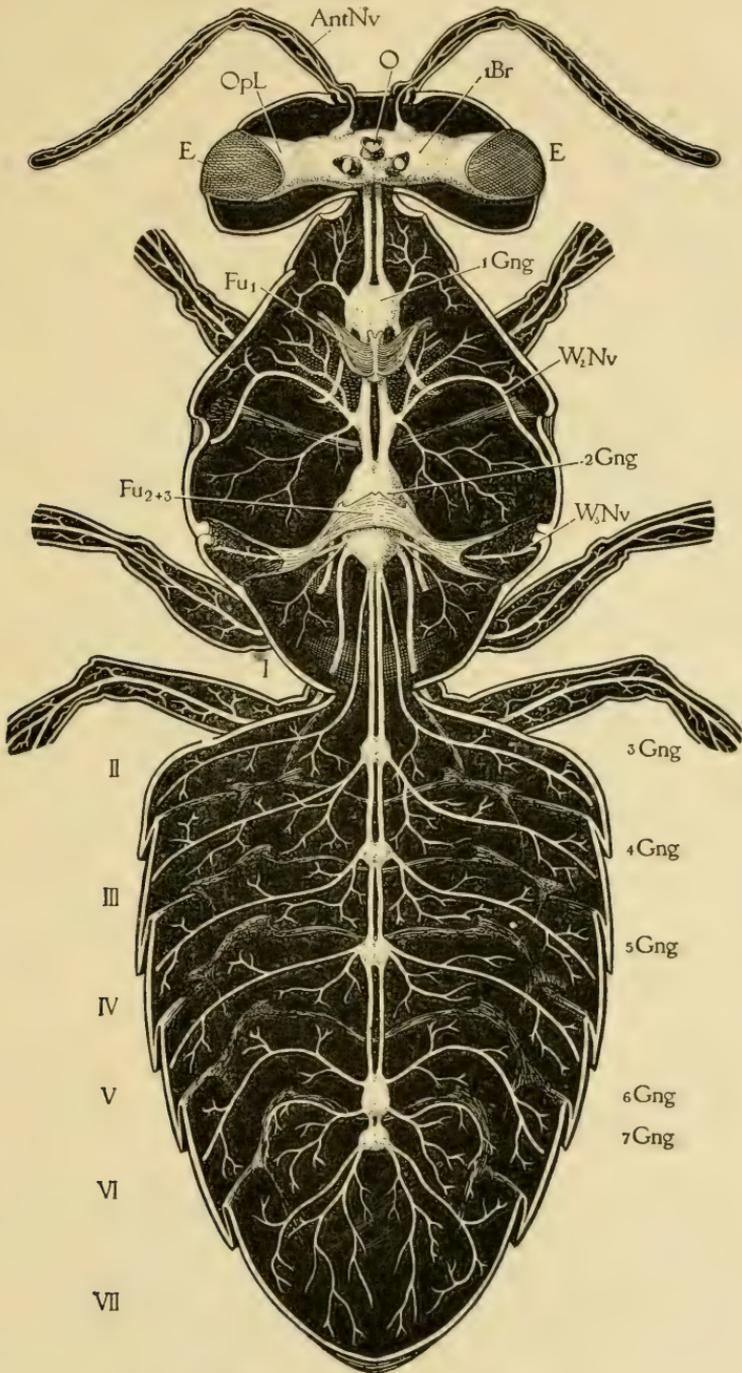


FIG. 52.—Nervous system of worker, dorsai view.

these things. Some authors have tried to prove that insects reason, but the burden of proof is still with them. We can admit that insects *may be* possessed of very slight conscious intelligence, but we can not admit that any one has ever *proved* it. Of course, a great deal of very interesting insect literature owes its readableness to the fact that the author endows his subjects with human emotions and some intelligence, or makes it appear that they consciously do things from a blind sense of obligation. The bee of literature is often quite a different creature from the bee of science.

If, then, we are forced to admit that we have no proof of intelligence or of conscious sensations in insects, we have, on the other hand, all the more evidence of a very high degree of nervous coordination. The body of a bee can be very greatly mutilated and the creature will still remain "alive" as long as the nervous system is left intact. The segments can be cut apart and each will yet be able to move its appendages as long as its nerve center is not destroyed. This shows that there are numerous vigorous centers of nervous stimulation, but proper coordination results only when all the parts are together and intact.

The **nervous system** of insects (figs. 1 and 52) is comparatively simple, consisting of a series of small nerve masses called *ganglia* (*ting*) lying along the mid-ventral line of the body, each two consecutive ganglia being connected by a pair of cords called the *commissures*. The ganglia contain the nerve cells, which are the source of the stimuli sent out to the other tissues, while they also receive the stimuli from the ectodermal sense organs. Thus there are incoming or *afferent* stimuli and outgoing or *efferent* stimuli. The commissures and the nerve-trunks that branch to all parts of the body consist of fibers which are fine prolongations of the nerve cells. These fibers are the electric wires that convey the stimuli to and from the nerve centers and are of two kinds, afferent and efferent, according to the direction of the stimulus each transports.

In a generalized embryo we should theoretically find a nerve ganglion developed from the ventral wall of each segment, making seven head ganglia, three thoracic, and at least ten abdominal ones. In the adult, however, many of these fuse with one another. In the head, for example, in place of seven ganglia there are only two, one situated above the œsophagus, called the *brain*, and one situated below it and called the *subœsophageal ganglion*. The connecting cords are known as the *circumœsophageal commissures*. The brain is composed of three embryonic ganglia, and in the adults of many lower insects these are still evident as three well-marked cerebral divisions or swellings, called the *protocerebrum*, the *deutocerebrum*, and the *tritocerebrum*. The first carries the *optic lobes* and innervates the compound and simple eyes, the second bears

two large *antennal lobes*, from which are given off the antennal nerves. The third innervates the lower part of the face and the labrum, while it gives off also a pair of nerves which unite in a small swelling, the *frontal ganglion*, that lies between the pharynx and the front of the head. A nerve runs posteriorly from this on the dorsal side of the pharynx or œsophagus to behind the brain, where it divides into several branches, some of which bear small ganglia while others extend backward on the œsophagus to the stomach. These nerves, originating in the frontal ganglion, constitute the *stomato-gastric system*, sometimes called also the "sympathetic system."

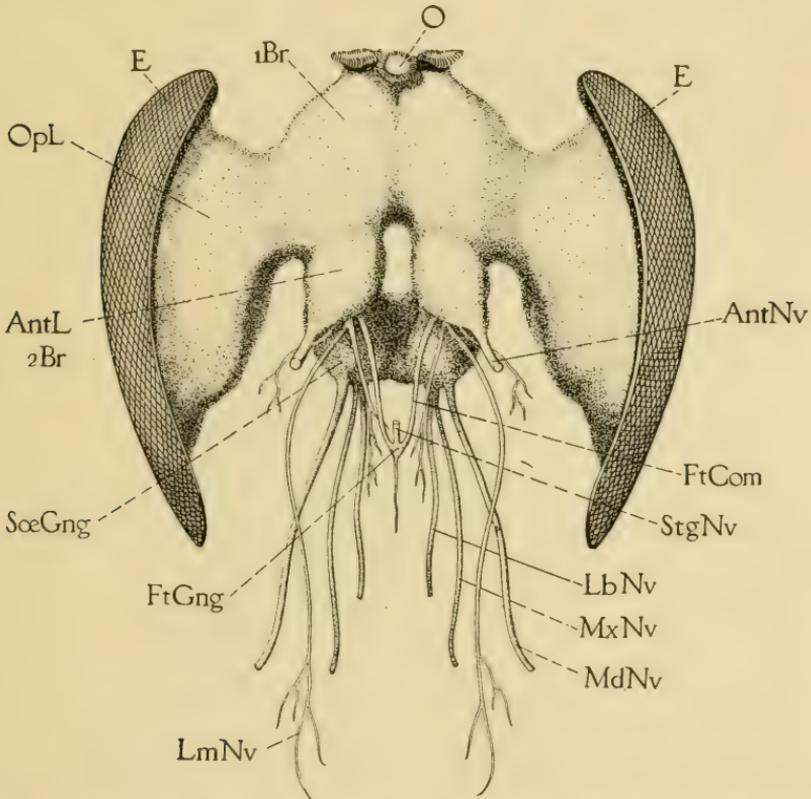


FIG. 53.—Brain and subœsophageal ganglion of worker and their principal nerves, anterior view.

The subœsophageal ganglion consists of at most four ganglia which innervate the mandibles, the hypopharynx, the first maxillæ, and the labium or second maxillæ. In adult insects the body ganglia also very commonly fuse with one another in varying combinations, for the number present is always less than the number of segments, varying from eleven to one.

The brain of the bee (fig. 53, *Br*) is distinctly composed of two parts, the protocerebrum (*1Br*), carrying the large optic lobes (*OpL*), and the deutocerebrum (*2Br*), which consists principally of the con-

spicuous antennal lobes (*AntL*) that give off the large antennal nerves (*AntNv*). The tritocerebrum is not present as a distinct brain division, and its nerves, the labral (*LmNv*) and the frontal (*FtCom*), appear to arise from the deutocerebrum at the base of the antennal lobes. The frontal ganglion (*FtGng*), formed at the union of the two frontal nerves, gives off a very small, anterior, median nerve and a much larger, posterior, stomatogastric trunk (*StgNv*, represented in the drawing as cut off a short distance behind the frontal ganglion) which goes backward on the dorsal side of the pharynx beneath the brain. Behind the latter, and just where the pharynx contracts to the tubular œsophagus, the stomatogastric nerve bears a pair of small ganglia which are connected by short nerves with the brain, and then it breaks up into branches that go posteriorly along the œsophagus but have not been traced.

The circumœsophageal commissures are so short in the bee that the subœsophageal ganglion appears to be attached directly to the lower ends of the brain, while the œsophagus appears to penetrate the latter between the antennal lobes. The three principal pairs of nerves from the lower ganglion (*MdNv*, *MeNv*, and *LbNv*) go to the mouth parts.

A most thorough study of the internal structure of the brain of the bee has been made by Kenyon (1896), to whose paper the reader is referred if interested in this subject. Kenyon's descriptions have never been verified, but his work has an appearance of thoroughness and carefulness. He applies the term "brain" to both of the nerve masses of the head, distinguishing the upper as the "dorsocerebrum" and the lower as the "ventrocerebrum," being led to do this from physiological considerations, the separation of the two being merely incidental to the passage of the œsophagus.

In the thorax of the bee (figs. 1 and 52) there are two large ganglia (*1Gng* and *2Gng*). The first is prothoracic, being situated above the prosternum, in front of the entosternum (fig. 52, *Fu₁*), and it innervates the prothorax and the first pair of legs. The second, which is situated in front of the middle legs and is protected above by the arch of the common entosternum of the mesothorax and metathorax (fig. 52, *Fu₂₊₃*), is a combination of the mesothoracic and metathoracic ganglia and the first two abdominal ganglia. This composite structure is evident from the fact that it innervates both the middle and the hind legs, the bases of both pairs of wings, the mesothorax, the metathorax, the propodeum, and the first abdominal segment behind the constriction (the true second segment). The first and second ganglia of the abdomen (fig. 52, *3Gng* and *4Gng*) lie in the first two segments (*II* and *III*) behind the constriction, which are the true second and third segments. But since the nerve trunks of these ganglia go, in each case, to the segments behind them, we

assume that they really belong to these latter segments, that is, to segments *III* and *IV*. The next three ganglia (*5Gng*, *6Gng*, and *7Gng*) lie in the segments they innervate (*V*, *VI*, and *VII*) and, hence, belong to the fifth, sixth, and seventh abdominal segments. The last, that is, the seventh ganglion, supplies all of the segments behind it with nerves and is therefore probably a compound of the ganglia originally belonging to the seventh, eighth, ninth, and tenth segments.

In connection with the nervous system it is most convenient to give a description of the simple and compound eyes. The other

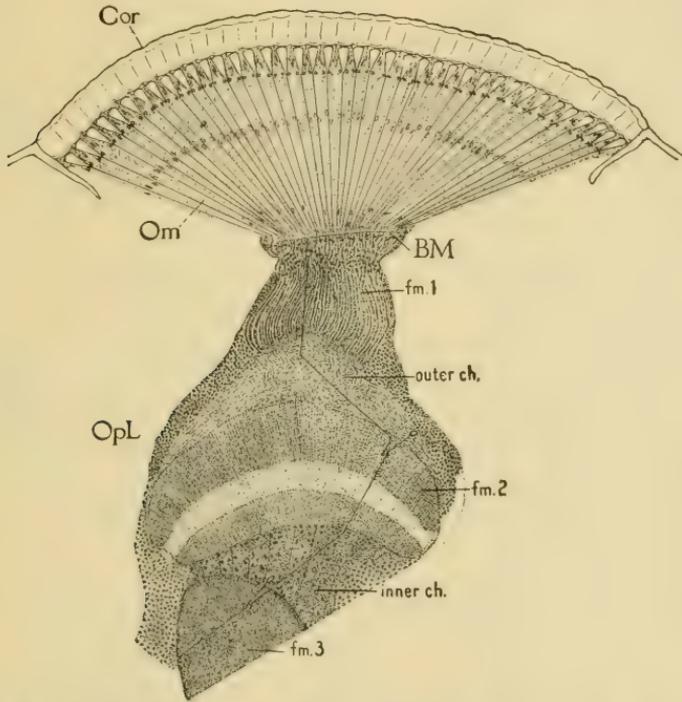


FIG. 54.—Horizontal section of compound eye and optic lobe of worker (after Phillips): *BM*, basement membrane; *Cor*, cornea; *fm₁*, *fm₂*, *fm₃*, outer, middle, and inner fibrillar bodies of optic lobe; *inner ch.*, inner chiasma; *Om*, ommatidium; *OpL*, optic lobe; *outer ch.*, outer chiasma.

sense organs will be found already described along with the parts on which they are located (see pp. 36 and 52). All the sense organs, to be sure, are of ectodermal formation and are only secondarily connected with the nervous system, but the eyes are so intimately associated with the optic lobes of the brain that their description here seems most appropriate.

The **compound eye** of the bee (figs. 9 A, 10, 52, and 53, *E*) has been specially studied by Phillips (1905) and figures 54 and 55 are reproduced from his drawings, while the following statements are based on his paper: The convex outer surface or *cornea* of the eye

presents a honeycomb appearance under the microscope, and each little hexagonal facet is the outer end of an eye tube called an *omma*-

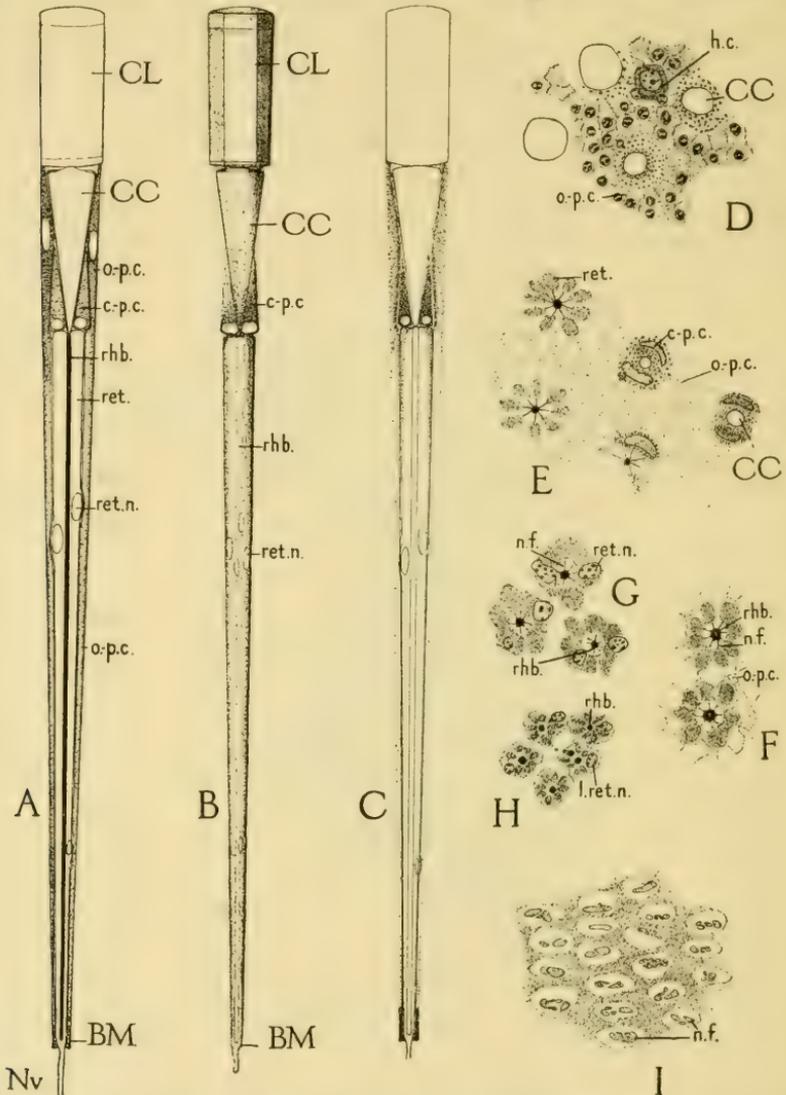


FIG. 55.—Histological details of compound eye of worker (after Phillips): A, entire ommatidium (somewhat diagrammatic), adult; B, entire ommatidium, as if dissected out, without outer pigment cells (diagrammatic), adult; C, section of entire ommatidium, showing distribution of pigment, adult; D, cross section just proximal to lens, slightly oblique; E, cross section through extreme distal ends of retinulae and proximal ends of cones, slightly oblique; F, cross section through retinulae, showing relation of outer pigment cells in this region; G, cross section through retinulae in region of nuclei; H, cross section through retinulae in region of proximal nucleus; I, cross section of eye, cutting basement membrane parallel (the distinctness of nerve fibers of each ommatidium is shown); BM, basement membrane; CC, crystalline cone; CL, crystalline lens; c.p.c., corneal pigment cell; h.c., hair-cell; l.ret.n., lower retinular nucleus; n.f., nerve fiber; Nv, nerve; o.p.c., outer pigment cell; ret., retinula; ret.n., retinular nucleus; rhb., rhabdome.

tidium, all of which converge toward the internal base of the eye, since each is vertical to the outer surface. Figure 54 is a horizontal

section through the eye and the optic lobe of the brain. The ommatidia (*Om*) are seen converging upon the *basement membrane* (*B.M*) which is penetrated by the nerve fibers from the optic lobe (*OpL*). The outer ends of the ommatidia are transparent, forming the facets which together constitute the cornea (*Cor*) of the eye. The nerve fibers, by a complicated course through the optic lobe, reach the nerve cells of the brain, which are the true seat of sight perception, as of all other sensations, whether conscious or otherwise.

The ommatidia (*Om*), or eye tubes, are separated from one another by cells containing a dark coloring matter and known as the *pigment cells*. Each tube (fig. 55 A) consists of several parts, as follows: First, on the outside, is a clear six-sided, prismatic structure, with convex outer and inner surfaces, called the *crystalline lens* (*CL*), and which forms one of the facets of the cornea. Beneath the lens is a *crystalline cone* (*CC*) having its apex directed inward and followed by a *crystalline rod* or *rhabdome* (*rhb*) which extends to the basement membrane (*B.M*) through the middle of the ommatidium. (The rhabdome is represented black for the sake of distinctness in figure 55 A; its natural appearance is more as shown in B and C.) Surrounding the rod is a circle of eight or nine long *retinula cells* (*ret*), each containing a conspicuous nucleus (*ret. n*) above its middle and continuing basally into an optic nerve fiber (*Nr*) penetrating the basement membrane. The arrangement of these cells about the rhabdome is shown in cross section at F and G. The inverted apex of the crystalline cone (A, B, and C, *CC*) is surrounded by the *corneal pigment cells* (*c.-p. c.*), while the entire ommatidium below the lens—the base of the cone, the corneal pigment cells, and the retinulae—is surrounded by the long outer pigment cells (*o.-p. c.*), forming a packing between all the ommatidia, as shown in cross section at E.

The entire compound eye is simply a modified part of the epidermis (so-called "hypodermis" of insect histologists) in which the cuticle is transformed into the lenses or cornea, the cones, and the rods, the epithelium into the pigment and retinulae cells, and the basement membrane into the floor of the eye perforated by the optic nerve fibers. According to Phillips the ommatidia arise from the ectoderm of the bee larva as groups of epithelial cells which become arranged in the form of spindles surrounded by smaller cells. The cells of the spindles become the retinulae, while the surrounding small cells become the pigment cells and the cone cells. The cone cells come to occupy a position external to the retinulae by an invagination of the latter, and, through a transformation of most of their protoplasm into a crystalline substance, they form the crystalline cone of the eventual ommatidium. The approximated edges of the retinulae cells are

transformed into the crystalline rod. The cornea is secreted by the corneal pigment cells, which at first lie distal to the cone, and possibly also by the outer pigment cells. The nerve fibers are formed as differentiated parts of the retinulae which penetrate through the basement membrane (fig. 54, *B.M.*) and enter the retinular ganglion beneath it at the outer end of the optic lobe of the brain. Hence the retinulae are simply sense end-organs of the skin comparable at an early stage of their development with other sensory epidermal cells, and we thus see how a simple layer of epithelium may be transformed into such an immensely complex organ as the compound eye.

There has always been a great deal of discussion as to how insects see by means of the compound eyes. The weight of opinion now favors the theory that they see a part of the object or field of vision with each ommatidium. But it is most certain that, at best, most insects see very indistinctly, and, in fact, it is often questioned whether they really see the shape of objects at all or not. A few of them, however, such as dragonflies, appear to have a very acute vision. In the case of the honey bee there is yet much difference of opinion as to whether the workers discover nectar by the bright color of the flowers (i. e., by the sense of sight) or by the sense of smell. The sense of sight in bees and in insects generally, however, may be found elaborately discussed in many books dealing with the senses of insects.

The **simple eyes** or **ocelli** (figs. 9 A, 10, 52, and 53, *O*) are constructed on quite a different plan from that of the compound eyes, each consisting of a lenslike thickening of the cuticle back of which the epithelial cells are specially elongated, and sensitized by nerve connections. The ocelli of the bee, however, have never been carefully studied.

XI. THE REPRODUCTIVE SYSTEM.

The reproductive organs are those that produce the cells from which new individuals are formed. All animals grow from at least one cell called the *egg* and almost all from a combination of the egg with another cell called a *spermatozoon*. The uniting of these two cells is called the *fertilization of the egg*. In a few animals the two different kinds of reproductive cells are formed in the same individual, but in most of them, including all insects, the sperm and the eggs are produced in different individuals—the *males* and the *females*. In the honey bee the males are called *drones*, while the females are called *queens* or *workers*, according to their functions in the hive. The queens have the egg-producing organs or ovaries greatly developed, while these organs are rudimentary in the workers. The single active queen in each hive, therefore, normally produces all the eggs of the colony, while the work of rearing and providing for the brood

falls to the lot of the workers. Most other female insects lay their eggs at some place where the young will be able to find food when they hatch out, and the mother never in any way feeds or protects her offspring; in most cases she dies before her brood emerges from the eggs. But the wasps and bees are different in that nearly all of them make a nest of some sort for the protection of the young larvæ when they hatch, in which also they store up food for them to eat. In many species of wild bees all the work of constructing the nest, laying the eggs, and collecting and storing food for the young devolves upon the single female, as it naturally should, since insects do not ordinarily have servants, and the males of most species are utterly irresponsible in such matters. In some of the higher wasps, such as the hornets and yellow jackets, however, the first females that hatch out as adults in the spring help their mother provide for a still larger family by increasing the size of the house and collecting more provisions. Nature designed them for this purpose, moreover, by making them all sterile, allowing them to retain the maternal instincts, but depriving them of organs capable of producing offspring of their own. Thus there is here a beginning of that division of labor which reaches its highest development in the honey bee, where one form of the female is specialized entirely to produce the young and the other to rear the brood, keep the home in order, gather the food, and ward off enemies. The differences between the queens and the workers are supposed to result from the different diet on which larvæ designed to be queens are brought up, but a more thorough investigation of the food given to the different larvæ of the brood is yet needed before we can decide on the merits of this explanation. The work of numerous investigators seems to have demonstrated conclusively that the drone of the honey bee is always produced from an egg cell alone—that is, from an unfertilized egg—while the queens and workers are produced from fertilized eggs. The production of eggs that develop normally without the addition of the male element is called *parthenogenesis*. In a number of insects, such as some species of scales, a few beetles, and some of the gall-forming Hymenoptera, there are no males known, although the females are extremely abundant. Such cases are often regarded by entomologists as examples of parthenogenesis, and, if they are such, the result of the development of unfertilized eggs is here the formation of females only. A few other insects, such as some of the plant lice, produce eggs that develop without fertilization into females or into both males and females, but such cases nearly always occur in a cycle of alternating generations in which, at some stage, all the eggs are fertilized. As far as is known the production of males alone from parthenogenetic eggs is confined to the order Hymenoptera.

1. THE MALE ORGANS.

The reproductive organs of the drone are shown by figure 56 A. They consist of the *testes* (*Tes*), the *vas deferens* (*VDef*), the *vesicula seminales* (*Ves*), the *accessory* or *mucous glands* (*AcGl*), the *ductus ejaculatorius* (*EjD*), and the *penis* (*Pen*).

The *testes* of the bee (*Tes*) are said to be best developed in the pupa, at which stage they form the spermatozoa. Each consists of a large number of small tubules opening into a collecting reservoir at the end of the *vas deferens*. The spermatozoa pass down through the coiled *vas deferens* (*VDef*) and collect in the saclike enlargement of this duct, which constitutes the *vesicula seminalis* (*Ves*). In the mature adult drone these elongate sacs are densely packed with the active spermatozoa, while the testes that produced them become rudimentary. The vesiculæ when freshly dissected appear to be alive, for they bend and twist themselves about like small worms. Each opens by a short duct into the base of the *accessory mucous gland* (*AcGl*) of the same side. These organs have the form of two great sacs and are filled with a thick, white, homogeneous, finely granular liquid, which is supposed to mix with the spermatozoa as the latter are discharged. The two open at the bases into the single median *ejaculatory duct* (*EjD*) which opens into the anterior end of the *penis* (*Pen*). This last organ, shown in lateral view by figure 56 E, is an unusually large structure in the bee and is deeply invaginated into the cavity of the abdomen from the end of the ninth segment (*D, Pen*) as already described (see page 73). While the penis is simply an ectodermal tube, its walls present a number of very curious differentiations. The upper part is enlarged into a bulb (fig. 56 A and E, *B* and *PenB*) having two large irregular but symmetrical chitinous plates (*tt*) in its dorsal wall, beneath which is a large gelatinous thickening (*B, ss*). Near the base of the bulb is a double pinnate lobe (*A* and *E, uu*) projecting from the dorsal wall. Below this, on the ventral side, is a series of close-set, transverse plates (*E, vv*), followed again by large dorsal and ventral plates (*ww* and *xx*). The terminal part makes a thin-walled chamber (*A* and *E, yy*), from which project backward two very large membranous pouches (*zz*) ending in blunt points. The whole tube of the penis is capable of being turned inside out, and it is said that copulation is effected by its eversion into the oviduct of the queen, the basal pouches of the penis (*zz*) being forced into corresponding pouches of the oviduct, and the spermatozoa in the bulb placed near the opening of the spermatheca in the vagina. By their own activity probably the spermatozoa now make their way up into this receptacle of the female, the spermatheca, where they remain until ejected upon eggs passing down the oviduct. The spermatozoa received from one drone normally last the queen

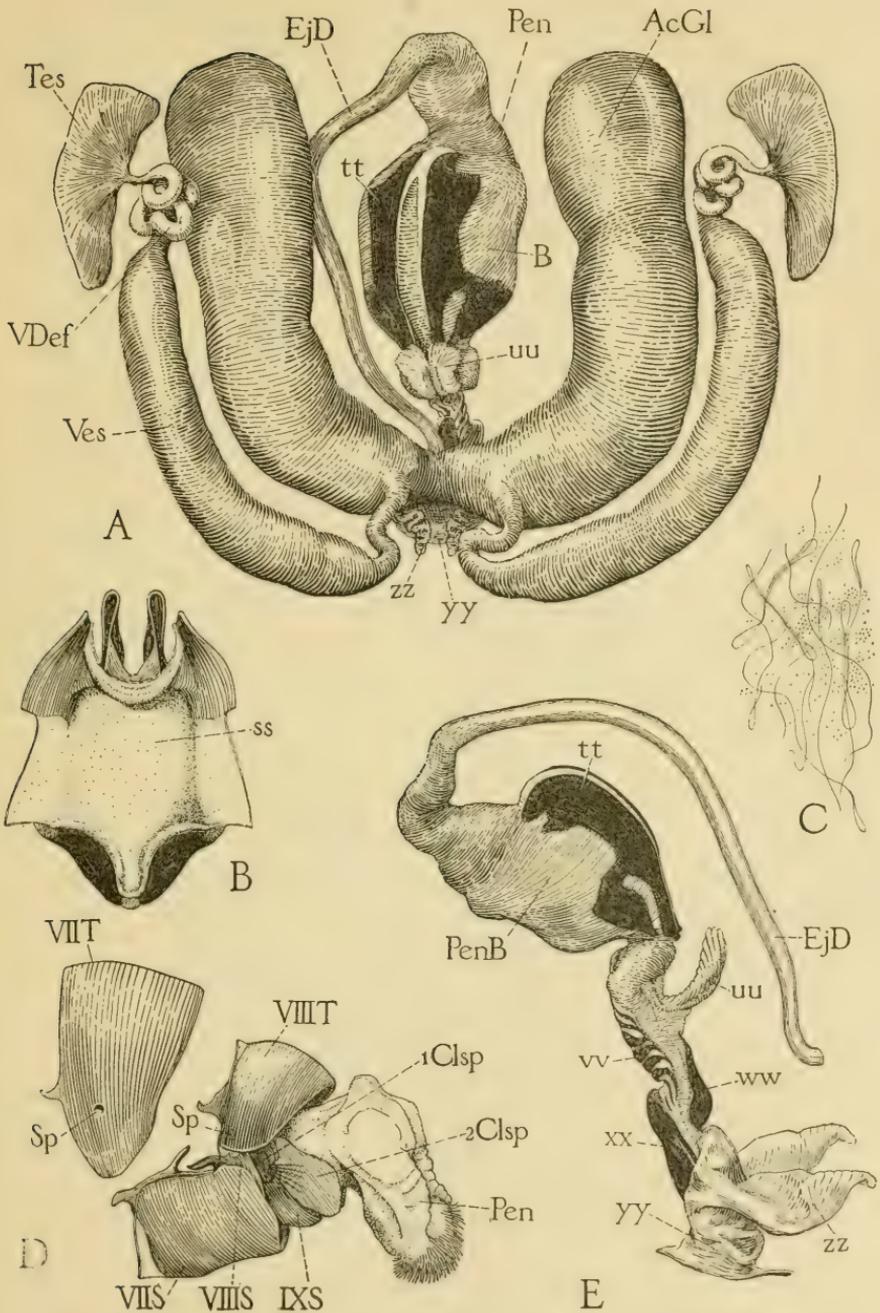


FIG. 56.—A, reproductive organs of drone, dorsal view, natural position; B, inner surface of dorsal wall of bulb of penis (E, *PenB*), showing gelatinous thickening (*ss*); C, group of spermatozoa and intermixed granules; D, terminal segments of male abdomen, showing the seventh tergum (*VIIIT*) removed from its sternum (*VIIIS*) and the penis (*Pen*) partly protruded; E, lateral view of penis as invaginated within abdomen, and ejaculatory duct (*EjD*).

throughout her life, so that after mating she goes into the hive never again to emerge except with a swarm, and her entire life is devoted to egg laying. The drone, on the other hand, dies immediately after mating, while those that do not mate are driven out of the hive in the fall and left to starve.

The *spermatozoa* (fig. 56 C) are minute threadlike cells, capable of a vibratory motion. As found in the vesiculae, they are usually bent into closely compressed loops, although many are extended to their entire length. One end is blunt, but not noticeably enlarged, the other is tapering, while the half toward the tapering end seems to be the part chiefly endowed with the power of motion. The sperm threads are contained in a liquid within the vesiculae, in which float also a great number of minute granules. The vibrations of the spermatozoa keep these granules in constant motion.

2. THE FEMALE ORGANS.

The organs of the female that produce the eggs are called the *ovaries* (fig. 57, *Ov*). In insects they consist of a varying number of egg tubules or *ovarioles* (*ov*) forming two lateral groups, in each of which the tubules converge at both ends, the anterior ends being drawn out into fine threads whose tips are connected, while the posterior ends are widened and open into the anterior end of the *oviduct* (*OvD*) on the same side of the body. An egg is simply a very large cell whose size is due to the great accumulation of yolk in its protoplasm, which serves as food for the future embryo. The eggs are formed in the terminal threads of the ovarioles and are at first apparently ordinary undifferentiated cells, but as they pass downward in the tubule they increase in size at the expense of some of the other ovarian cells. Hence the ovarioles usually have the form of a string of beads arranged in a graded series from very tiny ones at the upper end to others the size of the mature egg at the lower end. The two oviducts converge posteriorly and unite into the common median duct or *vagina* (*Vag*) which in most insects opens to the exterior upon the eighth sternum, as already described in the general account of the external anatomy of insects (see page 25), but in the bee and many other insects the eighth sternum is entirely lacking as a distinct sclerite, and the genital opening is therefore behind the seventh sternum and below the base of the sting. The posterior part of the vagina is very large, forming a *bursa copulatrix* (*BCpx*). In addition to these parts there is nearly always present in insects a special receptacle for the spermatozoa called the *spermatheca* (*Spm*). This, in most insects, opens directly into the vagina as it does in the bee, but in some it opens into the roof of the genital chamber above the eighth sternum, when this is present, by a separate orifice behind that of the

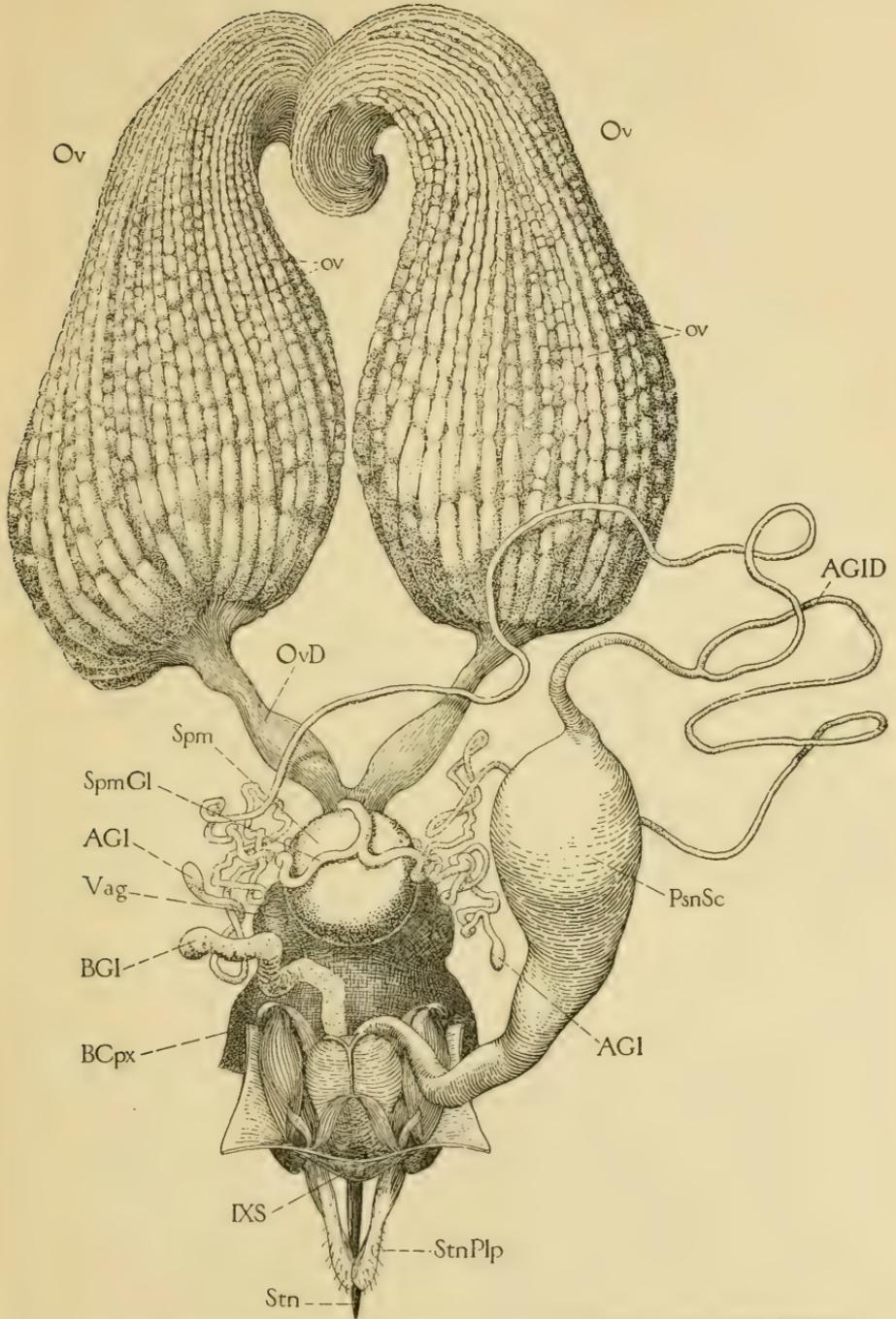


FIG. 57.—Reproductive organs, sting, and poison glands of queen, dorsal view.

vagina. In the bee the two poison glands (*AGL* and *BGL*) do not open into the vagina but, as already described, into the base of the sting. They are, hence, probably special organs having no homologues in nonstinging insects.

The ovaries of the queen bee form two large gourd-shaped masses (fig. 57, *Oⁿ*) whose posterior or basal ends are enlarged and whose anterior ends are narrowed, curved, and attached to each other. Since the queen lays eggs continuously during her entire life the ovaries always contain eggs in all stages of growth, and consequently do not vary so much in appearance as they do in those insects that ripen only one lot of eggs and deposit these all at one time.

The structure of the ovarioles and the formation of the eggs in the bee have been specially studied by Pauleke (1900) and the following is a résumé of his paper: The terminal threads of the ovarioles are covered by a thin tunica propria and are filled with a protoplasmic mass containing transversely elongate nuclei in a single close series, but no cell outlines. Farther down, in the upper end of the ovariole proper, the nuclei become arranged in two rows, while here also the cell boundaries begin to appear; still farther along, where the cells are clearly defined, the latter become differentiated into epithelial cells and germ cells. Next, the germ cells themselves divide into egg cells and food or nurse cells. When first formed the egg cells occur in any part of the diameter of the tube, but they soon become arranged in a row down the middle of the ovariole and are separated by groups of nurse cells. The epithelial cells at this time arrange themselves on the periphery just within the tunica propria, but farther down they form a capsule or follicle about the egg and, less definitely, about the group of nurse cells at its upper end. The upper end of the egg becomes narrowed by a constriction of the epithelial capsule, which, however, does not shut it off from the nurse cells, a connection being retained with the latter in the form of a neck from the egg abutting against them. There are 48 of these nurse cells to each egg, which fact is accounted for by supposing that each original germ cell divides into 4, one of which ceases further division and becomes the egg cell, while each of the other 3 divides into 16 by four consecutive divisions. The latter are the nurse cells and their function is to nourish the egg cells. They persist down to the time when the egg is fully formed, when they suddenly disappear by being absorbed bodily into its yolk. Toward the end of the growth of the egg the follicle cells become thinner and thinner, so that when the egg is ready to go into the oviduct it has but a thin membrane to break through.

The organs of most especial interest to the student of the bee are the spermatheca and the apparatus by means of which the queen is able to dole out the spermatozoa to the eggs as she deposits the latter.

The spermatheca consists of a globular seminal sac (fig. 57, *Spm*), of a pair of tubular accessory glands (*SpmGl*), and of a duct whose upper end is connected with the sac and receives also the duct of the glands, and whose lower end opens into the anterior part of the dorsal wall of the vagina just caudad of the united bases of the oviducts.

The spermatozoa are discharged by the male into the upper end of the vagina, and in some manner they make their way up into the sperm sac through the duct. Cheshire (1885) described the latter as forking toward its lower end into an anterior branch which opens into the vagina and into a posterior branch which turns backward and becomes lost in the lower end of the vaginal wall. This second branch he believes is open in the young queen and is the one through which the spermatozoa enter the sac. Breslau (1906) has shown, however, that Cheshire was entirely wrong in his supposed observation of the forking of the duct, that the latter is a single tube, and that consequently the spermatozoa must both enter and leave the sac by the same conduit. It used to be supposed that the sperm sac had muscular walls and that it forced the spermatozoa out as from a compressed bulb, but Breslau has shown that this also is a mistaken notion, that the walls of the sac are entirely devoid of muscular fibers, and that the spermatozoa are sucked out by a muscular apparatus in the wall of the duct, which structure he names the *sperm pump*. Cheshire (1885) had previously described this apparatus in a very imperfect manner without recognizing any pumping function, for he supposed that by the relaxation of certain muscles the spermatozoa simply passed out of the sac and went down the tube. Breslau says, however, that the spermatozoa have not enough energy of their own to come out of the sac and, hence, do not need to be kept in by a special sphincter muscle, as described by Leydig.

The upper end of the spermathecal duct makes an **S**-shaped bend just beyond the opening of the sac, and a number of muscles disposed upon this part constitute Breslau's sperm-pump. Breslau shows that a contraction of certain of these muscles flattens the bend of the **S** and causes an enlargement of the lumen of the upper end of the loop. This, therefore, sucks into itself a small bundle of spermatozoa from the sac. The contraction then of other muscles forces the rest of the sperm-threads back into the mouth of the sac and drives the small bundle thus cut off down through the duct and into the vagina. Moreover, Breslau claims that this explanation is not theory only, for, by preparing histological sections from queens killed at different moments of egg-laying, he procured specimens showing the various stages in the pumping process and in the passage of the sperm through the duct. Cheshire calculated that a normal queen lays 1,500,000 eggs in her lifetime and that the spermatheca

holds about 4,000,000 spermatozoa, and therefore, allowing for drones, he concludes that there can not be more than four sperm-threads given to each female egg. But Breslau, figuring from the size of the sperm-bundle taken into the duct for each egg, states that each egg is actually given 75 to 100 spermatozoa. We feel that the latter calculation must be much more reliable than that of Cheshire because it is based on an actual observation of the size of the sperm mass delivered to the egg. Moreover, the myriads and myriads of tiny spermatozoa contained in the spermathecal sac make any attempt at a calculation of the number look absurd, and we can not believe that it is possible to even approximate the number present. Furthermore, as Breslau states, 100 spermatozoa make such an excessively small bundle that it requires a most effective and perfect apparatus to deliver even this number with anything like exactness—it is inconceivable that a mechanism could be perfect enough to give out only 4 or 5 or even 7 at a time.

On the floor of the vagina, opposite the opening of the spermathecal duct, is a free flap provided with muscles, which is so situated that when elevated its end fits into the opening of the duct above. Leuckart (1858) explained this flap as a contrivance for holding the passing egg tight against the upper vaginal wall so that its aperture through which the spermatozoa is received, called the micropyle, would come against the opening of the duct and thus insure fertilization. Breslau, on the other hand, does not think the flap in question has any such function and he regards it as a valve which by fitting into the orifice of the spermathecal duct closes the latter and so prevents the pump from sucking up the contents of the vagina at the same time that it sucks a bundle of spermatozoa out of the sac. Since, however, the flap is on the floor of the vagina and is pressed down by the passing egg it is not clear how it can at such a time act as a valve to close the orifice of the duct in the dorsal wall, since the pump is supposed to work by reflex action as the egg is entering the vagina, though, of course, it may so function before the egg has gone far enough to intervene between it and the duct opening; but it would certainly seem that a valve to close the latter, if needed at all, would be developed in the dorsal wall of the vagina in connection with the orifice itself. Furthermore, a collapsible tube like the spermathecal duct, even though lined with chitin, should automatically close at its lower end when a suction force is applied at the upper end.

Finally, Breslau attributes to the sperm pump not only the function of delivering a definite mass of spermatozoa to each egg, but also that of sucking the spermatozoa up from the vagina of a newly fertilized queen into the spermathecal sac. He does not seem now to see in the valve any obstacle to such an action. The spermatozoa are usually supposed to make their way up the duct by their own vibratory motion.

The anatomy of the spermatheca and the muscular apparatus of its duct for delivering the spermatozoa to the egg does not, as Breslau points out, throw any light on the **determination of sex in bees**. It is a common notion that all eggs of an unfertilized female develop into drones, but this is by no means proved; in fact, there is just as good reason for believing that, while no females develop, there are also no more than the normal number of drones produced—the eggs that might otherwise have developed into females, if laid by a fertile queen, all dying in the cells of the comb, from which they are removed by the workers. Modern investigation of the determination of sex shows that there is probably just as much reason in many cases for supposing that sex is established in the egg of the ovary before fertilization, as there is for believing it to result from fertilization or from subsequent environment of the egg or young embryo. Hence, it is not only very doubtful that the queen determines the sex of her offspring by controlling the fertilization of the eggs, but it is also very uncertain that fertilization itself has anything to do with it. Parthenogenesis in the bee may amount simply to this, that the male eggs, predetermined as such in the ovary, are capable of developing without fertilization, while the female eggs are incapable of such a development and die if they are not fertilized.

Each unlaidd egg of insects in general has a small hole in the upper end of its shell, called the *micropyle*, which admits the spermatozoa to its interior. One or several spermatozoa may enter the egg through this aperture, but the nuclear part of only one unites with the egg nucleus, this constituting the **fertilization of the egg**. After this the micropyle closes and the egg is deposited in a cell of the comb by the queen. The nucleus and a part of the protoplasm of the egg then begin to split up into a number of small cells which—but this is taking us into the development of the next generation, which is beyond the limits of our subject, and so here we must stop.

EXPLANATION OF THE SYMBOLS AND LETTERS USED ON THE ILLUSTRATIONS.

The writer has made an attempt to work out a set of convenient symbols for all the principal external and internal parts in the anatomy of an insect. It has been found, however, that entire consistency is incompatible with practicability, especially in making compound abbreviations, and, therefore, the latter has been given first consideration in many cases. For example, the symbol *Det* suggests the word "duct" when standing alone much better than simply the letter *D*, but such combinations as *SalDet* and *OvDet* are unnecessarily long and the shortened forms of *SalD* and *OvD* are sufficiently suggestive of "salivary duct" and "oviduct." The abbreviation *Sc* is used in such compound symbols as *PsnSc* for "poison sac" and *TraSc*

for "tracheal sac," notwithstanding that *Sc* alone means "subcosta." The symbol *T* is used for "tergum," and $T_1, T_2,$ etc., and *IT, IIT,* etc., indicate individual thoracic and abdominal terga, but *TMcl* is used to signify "transverse muscle." And so, in several other cases, it has been found expedient to sacrifice strict uniformity to practical considerations.

A combination of lower-case letters duplicating one entirely or partly of capitals signifies that the part so designated is a part or subdivision of the other. For example, *Ten* refers to the principal part of the tentorium and *ten* to a minor part; *Pl* and *pl* are subdivisions of the same pleurum; *Lmcl* and *lmcl* are both longitudinal muscles.

The most logical method of referring symbols to any particular segment of the body would be, perhaps, to prefix them with either a Roman or an Arabic numeral corresponding with the number of the segment. A common objection, however, to both would arise from the fact that entomologists are not at all agreed as to how many segments there are in any region of an insect's body. Furthermore, Roman numerals prefixed to all the symbols necessarily used on a drawing of the thorax, for example, would occupy entirely too much space. Finally, it is very desirable to have a method of referring to repeated structures without implying any segmental connection, and prefixed Arabic numerals are certainly most convenient and suggestive for such a purpose. A system often adopted to indicate the segment to which a part belongs, especially in the thorax, is the use of one, two, or three accents in connection with the abbreviation. But accented symbols lack artistic unity, and some of the accent marks are too easily lost in the engraving and printing. For these several reasons the writer has adopted the following system:

Numerical order of any repeated structure is indicated by an Arabic numeral placed before the abbreviation, and has no segmental significance. Thus *1P, 2P,* etc., mean simply "first parapterum," "second parapterum," etc; *1Gng, 2Gng,* etc., mean "first ganglion," "second ganglion," etc., without implying that the ganglion belongs to any particular segment.

Symbols are referred to the prothorax, the mesothorax, or the metathorax, respectively, by the figures 1, 2, and 3 placed below and after them, except on the wings, where such numbers designate the branches of the veins according to the Comstock-Needham system.

The abdominal segments, counting the propodeum as the first, are indicated by the Roman numerals *I* to *X*, and, when any one of these is placed before an abbreviation, it refers the symbol to that individual segment.

The lower-case letters are used, singly and in pairs, to refer to miscellaneous parts having, in most cases, no individual or general anatomical names.

1. SYMBOLS.

<i>A</i> ,	anal vein; <i>1A</i> , first anal, <i>2A</i> , second anal, etc.
<i>AcGl</i> ,	accessory gland of male reproductive organs.
<i>AGl</i> ,	acid gland of sting, opening into poison sac (<i>PsnSc</i>).
<i>AGlD</i> ,	duct of acid gland of sting.
<i>An</i> ,	anus.
<i>ANP</i> ,	anterior wing process of notum.
<i>ANR</i> ,	anterior marginal ridge of notum.
<i>Ant</i> ,	antenna.
<i>AntL</i> ,	antennal lobe of brain.
<i>AntNv</i> ,	antennal nerve.
<i> Ao</i> ,	aorta.
<i>Ap</i> ,	apodeme, any internal chitinous process of body-wall.
<i>Aph</i> ,	anterior phragma of any tergum, prephragma.
<i>Ax</i> ,	the axillaries or articular sclerites of the wing base, designated individually as <i>1Ax</i> , <i>2Ax</i> , <i>3Ax</i> , and <i>4Ax</i> .
<i>ax</i> ,	accessory axillary sclerites of irregular occurrence in connection with the principal axillaries (<i>Ax</i>).
<i>AxC</i> ,	axillary cord, or ligament-like thickening of posterior edge of basal membrane of wing, attached to posterior angle of scutellum.
<i>AxM</i> ,	axillary membrane, the thin membrane of wing base, containing the axillary sclerites and forming in some cases the lobes called alulae.
<i>B</i> ,	bulb (bulb of penis or of sheath of sting).
<i>BC</i> ,	body-cavity.
<i>bc</i> ,	any particular part of body cavity such as that prolonged into the mouth parts, legs or pieces of the sting.
<i>BCpx</i> ,	bursa copulatrix.
<i>BGl</i> ,	alkaline gland of sting.
<i>BM</i> ,	basement membrane.
<i>Br</i> ,	brain.
<i>1Br</i> ,	protocerebrum.
<i>2Br</i> ,	deutocerebrum.
<i>3Br</i> ,	tritocerebrum.
<i>Brb</i> ,	barb.
<i>BW</i> ,	body-wall.
<i>C</i> ,	costa, first vein of wing.
<i>Cb</i> ,	pollen basket or corbiculum on hind tibia of worker.
<i>CC</i> ,	crystalline cone of compound eye.
<i>Cd</i> ,	cardo.
<i>Ccr</i> ,	cercus.
<i>CL</i> ,	crystalline lens of compound eye.
<i>Cl</i> , <i>ClS</i> ,	cell, cells.
<i>Cla</i> ,	claw.
<i>Clp</i> ,	clypeus.
<i>Clsp</i> ,	clasping lobes of ninth segment of male, perhaps equivalent to the four gonapophyses of ninth segment of female.
<i>1Clsp</i> ,	upper or outer clasper.
<i>2Clsp</i> ,	lower or inner clasper.
<i>Com</i> ,	commissure (of either nervous or tracheal system).
<i>Cor</i> ,	cornea.
<i>CU</i> ,	cuticle, the chitinous layer of the epidermis.
<i>Cu</i> ,	cubitus, fifth vein of generalized wing.

<i>Cv</i> ,	cross-vein.
<i>Cx</i> ,	coxa.
<i>CxP</i> ,	pleural coxal process.
<i>Det</i> ,	duct.
<i>DDph</i> ,	dorsal diaphragm.
<i>Dph</i> ,	diaphragm.
<i>DphCls</i> ,	diaphragm cells.
<i>Dphmb</i> ,	membrane of diaphragm.
<i>DphMcl</i> ,	muscle fibers of diaphragm.
<i>E</i> ,	compound eye.
<i>EAp</i> ,	apodeme of extensor muscle.
<i>EjD</i> ,	ejaculatory duct.
<i>Em</i> ,	lateral emargination of notum.
<i>EMcl</i> ,	extensor muscle.
<i>Emp</i> ,	empodium.
<i>Enz</i> ,	digestive vesicles formed by ventricular epithelium.
<i>Ep</i> ,	epicranium.
<i>Ephy</i> ,	epipharynx.
<i>Epm</i> ,	epimerum.
<i>Eps</i> ,	episternum.
<i>Epth</i> ,	epithelium.
<i>F</i> ,	femur.
<i>Fl</i> ,	flagellum.
<i>For</i> ,	foramen magnum.
<i>Ft</i> ,	front.
<i>FtCom</i> ,	frontal commissure.
<i>FtGng</i> ,	frontal ganglion.
<i>FtNv</i> ,	frontal nerve.
<i>Fu</i> ,	furca or median entosternal apodeme of thoracic sterna.
<i>G</i> ,	gonapophysis.
<i>Ga</i> ,	galea.
<i>Ge</i> ,	gena.
<i>Gl</i> ,	gland.
<i>1Gl</i> ,	large pharyngeal gland in anterior part of head of worker.
<i>2Gl</i> ,	salivary gland in posterior part of head.
<i>3Gl</i> ,	thoracic salivary gland.
<i>4Gl</i> ,	small median gland below pharyngeal plate (<i>s</i>).
<i>Gls</i> ,	glossa.
<i>Gng</i> ,	ganglion.
<i>Gu</i> ,	gula.
<i>H</i> ,	head.
<i>Hk</i> ,	hooks on front edge of hind wing.
<i>Hphy</i> ,	hypopharynx.
<i>Hr</i> ,	hair.
<i>hr</i> ,	surface disk of "auditory" organ of antenna, probably modified base of sensory hair.
<i>HS</i> ,	honey stomach.
<i>Ht</i> ,	heart.
<i>ht</i> ,	individual chamber of heart.
<i>HtCls</i> ,	pericardial cells.
<i>HtTraSc</i> ,	pericardial tracheal sac.
<i>Int</i> ,	intima, the chitinous lining of any internal organ.
<i>IT</i> ,	tergum of first abdominal segment, the <i>median segment</i> , or <i>propodeum</i> , incorporated into thorax.

<i>L</i> ,	leg.
<i>Lb</i> ,	labium.
<i>Lbl</i> ,	labellum.
<i>LbNv</i> ,	labial nerve.
<i>LbPlp</i> ,	labial palpus.
<i>Lc</i> ,	lacinia.
<i>Lct</i> ,	lancet of sting, equivalent to first gonapophysis (<i>IG</i>).
<i>Lg</i> ,	ligula.
<i>LGl</i> ,	"lubricating" gland of sting (not shown in figures).
<i>Lin</i> ,	median lobe of lingua or hypopharynx.
<i>Lm</i> ,	labrum.
<i>LMcl</i> ,	longitudinal muscles.
<i>lmcl</i> ,	ventral longitudinal muscles of thorax.
<i>LmNv</i> ,	labral nerve.
<i>Lr</i> ,	lorum.
<i>lTra</i> ,	trachea of leg.
<i>Lum</i> ,	lumen, the cavity of any hollow organ, whether the glossa, sting, alimentary canal, or gland.
<i>M</i> ,	media, fourth vein of wing. M_1-M_4 , first to fourth branches of media.
<i>m</i> ,	median plate or plates of wing base.
<i>Mal</i> ,	Malpighian tubules.
<i>Mb</i> ,	intersegmental membrane.
<i>mb</i> ,	membrane.
<i>m-cu</i> ,	medio-cubital cross-vein.
<i>MD</i> ,	diselike muscle apodeme.
<i>Md</i> ,	mandible.
<i>1MdGl</i> ,	outer saclike mandibular gland.
<i>2MdGl</i> ,	inner racemose mandibular gland.
<i>MdNv</i> ,	mandibular nerve.
<i>Mes</i> ,	metathorax, designated by figure 3 placed after and below any thoracic symbol.
<i>Met</i> ,	metathorax, designated by figure 3 placed after and below any thoracic symbol.
<i>Mi</i> ,	the chitinous plates of the neck collectively, the "microthorax," individually designated <i>mi</i> .
<i>mi</i> ,	cervical (microthoracic) sclerites.
<i>m-m</i> ,	median cross-vein.
<i>Mps</i> ,	mouth parts or trophi.
<i>Mt</i> ,	mentum.
<i>Mth</i> ,	mouth.
<i>Mx</i> ,	maxilla.
<i>MxPlp</i> ,	maxillary palpus.
<i>MxNv</i> ,	maxillary nerve.
<i>N</i> ,	notum.
<i>Nu</i> ,	nucleus.
<i>Nv</i> ,	nerve.
<i>O</i> ,	ocellus.
<i>Ob</i> ,	oblong plate.
<i>Oc</i> ,	occiput.
<i>Œ</i> ,	œsophagus.
<i>ŒCom</i> ,	circumœsophageal commissures.
<i>Om</i> ,	ommatidium.
<i>OpL</i> ,	optic lobe.

<i>Ost</i> ,	ostium or lateral aperture of heart.
<i>Or</i> ,	ovary.
<i>or</i> ,	ovariole, individual ovarian tube.
<i>OrD</i> ,	oviduct.
<i>OrO</i> ,	opening of vagina or median oviduct.
<i>P</i> ,	paraptera, small pleural plates below base of wing, typically two episternal paraptera or preparaptera (<i>1P</i> and <i>2P</i>) before pleural wing process (<i>WP</i>), and two epimeral paraptera or postparaptera (<i>3P</i> and <i>4P</i>) behind wing process.
<i>1P</i> , <i>2P</i> ,	episternal paraptera, preparaptera.
<i>3P</i> , <i>4P</i> ,	epimeral paraptera, postparaptera.
<i>PA</i> ,	arm of pleural ridge.
<i>Pcl</i> ,	postclypeus.
<i>PD</i> ,	muscle disc of episternal paraptera, giving insertion to pronator muscle (not present in the bee).
<i>Pd</i> ,	peduncle.
<i>Pen</i> ,	penis.
<i>PenB</i> ,	bulb of penis.
<i>Peps</i> ,	preepisternum.
<i>Pge</i> ,	postgena.
<i>Pgl</i> ,	paraglossa.
<i>Pgu</i> ,	pregula.
<i>Ph</i> ,	phragma.
<i>Phy</i> ,	pharynx.
<i>Pl</i> ,	pleurum.
<i>pl</i> ,	subdivision of pleurum.
<i>Plf</i> ,	palpifer, palpus-carrying lobe of maxilla.
<i>Plg</i> ,	palpiger, palpus-carrying lobe of labium.
<i>Plp</i> ,	palpus.
<i>Pmb</i> ,	peritrophic membrane.
<i>PMcl</i> ,	pronator muscle.
<i>PN</i> ,	postnotum or pseudonotum, the second or postalar tergal plate of the wing-bearing segments of most insects, the "postscutellum" of higher orders.
<i>pn</i> ,	small rod connecting postscutellum (postnotum <i>PN</i>) with upper edge of epimerum, probably a detached piece of the former (see figs. 22 and 24).
<i>PNP</i> ,	posterior notal wing process.
<i>PNR</i> ,	posterior marginal ridge of notum.
<i>Pph</i> ,	posterior phragma or postphragma of any tergum, carried by the second notal plate or postnotum (<i>PN</i>), the "postscutellum" of higher forms.
<i>PR</i> ,	internal pleural ridge, the entopleurum, marked externally by pleural suture (<i>PS</i>).
<i>Prb</i> ,	proboscis.
<i>PrbFs</i> ,	fossa of proboscis.
<i>PS</i> ,	pleural suture, external line separating episternum and epimerum, marking site of internal pleural ridge.
<i>Ps</i> ,	presternum.
<i>Psc</i> ,	prescutum.
<i>PscI</i> ,	postscutellum (postnotum).
<i>Psl</i> ,	poststernellum.
<i>PsnC</i> ,	poison canal of sting.
<i>PsnSc</i> ,	poison sac of sting into which opens the acid gland (<i>AGI</i>).

<i>Pt,</i>	sensory pit.
<i>Ptr,</i>	peritreme, spiracle-bearing sclerite.
<i>Pvent,</i>	proventriculus.
<i>Pvent Vlv,</i>	proventricular tube or valve in ventriculus.
<i>Qd,</i>	quadrate plate of sting.
<i>R,</i>	radius, third vein of generalized wing. R_1 – R_5 , first to fifth branches of radius. R_s , radial sector.
<i>RAp,</i>	apodeme of flexor muscle.
<i>Rd,</i>	posterior extension or reduplication of any tergal or sternal plate overlapping plate following it.
<i>Rect,</i>	rectum, the large intestine of insects.
<i>RGl,</i>	rectal glands.
<i>r-m,</i>	radio-medial cross-vein.
<i>RMcl,</i>	flexor muscle of mandible or wing.
<i>1RMcl,</i>	dorsal retractor muscle of ligula.
<i>2RMcl,</i>	ventral retractor muscle of ligula.
<i>R_s,</i>	radial sector, or second branch of radius at first forking.
<i>S,</i>	sternum.
<i>SalD,</i>	salivary duct.
<i>SalDO,</i>	external opening of salivary duct.
<i>Sc,</i>	subcosta, second vein of generalized wing.
<i>Scl,</i>	scutellum.
<i>Sep,</i>	scape.
<i>Set,</i>	scutum.
<i>Sga,</i>	subgalea.
<i>Sh,</i>	sheath of sting, equivalent to the second gonapophyses (<i>2G</i>) or middle pair on ninth abdominal segment.
<i>ShA,</i>	basal arm of sheath of sting.
<i>ShB,</i>	bulb of sheath of sting or ovipositor.
<i>ShS,</i>	shaft of sheath of sting.
<i>SInt,</i>	small intestine.
<i>Sl,</i>	sternellum.
<i>Slin,</i>	superlingua, embryonic lateral lobes of hypopharynx, true appendages of fifth head segment.
<i>Smt,</i>	submentum.
<i>SœGng,</i>	subœsophageal ganglion.
<i>Sp,</i>	spiracle.
<i>Spm,</i>	spermatheca.
<i>SpmGl,</i>	spermathecal gland.
<i>St,</i>	stipes.
<i>StgNv,</i>	stomatogastric nerve.
<i>Stn,</i>	sting.
<i>StnPtp,</i>	palpuslike appendages of the sting, equivalent to the third gonapophyses (<i>3G</i>) or the outer pair on ninth abdominal segment.
<i>T,</i>	tergum.
<i>IT,</i>	first abdominal tergum, the propodeum, incorporated into thorax.
<i>IIT,</i>	second abdominal tergum.
<i>Tar,</i>	tarsus.
<i>Tb,</i>	tibia.
<i>Ten,</i>	large tentorial arms of head, the mesocephalic pillars.
<i>ten,</i>	slender tentorial arch over foramen magnum.
<i>Tes,</i>	testes.
<i>Tg,</i>	tegula.

<i>TMcl.</i>	transverse muscle.
<i>Tn</i> ,	trochantin (not separated from sternum in bee).
<i>TnC</i> ,	coxal condyle of trochantin.
<i>Tr</i> ,	trochanter.
<i>Tra</i> ,	trachea.
<i>TraCom</i> ,	transverse ventral tracheal commissures of abdomen.
<i>TraSc</i> ,	tracheal sac.
<i>Tri</i> ,	triangular plate of sting.
<i>Vag</i> ,	vagina.
<i>VDef</i> ,	vas deferens.
<i>VDph</i> ,	ventral diaphragm.
<i>Vent</i> ,	ventriculus.
<i>VentVlv</i> ,	ventricular fold or valve in small intestine.
<i>Ves</i> ,	vesicula seminalis.
<i>Vlv</i> ,	valve of sting carried by lancet.
<i>VMcl</i> ,	large vertical muscles of thorax.
<i>VNR</i> ,	internal, median V-shaped notal ridge, the "entodorsum."
<i>Vx</i> ,	vertex.
<i>W</i> ,	wing.
<i>W₂Nv</i> ,	mesothoracic wing nerve.
<i>W₃Nv</i> ,	metathoracic wing nerve.
<i>WP</i> ,	wing process of pleurum.

2. ALPHABETICAL LETTERING.

<i>a</i> ,	clypeal suture.
<i>b</i> ,	anterior tentorial pit, in clypeal suture.
<i>c</i> ,	posterior tentorial pit, in occiput beside foramen magnum.
<i>d</i> ,	thickened posterior edge of lateral wall of fossa of proboscis.
<i>e</i> ,	process at upper end of <i>d</i> articulating with cardo of maxilla and forming maxillary suspensorium.
<i>f</i> ,	internal median keel of vertex in cranium of drone.
<i>g</i> ,	suspensorial ligaments of anterior end of œsophagus.
<i>h</i> ,	pharyngeal rod.
<i>i</i> ,	convolutions of dorsal blood vessel.
<i>j</i> ,	anterior articular knob of mandible.
<i>k</i> ,	ventral groove of glossa.
<i>l</i> ,	ventral groove of maxillary rod.
<i>m</i> ,	median plates of wing base.
<i>n</i> ,	basal hooks of glossa.
<i>o</i> ,	median ventral plate of ligula.
<i>p</i> ,	dorsal plates of anterior end of mentum, supporting ligula.
<i>q</i> ,	inner wall of canal of glossa.
<i>r</i> ,	chitinous rod of glossa.
<i>s</i> ,	pharyngeal plate, on anterior part of floor of pharynx.
<i>t</i> ,	salivary pouch opening on dorsal side of base of ligula, receiving common duct of salivary glands (<i>SalD</i>).
<i>u</i> ,	oblique muscles inserted upon dorsal side of salivary pouch of ligula.
<i>v</i> ,	transverse or V-shaped suture on surface of mesonotum or metanotum, formed by the internal V-shaped ridge or "entodorsum" (<i>VNR</i>).
<i>w</i> ,	lateral lobe of pronotum projecting posteriorly over the first spiracle.

- x*, thoracic plate lying laterad of anterior part of sternum, often regarded as a part of presternum.
- y*, accessory sclerite of fourth axillary (*4Ax*) of front wing, affording insertion for slender muscle (fig. 28, *cc*) attached below to common apodeme of mesosternum and metasternum.
- z*, coxal condyles of mesothoracic and metathoracic sterna, probably really the coxal condyles of trochantins (fig. 4, *TnC*) fused entirely with the sterna and episterna in each segment.
- aa*, muscle arising from inner wall of mesothoracic pleurum and inserted upon outer end of corresponding scutellum, probably accessory in function to the great vertical muscles (fig. 27, *VMcl*) between the mesothoracic sternum and scutum.
- bb*, coxo-axillary muscle, extending from upper end of coxa to third parapterum (*3P*).
- cc*, muscle inserted upon accessory sclerite (*y*) of fourth axillary (*4Ax*) from common entosternum of mesothorax and metathorax.
- dd*, notch of antenna cleaner on first tarsal joint (*1Tar*) of front leg.
- ee*, spine of antenna cleaner situated on distal end of tibia (*Tb*).
- ff*, so-called "wax shears" or "wax pincers."
- gg*, transverse chitinous band of empodium (*Emp*); which compresses its two lobes when not in use and spread out by muscular effort.
- hh*, dorsal plate supporting empodium.
- ii*, ventral plate supporting empodium.
- jj*, dorsal groove of lancet interlocking with ventral ridge of sheath of sting.
- kk*, sting chamber within end of seventh abdominal segment, lodging sting whose accessory plates are derived from eighth and ninth segments.
- ll*, reservoir of thoracic salivary gland.
- mm*, receptacular chitinous pouches on ventral side of pharyngeal plate (*s*) receiving ducts of large lateral pharyngeal glands of head (*1GI*).
- nn*, "stomach-mouth" at summit of proventricular projection within honey stomach (*HS*).
- oo*, pores on lancets (fig. 40 E) and shaft of sting sheath (F) opening to exterior from prolongation of body-cavity (*bc*) contained in each.
- pp*, gelatinous layer secreted upon inner surface of ventricular epithelium.
- qq*, food contents of alimentary canal.
- rr*, cells of ventricular epithelium apparently forming the internal gelatinous layer.
- ss*, cartilaginous mass on inner surface of dorsal wall of bulb of penis (fig. 56 E, *PenB*).
- tt*, dorsal plates of bulb of penis.
- uu*, fimbriated dorsal lobes of penis at base of bulb.
- vv*, ventral scalariform row of plates on tube of penis.
- ww*, dorsal basal plates of penis.
- xx*, ventral basal plates of penis.
- yy*, basal pouch of penis.
- zz*, copulatory sacs of penis.

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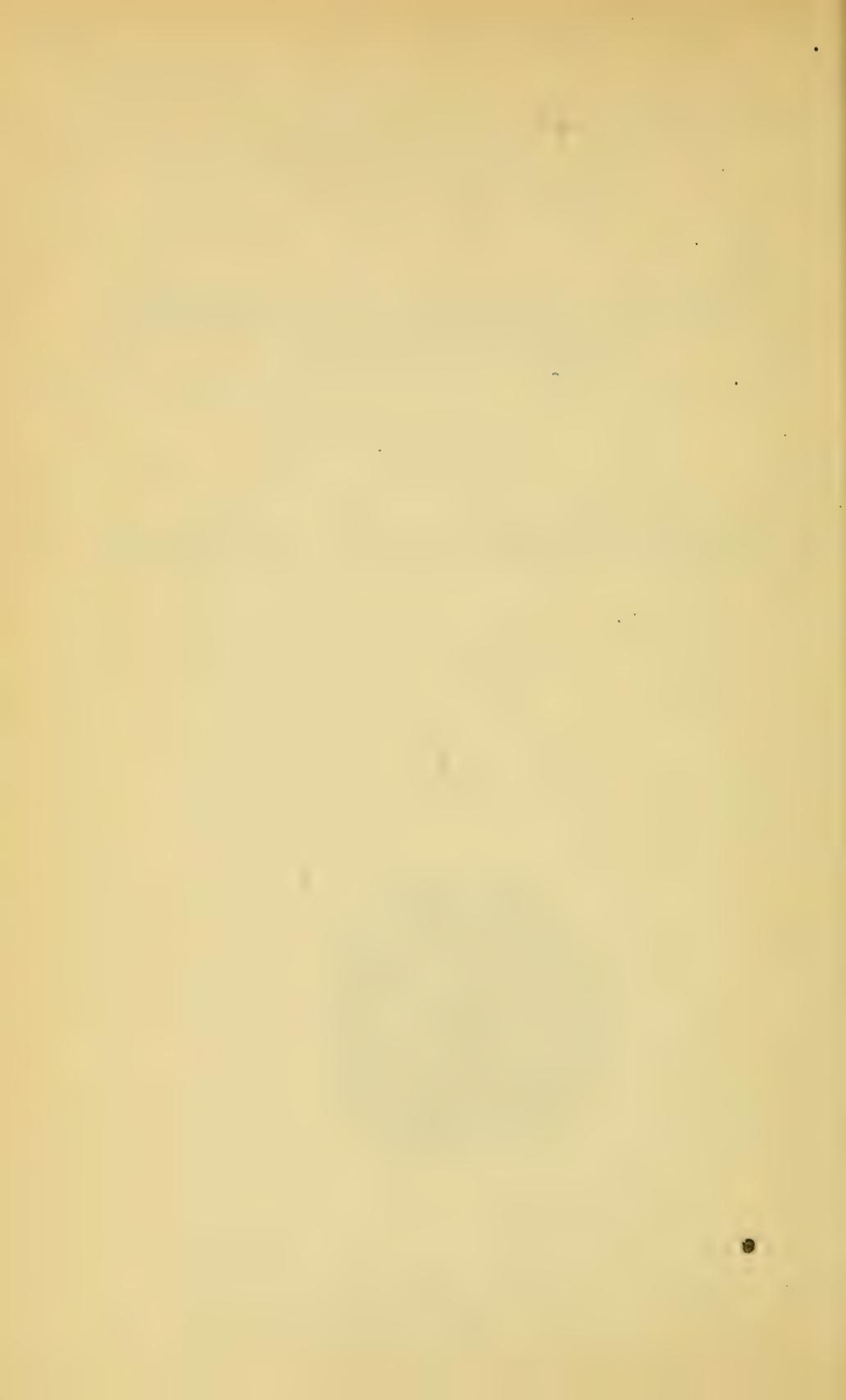
TECHNICAL RESULTS FROM THE GIPSY MOTH
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CONTENTS AND INDEX.

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MOTH PARASITE LABORATORY.

I. THE PARASITES REARED OR SUPPOSED TO HAVE BEEN REARED
FROM THE EGGS OF THE GIPSY MOTH.

By L. O. HOWARD, Ph. D.

II. DESCRIPTIONS OF CERTAIN CHALCIDOID PARASITES.

By J. C. CRAWFORD, *Assistant Curator, Division of Insects, United States National Museum.*

III. INVESTIGATIONS INTO THE HABITS OF CERTAIN SARCOPHAGIDÆ.

By T. L. PATTERSON, *Assistant in Biology, Sheffield Scientific School, Yale University*

WITH AN INTRODUCTION

By W. F. FISKE, *In Charge of Gipsy Moth Parasite Laboratory, Bureau of Entomology.*

IV. THE CHALCIDOID GENUS PERILAMPUS AND ITS RELATIONS TO
THE PROBLEM OF PARASITE INTRODUCTION.

By HARRY S. SMITH, *Expert.*

V. EXPERIMENTAL PARASITISM: A STUDY OF THE BIOLOGY OF
LIMNERIUM VALIDUM (CRESSON).

By P. H. TIMBERLAKE, A. M., *Agent and Expert, Gipsy Moth Parasite Laboratory.*



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GIPSY MOTH AND BROWN-TAIL MOTH INVESTIGATIONS.

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PREFACE.

In the course of more than three years' work with the parasites and natural enemies of the gipsy moth and brown-tail moth, nearly all imported from Europe or Japan, it has been necessary to work with a number of species new to science and to make the most careful life-history observations upon all the species concerned in order to ascertain points of possible importance in the practical handling of the material. It is proposed in this Technical Series No. 19 to include a series of short papers giving some of the systematic and biological results of this work, the practical deductions for the most part being reserved for consideration in the bulletins of the general series.

Technical Series No. 12, Part VI, entitled "A Record of Results from Rearings and Dissections of Tachinidae," by Charles H. T. Townsend, published September 18, 1908, really should have started this Technical Series No. 19, since it directly concerns itself with results of work at the gipsy-moth parasite laboratory.

The laboratory in question, it should be stated, is now stationed at Melrose Highlands, Mass. (No. 17 East Highland Avenue). It is conducted with the cooperation of the State of Massachusetts and the United States Department of Agriculture.

L. O. HOWARD.

JANUARY 28, 1910.

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¹ The five papers constituting this bulletin were issued in separate form on Jan. 28 and Apr. 30, 1910, Mar. 22, 1911, and Apr. 22 and May 29, 1912, respectively.

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ERRATA.

Page 1, line 3, for *On some* read *The*.

Page 18, line 4, after *German* insert period.

Page 68, line 18, omit comma after *parasites*.

Page 68, line 19, omit comma after *encountered*.

Page 72, line '9, for *Hypantria* read *Hyphantria*.

Page 76, line 23, for *incapsulated* read *encapsulated*.

Page 76, line 24, after *always* omit comma.

Page 76, line 25, after *frequently* insert comma.

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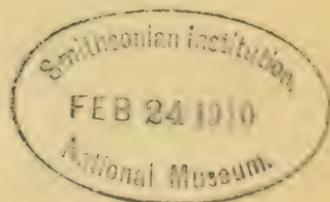
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By L. O. HOWARD, PH. D.

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PREFACE TO BULLETIN.

In the course of rather more than three years' work with the parasites and natural enemies of the gipsy moth and brown-tail moth, nearly all imported from Europe or Japan, it has been necessary to work with a number of species new to science and to make the most careful life-history observations upon all the species concerned in order to ascertain points of possible importance in the practical handling of the material. It is proposed in this Technical Series No. 19 to include a series of short papers giving some of the systematic and biological results of this work, the practical deductions for the most part being reserved for consideration in bulletins of the general series.

The present paper, therefore, forms the first of such a series. It describes several new egg-parasites and gives some consideration to others already described. It also includes a brief consideration of other forms supposed to have been reared from gipsy moth eggs.

Technical Series No. 12, Part VI, entitled "A Record of Results from Rearings and Dissections of Tachinidæ," by Charles H. T. Townsend, published September 18, 1908, really should have started this Technical Series No. 19, since it directly concerns itself with results of work at the gipsy moth parasite laboratory.

The laboratory in question, it should be stated, is now stationed at Melrose Highlands, Mass. (No. 17 East Highland avenue). It is conducted under the joint cooperation of the State of Massachusetts and the U. S. Department of Agriculture. The rental of the building, all construction work, nonexpert assistance, and the expendable supplies, together with the compensation of foreign agents, are charged to the State of Massachusetts. The Bureau of Entomology of the Department of Agriculture is charged with the salaries and expenses of all expert assistants and with all nonexpendable supplies and apparatus.

L. O. H.

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TECHNICAL RESULTS FROM THE GIPSY MOTH PARASITE LABORATORY.

On Some Parasites Reared or Supposed to have been Reared from the Eggs of the Gipsy Moth.

By L. O. HOWARD, Ph. D.

INTRODUCTORY.

No native American egg-parasites have ever been reared from the eggs of the gipsy moth (*Porthetria dispar* L.) since its introduction into this country in the late sixties. This seems strange, since native Lepidopterous eggs are very frequently attacked by egg-parasites of several genera, notably by *Trichogramma* and *Telenomus*, as well as occasionally by *Anastatus* and *Ooencyrtus*. Nonparasitism of *dispar* by native species is probably due to the character of its egg-mass, which is so compact and so thoroughly protected by the scales of the parent as possibly to disguise its character from species unacquainted with it for many generations, while actual experiments with *Trichogramma* seem to show that it is unable to pierce the shell of the gipsy moth egg.

In the course of the extensive importations of parasites of this species from Europe and Japan, however, carried on cooperatively by the State of Massachusetts and the Bureau of Entomology of the U. S. Department of Agriculture, several primary and secondary parasites have been reared from these eggs at the Gipsy Moth Parasite Laboratory at Melrose Highlands, Mass., where they have been studied in greater or less numbers by Mr. W. F. Fiske, of the Bureau of Entomology, in charge of the laboratory, and by the corps of assistants working under his direction, and have in some cases been colonized in the open. In the following pages descriptions are given of the new forms, together with brief notes concerning their habits, the notes being the result of the observations of Mr. Fiske and assistants. Only two of the species, namely, *Anastatus bifasciatus* Fonsc. and *Schedius kuvanae* How., appear to be of primary importance, but it is obvious that once acclimatized these two species will perform a very considerable part in the reduction in numbers of the gipsy moth in the United States.

The parasites so far reared have all come from Japan, southern Russia, and Hungary. The *Anastatus* has a wider range, occurring

in many parts of Europe, but has other hosts. Shipments of *dispar* eggs received at the Parasite Laboratory from Switzerland and northern Germany have given out no parasites whatever. Silvestri states that he has never been able to secure parasites from the eggs of *dispar* in Italy, but there is a reasonable chance that he did not keep his material long enough to have secured the summer-issuing forms had they been present. There is no evidence as yet that gipsy moth egg-parasites occur in western Europe—that is, France or Spain.

Other insects are occasionally sent to this country accidentally with these egg-masses, one of them, a small Dermestid beetle, really feeding upon the eggs. This insect was found in considerable numbers in a large shipment of *dispar* eggs, sent by Prof. Trevor Kincaid from Japan, which were collected after the caterpillars had emerged. This species has been examined by Mr. E. A. Schwarz, who states that it is probably an undescribed species and genus of the group *Attageni*. The larvæ of *Anthrenus verbasci* L. are constantly found in the old cocoon masses of the white-marked tussock moth (*Hemerocampa leucostigma* S. & A.) in this country and under the batches of eggs already hatched, where they are engaged in feeding upon the dry remains of pupæ and eggs. The writer ^a has pointed out that these larvæ also eat the healthy eggs, and that *Trogoderma tarsale* Melsh., another Dermestid, has the same habit. This has since been seen to be the case with the white-marked tussock moth in Massachusetts, and one of these species has several times been reported as destroying the eggs of the gipsy moth in Massachusetts.

The cocoons of *Glyptapanteles* have also been sent in on bits of bark attached to the egg-masses; and other small miscellaneous insects, including several species of small moths which had sought the protection of the egg-masses for pupation, have come in, indicating not only the great possibility of error in rearing insects from large masses of material, but also the necessity for great care to avoid the introduction of new insect pests.

Family ENCYRTIDÆ Walker.

Subfamily ENCYRTINÆ Howard.

Tribe MIRINI Ashmead.

Genus SCHEDIUS, new genus.

Female.—Mandibles broad at apex, very obscurely tridentate; outer tooth rather short, acute; middle tooth rounded, inner tooth flat and with a straight edge. Antennæ inserted just above border of the mouth; facial depression well marked; clypeus well rounded and elevated; vertex rather narrow, head well produced in front;

^a Technical Series No. 5, Bur. Ent., U. S. Dept. Agr., p. 46, 1897.

ocelli at angles of slightly acute-angled triangle, lateral ocelli nearer eye-border than to each other; occipital margin somewhat rounded; eyes large, well rounded, rigid (keeping their shape after death), very faintly hairy. Antennal scape slender, subcylindrical; pedicel nearly three times as long as broad; funicle subcylindrical, joint 1 short, about one-half length of pedicel, remaining joints increasing slightly in length and width to club, except that joint 6 is slightly shorter than 5; club ovate, flattened, nearly as long as last three funicle joints together, basal joint longest. Body stout; mesonotal axillæ well separated at tips; mesoscutellum well rounded; abdomen shorter than thorax, short-ovate. Wings long and broad; marginal vein punctiform; stigmal rather long, slender, slightly enlarged at tip, extending into the wing-disc at an angle of about 35 degrees with the costa; postmarginal evident, but not so long as stigmal; wing-disc with an oblique hairless streak extending from stigmal vein toward the base of the wing; hind wings rather narrow, but densely and uniformly ciliate.

Male.—Differs from female principally in the shorter abdomen and in the antennæ. Antennæ with scape slightly widened below; pedicel obconical, very slightly longer than width at tip; first funicle joint slightly longer than pedicel; funicle joints 1 to 5 subequal in length and width, 6 somewhat shorter; all funicle joints somewhat convex on outer side, nearly straight on inner side; club ovate, rather broadly flattened, somewhat longer than funicle joints 5 and 6 together; all of flagellum beyond pedicel rather closely furnished with hairs averaging about two-thirds the length of the respective sclerites that bear them.

Type.—The following species:

SCHEDIUS KUVANÆ, new species.

(Figs. 1-3.)

Female.—Length, 0.99^{mm}; expanse, 2.39^{mm}; greatest width of fore wing, 0.43^{mm}. Vertex and cheeks very faintly shagreened; mesoscutum nearly smooth, shining, with minute, rather sparse punctures; mesoscutellum densely and rather coarsely shagreened, well rounded at tip; propleura very faintly shagreened, somewhat shining. General color black; mesoscutellum with a bronzy luster; trochanters, tips of femora, apical half or a little more of front and middle and hind tibiæ yellowish; all tarsi lighter; antennæ dark brown; dark parts of the legs more brown than black. Wings hyaline.

Male.—Length, 0.9^{mm}; expanse, 2.28^{mm}; greatest width of fore wing, 0.43^{mm}. Resembles female, except that the flagellum of the antenna is light brown, and except for the structural characters mentioned in the generic diagnosis.

Described from numerous male and female specimens reared September, 1908, at the Gipsy Moth Parasite Laboratory of the State of

Massachusetts and the Bureau of Entomology, at Melrose Highlands, Mass., from the eggs of *Porthetria dispar* received from Tokyo, Japan, from Prof. S. I. Kuwana, Entomologist of the Imperial Agricultural Experiment Station at Nishigahara, Tokyo, after whom the species is named in partial recognition of his great services to the United States in sending parasites from Japan.

Type.—No. 12158, U. S. National Museum; Gipsy Moth Laboratory No. 1698.

This species appears to be an important parasite of the gipsy moth. It has been imported in very large numbers through the courtesy of Professor Kuwana. The great majority of the specimens have been dead upon arrival, but small numbers have emerged living at the Gipsy Moth Parasite Laboratory at Melrose Highlands. The species appears to be more common in the vicinity of Tokyo than

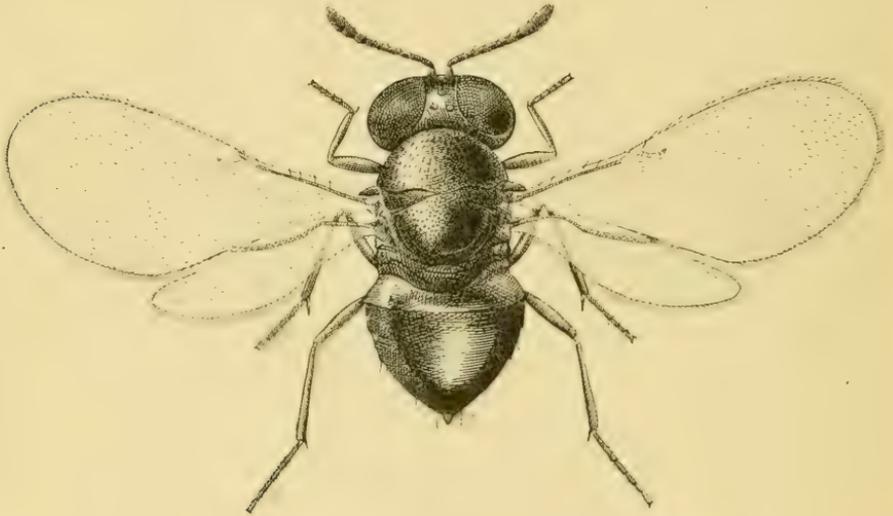


FIG. 1.—*Schedius kuranae*: Female. Highly magnified. (Original.)

in other parts of Japan. This parasite in the field issues from *dispar* eggs in the autumn after they have been deposited. For some reason it has not been reared freely from Japanese eggs collected and forwarded during the winter. The possible inference that it does not hibernate in the eggs of this host in Japan is not in accord with its behavior in America. There is ample time for two and possibly three generations in the same autumn after the gipsy moth has laid its eggs. The species is easily controlled in the laboratory, as determined by Mr. Fiske, and more than twenty thousand have been reared and liberated from a total importation of about twenty living individuals. The early stages have been worked out at the laboratory by Messrs. Fiske and H. F. Smith, and are very remarkable. It attacks the eggs of its host when freshly deposited and with equal

freedom those which contain the fully developed caterpillar all ready to hatch.

Genus TYNDARICHUS, new genus.

Female.—Mandibles like those of *Schedius*. Antennæ short; scape rather short, with a rather broad leaflike extension below; pedicel long, obconical, two and one-half times as long as width at tip and half as long as funicle; first funicle joint narrower than tip of pedicel and rather shorter than broad; funicle joints 2, 3, and 4 each about as long as 1, but gradually widening; 5 and 6 somewhat longer and considerably wider, thus making the width increase from 1 to 6; club very broad, somewhat flattened, having three segments subequal in length, but with the dividing sutures slightly oblique, tip obliquely truncate from a point immediately before the last suture; flagellum with sparse hairs, and scape and pedicel with a few bristles. Body short, stout, resembling *Schedius* in general appearance.



FIG. 2.—*Schedius kuvanæ*: ♂, Antenna of male; ♀, antenna of female. Highly magnified. (Original.)

Antennæ inserted slightly above mouth border; facial depression and clypeus resembling *Schedius*; vertex narrower than with *Schedius*, but ocelli placed in

the same manner; occipital margin acute; eyes naked, not rigid (falling in after death).

Axillæ of mesonotum barely meeting at tip; abdomen flattened above, triangular, nearly as long as thorax. Fore wings broad; disc closely ciliate though not so densely as with *Schedius*, oblique hairless line below stigma faintly indicated, but the entire disc below submarginal vein only

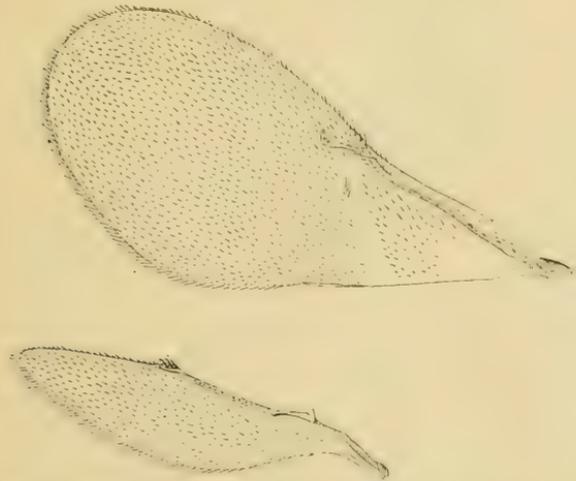


FIG. 3.—*Schedius kuvanæ*: Fore and hind wings of female. Highly magnified. (Original.)

sparingly ciliate; marginal vein punctiform, stigmal much as with *Schedius*; submarginal vein with a pronounced and curious break beyond middle as illustrated in figure 5; hind wings broader than with *Schedius*.

Male.—Body short, stout; mesonotum highly arched; abdomen flat, broadly ovate. Antennæ long, submoniliform, ventral outline

of funicle joints nearly straight, dorsal outlines somewhat rounded; scape short, subcylindrical, very slightly widened ventrally; pedicel shorter than first funicle joint; all funicle joints subequal in length and width, the sixth rather shorter; club slightly flattened, long-ovate, pointed at tip, one and one-half times longer than sixth funicle joint; the whole flagellum beyond pedicel rather abundantly furnished with long,



FIG. 4.—*Tyndarichus navæ*: a, Antenna of female; b, club of same, from below; c, antenna of male. Highly magnified. (Original.)

slightly curving bristles, having no marked tendency to form definite whorls, each bristle about as long as its sclerite.

Type.—The following species:

TYNDARICHUS NAVÆ, new species.

(Figs. 4, 5.)

Female.—Length, 1.08^{mm}; expanse, 2.19^{mm}; greatest width of fore wing, 0.39^{mm}. Entire body black, shining; head and mesonotum very faintly shagreened; vertex and cheeks with steel-blue reflections; mesoscutellum with coppery reflections; antennæ dark brown, with light brown pile; all legs dark brown, nearly black except at tips of tibiæ and all tarsi.

Male.—Length, 0.93^{mm}; expanse, 2.19^{mm}; greatest width of fore wing, 0.44^{mm}. Differs from female, aside from characters mentioned in generic description, very slightly. Antennæ brownish, with black

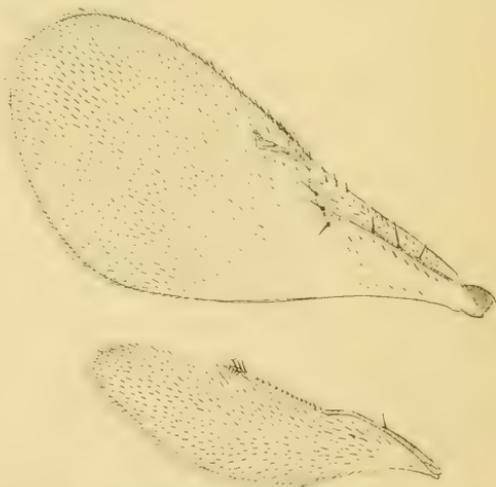


FIG. 5.—*Tyndarichus navæ*: Fore and hind wings of female. Highly magnified. (Original.)

hairs. General appearance of body more opaque than with the female and metallic reflections less distinct; leg coloration identical.

Described from seven female and four male specimens reared from the eggs of *Porthetria dispar*, June, July, and August, received from U. Nawa, Gifu, Japan, after whom the species is named.

Type.—No. 12159, U. S. National Museum; Gipsy Moth Laboratory Nos. 1625, 1020, and 1039.

This parasite has also been imported from Japan in eggs collected by Professor Kuwana, and seems to follow *Schedius* in distribution in Japan. It is very much less common, but varies in abundance in different lots of eggs. Unlike *Schedius*, it has been reared freely from the eggs collected and forwarded during the winter, emerging at various times in the spring and summer. So far as indicated by a considerable number of dissections made by Messrs. Fiske and

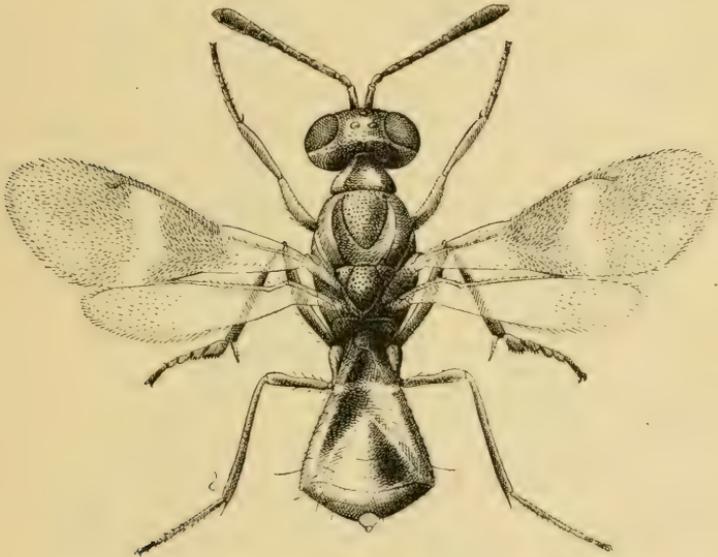


FIG. 6.—*Anastatus bifasciatus*: Female. Highly magnified. (Original.)

Smith, it is invariably secondary. Its host is usually *Schedius*, occasionally *Pachyneuron*, and possibly *Anastatus*.

Subfamily EUPELMINÆ Howard.

Tribe EUPELMINI Ashmead.

Genus ANASTATUS Motschulsky.

ANASTATUS BIFASCIATUS (Fonscolombe).

(Fig. 6.)

Cynips bifasciata Fonscolombe.

Eupelmus bifasciatus Förster, 1860.

Eupelmus bifasciatus Wachtl, 1882 (from eggs of *Ocneria dispar*).

This very widespread parasite is an important enemy of the gipsy moth. It has been reared at the Parasite Laboratory at Melrose

Highlands by Mr. Fiske and assistants from egg-masses received from all parts of Japan, but more commonly from those collected in Fukuoka, these egg-masses having been sent in by several of the energetic Japanese correspondents of the Bureau, but principally by Mr. U. Nawa and Prof. S. I. Kuwana. It has also been reared from eggs sent from the Crimea by Prof. S. Mokshetsky, and in especial abundance from eggs sent from Hungary by Prof. J. Jablonowski. The species appears to be much more common in European countries, but is apparently local in its European distribution. Dalla Torre records it from France and from lower Austria. Many thousands of specimens of this species have been reared at the Parasite Laboratory. It attacks the egg of *dispar* very shortly after the latter is deposited, and requires a full year for a generation—a fact which, while it would seem to reduce its possible value as an effective parasite of the gipsy moth, really enhances it as an introduced species, since it is independent of other insects for alternate hosts at seasons when eggs of the gipsy moth are not available. The accompanying figure was drawn from a museum specimen. In life the abdomen is not sunken dorsally.

Family PTEROMALIDÆ Ashmead.

Subfamily SPHEGIGASTERINÆ Ashmead.

Tribe PACHYNEURINI Ashmead.

Genus PACHYNEURON Walker.

PACHYNEURON GIFUENSIS Ashmead.

Pachyneuron gifuensis Ashmead, Journ. N. Y. Ent. Soc., XII, No. 3, p. 158, September, 1904.

This species, described by Ashmead as above, was part of a collection referred to the U. S. National Museum some years ago by Professor Mitsukuri, of Tokyo. It has recently been imported from Japan in eggs of *dispar* collected by Prof. S. I. Kuwana, and is apparently common in the vicinity of Tokyo. In habits it is like *Tyndarichus naræ*, as determined by Messrs. Fiske and Smith at the Parasite Laboratory, but it is a little less common and issues in the spring. It is a hyperparasite, and attacks *Schedius kuvanæ* and *Tyndarichus naræ* as well; in the first instance being secondary and in the other instance tertiary. In one instance at the laboratory it was reared from an egg which originally contained *Anastatus bifasciatus*. The type and two other specimens were reared by Mr. Y. Nawa from an aphid at Gifu, Japan, undoubtedly parasitic on some primary parasite of the Aphidid.

Family EULOPHIDÆ Ashmead.

Subfamily ELACHERTINÆ Ashmead.

Tribe ELACHERTINI Ashmead.

Genus ATOPOSOMOIDEA, new genus.

Female.—Apparently this genus comes near *Atoposoma* Masi, as the proposed name suggests, and is distinguished chiefly by the solid thorax, naked eyes, somewhat less elevated vertex, slightly different dentation of the mandibles, low insertion of the antennæ, different proportions of the antennal sclerites, and greater length of post-marginal vein—all of which are indicated in the accompanying illustration (fig. 7). *Atoposoma* is closely related to *Zagrammosoma* Ashmead, also parasitic on a Lepidopterous larva.

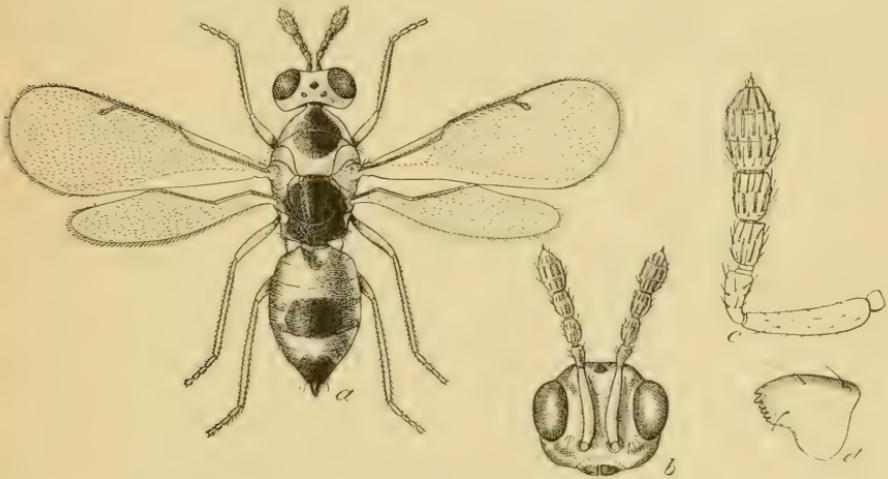


FIG. 7.—*Atoposomoidea ogimæ*: a, Female; b, head of same, anterior aspect; c, antenna of same; d, mandible of same. a, Very much enlarged; b-d, highly magnified. (Original.)

Male.—Differs from female in its shorter antennæ, which are furnished with rather dense pile which is shorter than with female. It also has a shorter abdomen.

Type.—The following species:

ATOPOSOMOIDEA OGIMÆ, new species.

(Fig. 7.)

Female.—Length, 1.65^{mm}; expanse, 2.66^{mm}; greatest width of fore wing, 0.5^{mm}. Pronotum and entire mesonotum finely shagreened. Mesopleura also finely shagreened. General color lemon-yellow. Head with a large, black occipital spot; a large, nearly circular, black spot on pronotum and mesonotum, divided in about its middle by the pronotal suture; central portion of mesoscutellum black, and

the sides as well, below middle; metanotum black; abdomen with a black, rounded spot dorsally just below middle, abdomen also black at tip; antennæ brownish, with a whitish pile; all legs light yellow.

In the markings the species is extremely variable. A frequent variation from what we may call the typical markings as shown in the illustration, is the absence of the black spot on mesoscutellum, although sometimes it is represented by a minute central dot; the occipital black spot is frequently lacking; the pronotal and mesoscutal spots frequently become greatly reduced in size. On the other hand, in many specimens the black spots become greatly enlarged so as to make black almost the predominant color of the insect.

Male.—Length, 1.26^{mm}; expanse, 2.43^{mm}; greatest width of fore wing, 0.43^{mm}. Antennæ yellowish, with abundant, long, white pile. Color as with female, except that entire apical half of dorsum of abdomen is black, and entire pronotum is black. There is almost the same range of variation in size of black spots as with the female.

Described from 43 female and 8 male specimens reared from cocoons of *Glyptapanteles japonicus* Ashmead, received from Trevor Kincaid during the summer of 1908 from various localities in Japan, and from other cocoons of the same species received from S. I. Kuwana during the summer of 1909 from different localities in Japan. Named after Prof. G. Ogima, Assistant Entomologist, Kyushiu Experiment Station, Kumamoto, Japan, in recognition of his valuable services.

Type.—No. 12681, U. S. National Museum; Gipsy Moth Laboratory Nos. 1623 and 1074.

There is a single female of this species, labeled "Kumamoto, Japan, reared 10th of May, 1907, by G. Ogima, egg-parasite of *P. dispar*." This specimen was not sent to the writer by Professor Ogima himself directly, but either through Professor Kuwana or Mr. Kincaid, and it is the receipt of this specimen which justifies the description of this new genus and species in a paper on the egg-parasites of the gipsy moth. Very large numbers of this parasite, however, have been reared at the Parasite Laboratory at Melrose Highlands, by Mr. Fiske, from the cocoons of the *Glyptapanteles*, and it is very possible that a mistake has arisen in Japan through the rearing of this species apparently from an egg-mass of *dispar* which had been laid over a mass of *Glyptapanteles* cocoons. Similar instances have occurred before, notably in the case of Ashmead's *Ablerus chisiocampæ*, which apparently came from an egg-mass of *Chisiocampa* but in reality from *Chionaspis furfura* on the bark of the twig under the egg-mass of the Lepidopterous insect. Similarly the writer's *Isodromus iceryæ* was apparently reared by Mr. D. W. Coquillett from egg-masses of *Icerya purchasi* but in reality came from a *Chrysopa*

cocoon hidden among the egg-masses and so covered with wax as probably to be indistinguishable.

Several species of Elachertines of this general type, including at least one undescribed genus in addition to *Atoposoma* and *Zagrammosoma*, have been reared from Microlepidopterous larvæ. The first one that the writer ever saw was reared from *Lithocolletis fitchella* in Washington in 1879. Others were reared from leaf-miners from Florida, but none of these striking forms was described until Ashmead^a described the genus *Hippocephalus* for a species, *multilineatus*, reared by Mr. C. L. Marlatt from *Lithocolletis ornatella*. On account of the preoccupation of the name *Hippocephalus*, Ashmead, in his monograph of the Chalcidoidea, changed the name to *Zagrammosoma*. Masi's type of *Atoposoma* (*A. variegatum*) fed in the larval state exteriorly on a larva of the Lepidopter, *Ecophyllembius neglectus*. The present genus, *Atoposomoidea*, appears to be the first Chalcidid of this markedly beautiful and peculiar facies to have been reared from a Braconid cocoon, and we must assume from the great numbers in which these rearings have been made that the habit is normal for this species.

Subfamily APHELININÆ Howard.

Tribe APHELININI Ashmead.

Genus PERISSOPTERUS Howard.

PERISSOPTERUS JAVENSIS Howard.

Perissopterus javensis Howard, New Genera and Species of Aphelininae, Tech. Ser. 12, Pt. IV, Bur. Ent., U. S. Dept. Agr., Washington, p. 88, July 12, 1907.

The type series of this beautiful little parasite was reared in February, 1900, by A. Koebele from a scale insect of the genus *Tachardia* on an ornamental plant at Singapore, Straits Settlements. All of the other species of the genus have been reared invariably from scale insects and nothing else. A record of the issuance of *P. javensis* from gipsy moth eggs is therefore open to doubt, and one's first impression is that it must have come from some scale insect over which a *dispar* egg-mass had been laid. Nevertheless, according to Mr. Fiske, the single female submitted to the writer for determination came from a *dispar* egg received from Professor Kuwana from near Tokyo. The apparent great discrepancy between this statement and the previous records renders it desirable to give an explicit statement of the facts as observed by Mr. Fiske. From his original notes it is found that December 9, 1908, a lot of 250 egg-masses of *dispar*, collected in Tokyo November 5, 1908, by Professor Kuwana, was received. One of these egg-masses was thin, with the hairy covering badly weathered, and many of the eggs exposed. Critical examina-

^aBulletin 3, Kans. St. Exp. Sta., 1888.

tion of this mass indicated that 181 of the eggs were apparently healthy. Parasites had emerged from 108, while the dead or doubtful eggs numbered 35. Mr. Fiske thinks that the parasites that had emerged were probably *Schedius*. On December 14 the 35 eggs of the third category were assorted into those which appeared to contain parasites and those which were dead. They were emptied into a watch glass, and a single, small, living parasite (the *Perissopterus* under consideration) was found. Careful examination of the eggs showed two which had very small round holes in the side, from either of which the parasite might have come. These holes were smaller than those usually made by any of the other known parasites. These eggs were separated from the others, and on March 4 one of them was boiled in caustic potash (KOH) and its contents examined. Fragments of the pupal exuvium of a small Chalcidid different from that of any other parasite studied was found and mounted. There was no other indication of any other parasite in the egg, and the one which emerged appeared to have fed upon the caterpillars primarily. No parasite remains were found in the other pierced egg. The parasite found on December 14 was placed in a small vial with a variety of eggs, including some of *dispar* that contained larvæ of *Anastatus*, others that contained healthy *dispar* caterpillars, and some of the tussock moth. The *Perissopterus* (which was a female) lived for some days, but showed no interest in any of the eggs.

Family PROCTOTRYPIDÆ Ashmead.

Subfamily SCELIONINÆ Howard.

Tribe TELENOMINI Ashmead.

Genus TELENOMUS Haliday.

TELENOMUS, new species.

In the autumn of 1897 there was received from Prof. S. Mokshetsky, of Simferopol, Russia, a single specimen of a new species of *Telenomus*, which he reared during September, 1906, from the eggs of the gipsy moth. As probably Professor Mokshetsky will describe this species himself, it is given no name at this time. Curiously enough, it belongs to the same group of the genus to which *Telenomus cultratus* Mayr belongs much more closely than to any of the species reared from Lepidopterous eggs. *T. cultratus* lives both as larva and pupa in the eggs of the Pentatomidæ, from which it has been reared by Rogenhofer and Hofmann. This new species does not appear to be an important parasite of *dispar* eggs, since this is the only rearing known to us, and none has been recorded.

TECHNICAL SERIES, No. 19, PART II.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

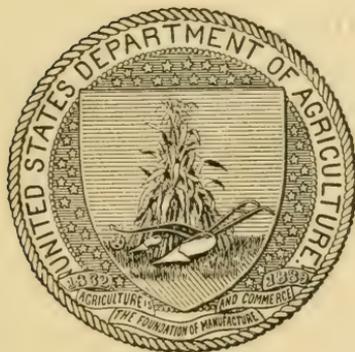
TECHNICAL RESULTS FROM THE GIPSY MOTH
PARASITE LABORATORY.

II. DESCRIPTIONS OF CERTAIN CHALCIDOID
PARASITES.

By J. C. CRAWFORD,

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TECHNICAL RESULTS FROM THE GIPSY MOTH PARASITE LABORATORY.

II. Descriptions of Certain Chalcidoid Parasites.

By J. C. CRAWFORD,
Assistant Curator, Division of Insects, U. S. National Museum.

INTRODUCTION.

The new species described in this paper came from material imported from Japan and Europe for the purpose of rearing parasites of the gipsy moth and the brown-tail moth. The work of rearing these parasites is conducted at the Gipsy Moth Parasite Laboratory, now situated at Melrose Highlands, Mass.

In the study of these parasites a Zeiss binocular microscope has been used with magnifications of from 24 to 35. In cases where the description states that the series includes more than one specimen of each sex the description is drawn from one specimen of each sex, and any variations in the other specimens, which are designated as paratypes, are cited.

In considering the genus *Chalcis* it has been deemed desirable to display in a synoptic table not only all of the species of this genus which have been introduced purposely as parasites of the gipsy moth or the brown-tail moth or accidentally included in shipments of parasite material, but also all of the species of the genus known to occur in the United States. In the same way it has been deemed desirable to publish a table separating the common American form from the two species of the genus *Hypopteromalus* accidentally included in shipments of parasite material, and also to separate in a synoptic table the different Japanese species of the genus *Pleurotropis* which have three funicle joints. As pointed out, *P. atamiensis* belongs probably to an undescribed genus.

Family CHALCIDIDÆ Walker.

Subfamily CHALCIDINÆ Howard.

Tribe CHALCIDINI Ashmead.

Genus CHALCIS Fabricius.

Since some of the species of *Chalcis* from Europe and Japan are being introduced into this country, it appears best to give a table of all of the species of the genus known to occur in the United States and to include in this table the exotic species which are involved.

In the following table and descriptions of species the term "tubercle of hind coxæ" refers to a small projection on the ventral side of certain species (fig. 9). The tubercle of the hind femur is the small elevation on the inner side near base and on the lower margin of the femur (fig. 20).

In all of the figures showing the carina which separates the malar space from the face, the drawings are made facing the left.

TABLE OF SPECIES OF THE GENUS *CHALCIS*.

1. Hind femora on outer side black or black and yellow.....	2
Hind femora on outer side red, or red and yellow, or red and black.....	12
2. Carina at front of malar space not branched, running direct to eye.....	3
Carina at front of malar space branched or directed backward before reaching eye.....	5
3. Hind femora closely punctured, tooth nearest base on lower margin of hind femora triangular. (America).....	<i>ovata</i> Say.
Hind femora almost impunctate, especially the inner side, tooth nearest base of hind femora massive.....	4
4. Hind femora on outer side yellow at base and apex. (America).....	<i>robusta</i> Cresson.
Hind femora yellow only at apex. (America).....	<i>incerta</i> Cresson.
5. Scape in front with a yellow spot.....	6
Scape in front entirely dark.....	7
6. Hind femora mostly yellow. (America).....	<i>regularis</i> Cresson.
Hind femora mostly black. (America).....	♂ <i>coloradensis</i> Cresson.
7. Inner side of hind femora distinctly, closely punctured.....	8
Inner side of hind femora almost entirely impunctate.....	11
8. Posterior tibiæ behind mostly black.....	9
Posterior tibiæ behind yellow except basally.....	10
9. Hind femora entirely black, hind tibiæ black with a small yellow spot at apex. (America).....	<i>tarsata</i> Dalla Torre.
Hind femora with a yellow spot at apex; hind tibiæ with a yellow annulus near base. (Japan).....	<i>fiskei</i> , new species.
10. Hind tibiæ at base black; a small area beneath antenna smooth; pupal skin light colored. (Japan).....	<i>obscurata</i> Walker.
Hind tibiæ at base yellow or reddish; no smooth area beneath each antenna; pupal skin dark brown. (Europe).....	<i>flavipes</i> Panzer.
11. Wings hyaline; tooth of metathorax less prominent, the outline more obtuse, the front edge directed backward. (Japan).....	<i>paraplesia</i> , new species.
Wings dusky; tooth on metathorax more prominent, the outline more acute, the front edge almost vertical. (Europe).....	<i>minuta</i> Linnæus.
12. Mesonotum red. (America).....	<i>belfragei</i> Crawford.
Mesonotum black.....	13
13. Face with a distinct carina between antennal fossa and eyes, originating back of anterior ocellus; antennal fossa carinate. (America).....	<i>pedalis</i> Cresson.
Face not so carinate.....	14
14. Antennal fossa very wide, separated from eyes by about length of first joint of funicle.....	15
Antennal fossa narrow; separated from eyes by more than length of first joint of funicle.....	16

15. Small; abdomen basally red; tooth nearest base of hind femora not larger than rest; hind coxæ of female not toothed. (America)..... *columbiana* Howard.
 Large; abdomen black; tooth basad on hind femora very large; hind coxæ of female toothed. (America)..... *slossonæ* Crawford.
 16. Scape in front with a yellow spot. (America)..... *coloradensis* Cresson.
 Scape in front black..... 17
 17. Small, about 4^{mm}, wings milky hyaline, lateral teeth on metathorax not prominent. (Europe)..... *fonscolombeï* Dufour.
 Larger, about 6^{mm}, wings dusky, lateral teeth on metathorax prominent, acute. (Japan)..... *callipus* Kirby.

CHALCIS OVATA Say.

(Figs. 8-10.)

Chalcis ovata Say, Keating's Narrat. Exped., II, app., p. 326, 1824.

This native species is separated from all the exotic species discussed in this article by the fact that the carina at the front of the



FIG. 8.—*Chalcis ovata*, female
 Head, showing carina at front of malar space. (Original.)



FIG. 9.—*Chalcis ovata*, female:
 Ventral view of hind coxa, showing tubercle. (Original.)

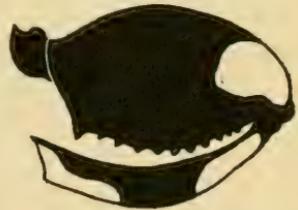


FIG. 10.—*Chalcis ovata*, female: Hind femur and tibia, showing markings. (Original.)

malar space runs direct to the eye; in the female the hind coxæ are armed with a small tubercle; the inner side of the hind femora is distinctly punctured, and without a tubercle on the lower margin near base; the hind tibiæ are either with or without a black annulus medially; the form with the annulus is illustrated.

CHALCIS ROBUSTA Cresson.

(Fig. 11.)

Chalcis robusta Cresson, Proc. Ent. Soc. Phila., IV, p. 101, 1865.

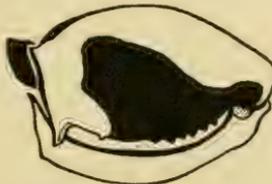


FIG. 11.—*Chalcis robusta*, female: Hind femur and tibia, showing markings. (Original.)

CHALCIS INCERTA Cresson.

(Fig. 12.)

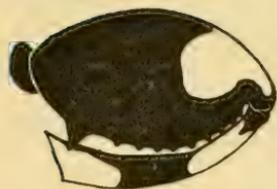


FIG. 12.—*Chalcis incerta*, female: Hind femur and tibia, showing markings. (Original.)

Chalcis incerta Cresson, Proc. Ent. Soc. Phila., iv, p. 101, 1865.

Both of the Cuban species, *Chalcis robusta* and *C. incerta*, are to be found in southern Florida. The massive basal tooth of the hind femora distinguishes them from the other species in the United States.

CHALCIS COLORADENSIS Cresson.

Chalcis coloradensis Cresson, Trans. Amer. Ent. Soc., iv, p. 60, 1872.

In the male of this species the hind femora are black, except the apex, which is yellow; the female, however, has the femora red; the hind femora have on the lower edge near base an indistinct tubercle. I am unable to distinguish *C. tachinæ* Howard from this species.

CHALCIS FISKEI, new species.

(Figs. 13-14.)

Female.—Length, about 6.5mm. Black, head and thorax strongly, umbilicately punctured, with long yellowish pubescence; face below insertion of antennæ rugoso-punctate; antennal fossa extending to anterior ocellus; carina at front of malar space running backward to join the carina at the rear, making a triangularly inclosed malar space; antennæ black, pedicel short, transverse; depressed apical margin of scutellum broad, slightly emarginate medially; me-

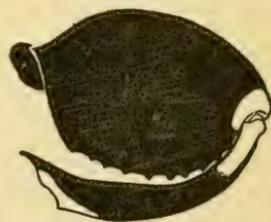


FIG. 13.—*Chalcis fiskei*, female: Hind femur and tibia, showing markings. (Original.)



FIG. 14.—*Chalcis fiskei*, female: Head, showing carina at front of malar space. (Original.)

tathorax, back of outer end of metathoracic spiracle, with a toothlike elevation; tegulæ yellow; wings dusky; postmarginal vein about twice as long as the short stigmal; legs black; front and middle legs with the femora apically, the tibiæ at bases and apices, the tarsi, and the anterior tibiæ in front, yellow; a small yellow spot at the apex of the hind femora, and a small yellow spot at the base and one at the apex of the hind tibiæ on the outer side; the hind tarsi entirely yellow;

hind femora on the lower margin with a triangular tooth near base, the space between this tooth and the apex of the femur occupied by about a dozen teeth, those in the middle of the series the largest and almost as large as the basal tooth, the teeth in the series decreasing in size from the middle toward both ends; hind femora distinctly punctured on the inner side; first segment of abdomen smooth, having a spot on each side with setigerous punctures; second segment at sides and on base with large setigerous punctures, the dorsal apical part of the segment with small punctures; the following segments basally smooth, the apical margins with fine punctures mixed with large setigerous punctures, sixth segment entirely covered with large punctures.

Male.—Length, about 6.5^{mm}. Similar to the female, but with more yellow on the legs, the front and middle tibiæ mostly yellow, the spots on the hind tibiæ larger and occasionally meeting, making a yellow stripe on the outer side; teeth along the lower margin of the femora smaller.

Habitat.—Japan.

Described from 12 specimens reared at the Gypsy Moth Parasite Laboratory from material received from Prof. Trevor Kincaid and Prof. S. I. Kuwana. This is a parasite of Tachinidæ.

Type.—Cat. No. 12789, U. S. National Museum.

CHALCIS OBSCURATA Walker.

(Figs. 15-16.)

Chalcis obscurata Walker, Trans. Ent. Soc. London, f. 1874, p. 399.

In this species the hind coxæ of the female have a small tubercle; the hind tibiæ are yellow except the extreme base, which is black; the face immediately below the antennal fossa is smooth and polished, especially a spot below the insertion of each antenna; the hind femora are distinctly punctured on the inner side and without a tubercle near the base. This species and the following resemble superficially the form of *C. ovata* which has the hind tibiæ without the medial black annulus but the structure of the carina at the front of the malar space readily separates them. This Japanese species is a parasite of *Porthetria dispar* and has been reared by G. Ojima, Kumamoto, and S. I. Kuwana, Tokyo.



FIG. 16.—*Chalcis obscurata*, female: Head, showing carina at front of malar space. (Original.)

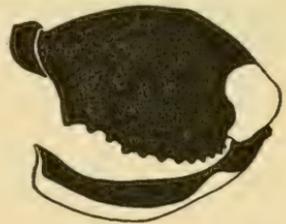
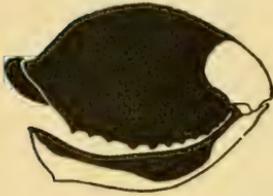


FIG. 15.—*Chalcis obscurata*, female: Hind femur and tibia, showing markings. (Original.)

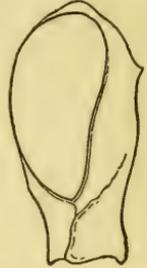
CHALCIS FLAVIPES Panzer.

(Figs. 17-18.)

Chalcis flavipes Panzer, Fauna Insect. German, vii, p. 78, 1801.FIG. 17.—*Chalcis flavipes*, female: Hind femur and tibia, showing markings. (Original.)

the table. It, also, is parasitic on *Porthetria dispar*.

This European species closely resembles the above, having the tubercle on the hind coxæ of the female, and the inner side of the hind femora punctured and without the tubercle near base, but is separated by the characters given in

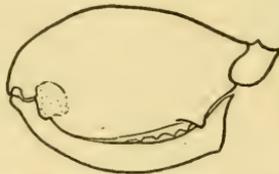
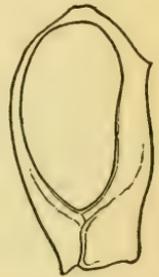
FIG. 18.—*Chalcis flavipes*, female: Head, showing carina at front of malar space. (Original.)

CHALCIS MINUTA Linnæus.

(Figs. 19-21.)

Vespa minuta Linnæus, Syst. Nat., Ed. 12, i, p. 952, 1767.

In this European species the hind femora have a tubercle near base on the inner side below. The inner side of the hind femora is not distinctly punctured. In the female the hind coxæ are without

FIG. 19.—*Chalcis minuta*, female: Hind femur and tibia, showing markings. (Original.)FIG. 20.—*Chalcis minuta*, female: Hind femur, inner side, showing tubercle near base. (Original.)FIG. 21.—*Chalcis minuta*, female: Head, showing carina at front of malar space. (Original.)

a tubercle. This species and the following superficially resemble *C. ovata*, but are distinguished by the form of the carina at the front of the malar space, as well as by having the inner side of the hind femora impunctured and with a tubercle near base. It is a parasite of flies of the family Sarcophagidæ, which are scavengers on the dead pupæ of the gipsy moth.

CHALCIS PARAPLESIA, new species.

(Figs. 22-23.)

Female.—Length, about 5.5^{mm}. Head and thorax coarsely, umbilicately punctured, face below insertion of antennæ rugoso-punctate; the carina at front of the malar space runs almost to eye, then obliquely backward and upward to join carina at rear; malar space shiny, weakly sculptured; depressed apical margin of scutellum deeply emarginate; metathorax at sides with a small toothlike projection; tegulæ yellow; wings hyaline; legs black, marked with yellow; all the tarsi, tips of all femora, bases and tips of front and middle tibiæ, a line on front of anterior tibiæ, and apical third of hind tibiæ and a spot near base, yellow; hind femora on inner side with small, sparse, indistinct punctures; hind femora on inner side below with a distinct tubercle near base; lower margin of hind femora with a sawlike tooth near base, followed by a series of about ten smaller teeth, these decreasing in size to apex of femora; abdomen smooth, second segment and following segments at sides with some large punctures and apically minutely punctured.

Male.—Length, 5^{mm}. Similar to the female, but the tooth of the metathorax represented by a slightly raised carinate ridge.

Habitat.—Japan.

Described from 6 specimens reared at the Gipsy Moth Parasite Laboratory from material collected by Prof. Trevor Kincaid and Prof. S. I. Kuwana. This species is parasitic in the pupæ of Sarcophagidæ.

Type.—Cat. No. 12791, U. S. National Museum.

This species is closely related to *C. minuta* Linnæus, but is distinguished by the hyaline wings and the less prominent tooth on the metathorax, which has the front edge running backward instead of almost vertical, as in *minuta*. The male of *minuta* occasionally has almost hyaline wings and is then easily separated by the strong teeth of the metathorax, the teeth being about as prominent in the male as in the female.

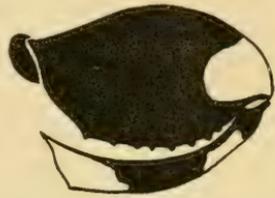


FIG. 22.—*Chalcis paraplesia*, female: Hind femur and tibia, showing markings. (Original.)



FIG. 23.—*Chalcis paraplesia*, female: Head, showing carina at front of malar space. (Original.)

CHALCIS FONSCOLOMBEI Dufour.

Chalcis fonscolombi Dufour, Ann. Soc. Ent. France, x, p. 16, 1841.

This European parasite of Sarcophagidæ often has the basal half of the hind femora black; the hind tarsi are red at base and apex and black medially, the red part ornamented with a small yellow spot; the hind femora have a small tubercle on the inner side below near the base; the hind coxæ of the female are without a tubercle.

CHALCIS CALLIPUS Kirby.

Chalcis callipus Kirby, Journ. Linn. Soc. London, Zool., xvii, p. 75, 1883.

In this species the hind coxæ of the female are without a tubercle, the hind femora are very sparsely punctured on the inner side and have a tubercle near the base; the carina at the front of the malar space has, before reaching the eyes, a branch directed backward.

Of this species only one female has been seen, collected at Nishigahara, Tokyo, Japan, by Prof. S. I. Kuwana, with the record "bred from the pupa of a gipsy moth, July 12, 1908."

Family PERILAMPIDÆ Förster.

Genus PERILAMPUS Latreille.

PERILAMPUS INIMICUS, new species.

Female.—Length, about 2^{mm}. Deep violaceous, with purple reflections, the head, metathorax, and abdomen more bluish; face not carinate; face and vertex impunctate, with scattered pubescence on the vertex; scape of antennæ blue or greenish, flagellum reddish brown, beneath more reddish; first joint of flagellum hardly longer than the pedicel; thorax umbilicately punctured, parapsidal areas along inner side, with a broad smooth area; punctures on disc of scutellum more separated, leaving a more or less distinct smooth line along center; wings hyaline; legs brown, hind legs in front purple; knees, anterior tibiæ in front, bases and tips of all tibiæ, and the tarsi entirely, light testaceous; apical margin of first abdominal segment straight.

Male.—Length, about 2^{mm}. Similar to the female; apical two-thirds of scape swollen and flattened in front, with a slight constriction between the normal base and the swollen part; legs with more light color at the bases and apices of tibiæ.

Habitat.—Japan.

Described from 6 specimens reared from cocoons of *Glyptapanteles japonicus* Ashmead at the Gipsy Moth Parasite Laboratory, from material received from Prof. Trevor Kincaid and Prof. S. I. Kuwana.

Type.—Cat. No. 12793, U. S. National Museum.

Family PTEROMALIDÆ Walker.

Subfamily PTEROMALINÆ Ashmead.

Tribe PTEROMALINI Ashmead.

Genus HYOPTEROMALUS Ashmead.

Since the type species of this genus has a well-developed neck to the metathorax and a short but plainly visible petiole, it does not well fit in the place in Doctor Ashmead's tables in which he has put it. The following table based on antennal characters and the color of the legs separates both sexes:

TABLE OF SPECIES OF THE GENUS HYOPTEROMALUS.

- | | |
|---|--------------------------------------|
| 1. First joint of funicle elongate, longer than the pedicel..... | 2 |
| First joint of funicle not elongate, scarcely longer than the pedicel. (America.) | |
| | <i>tabacum</i> Fitch. |
| 2. Femora and tibiæ light testaceous. (Japan.)..... | <i>apantelephagus</i> , new species. |
| Hind femora green; other femora partly dark; in female the tibiæ mostly dark. | |
| (Europe.)..... | <i>pæcilopus</i> , new species. |

HYOPTEROMALUS APANTELOPHAGUS, new species.

Female.—Length, about 2.75^{mm}. Bluish green, the head distinctly wider than the thorax; head, pronotum, mesonotum, and metathorax between the lateral folds, with thimblelike punctures; antennæ light brown, the scape testaceous; transverse line near rear of scutellum distinct; neck of metathorax with sculpture similar to that on basal part; lateral folds well developed; median carina wanting or very slightly indicated; wings hyaline, veins testaceous, postmarginal vein as long as the marginal, the stigmal vein distinctly shorter; coxæ blue-green, the rest of the legs yellowish testaceous, the femora and tibiæ more or less suffused with brownish; abdomen smooth, shiny, narrow, the apical segments finely lineolated.

Male.—Length, about 2^{mm}. Similar to the female except in secondary sexual characters; head and thorax more greenish than in the female; abdomen basally with a large yellowish spot; legs less suffused with brownish than in the female.

Habitat.—Japan.

Described from 6 females and 6 males from the series reared at the Gypsy Moth Parasite Laboratory from *Glyptapanteles japonicus*, received from Prof. Trevor Kincaid and Prof. S. I. Kuwana.

Type.—Cat. No. 12973, U. S. National Museum.

HYOPTEROMALUS PÆCILOPUS, new species.

Female.—Length, about 3^{mm}. Green or bluish-green; head slightly wider than the thorax; head, pronotum, mesonotum, and metathorax

between the lateral folds with thimblelike punctures; antennæ dark brown, the scape basally testaceous; transverse line on scutellum distinct, the punctures back of it larger than those immediately in front of it; neck of metathorax with sculpture similar to that of basal part; median carina distinct, lateral folds well developed; wings hyaline, veins testaceous; marginal and postmarginal veins subequal in length, the stigmal vein shorter; coxæ green, front and middle femora brown with a metallic tinge, basal half of middle and hind tibiæ brown; hind femora green; knees, front tibiæ, apical half of middle and hind tibiæ, and all tarsi yellowish; abdomen smooth, shiny, the apical segments finely lineolated.

Male.—Length, about 2^{mm}. Similar to the female, except in secondary sexual characters; the scape entirely testaceous; tibiæ entirely light, slightly suffused with brownish; front and middle trochanters light, abdomen with a light spot basally.

Habitat.—Europe.

Described from 2 specimens reared at the Gipsy Moth Parasite Laboratory from *Glyptapanteles* sp.

Type.—Cat. No. 12974, U. S. National Museum.

Family EULOPHIDÆ Foerster.

Subfamily ENTEDONINÆ Ashmead.

Tribe ENTEDONINI Ashmead.

Genus PLEUROTROPIS Foerster.

The species described from Japan by Ashmead in the genus *Derostenus* have lateral carinæ on the metathorax and a distinct ring-joint to the antennæ, so that they are properly to be referred to the genus *Pleurotropis*.

The following table will separate the females of the species from Japan which have 3 joints in the funicle; *P. atamiensis* Ashmead has 4 joints in the funicle and is probably an undescribed genus.

TABLE OF SPECIES OF THE GENUS PLEUROTROPIS.

1. Median lobe of mesothorax at apex with two large foveæ.....	<i>bifoveolatus</i> Ashmead.
Median lobe of mesothorax at apex without foveæ.....	2
2. Legs, including femora, testaceous.....	<i>mitsukurii</i> Ashmead.
Legs with the femora dark.....	3
3. Head above with deep thimblelike punctures.....	4
Head above weakly sculptured.....	<i>nawai</i> Ashmead.
4. Hind tibiæ whitish.....	<i>orientalis</i> , new species.
Hind tibiæ dark colored.....	<i>howardi</i> , new species.

PLEUROTROPIS ORIENTALIS, new species.

Female.—Length, about 1.5^{mm}. Bronzy black, with green or purple reflections, the vertex and base of abdomen more greenish, the metathorax distinctly green; vertex with coarse thimblelike punctures, the frontal declivity above transverse groove smooth, below furrow with finer punctures, those below the insertion of the antennæ still finer; antennæ brown; mesonotum reticulate, parapsidal furrows not very apparent; scutellum reticulate all over, basally the lines more regular and longitudinal; metathorax smooth, median and lateral carinæ distinct; femora green, tibiæ testaceous, tarsi more whitish; first segment of abdomen medially at apex and following segments finely punctured.

Male.—Unknown.

Habitat.—Japan.

Described from 5 specimens reared from *Glyptapanteles japonicus* at the Gypsy Moth Parasite Laboratory, from material received from Prof. Trevor Kincaid and Prof. S. I. Kuwana.

Type.—Cat. No. 12975, U. S. National Museum.

PLEUROTROPIS HOWARDI, new species.

Female.—Length, about 2^{mm}. Green, with bluish reflections, the sides of the scutellum, the apical part of the parapsidal areas, and the pleuræ purplish-black; face below the transverse furrow bluish, with fine thimblelike punctures down to the insertion of antennæ, below this still more finely and weakly punctured; above the furrow with coarse thimblelike punctures; antennæ green; pubescence of eyes distinct; mesothorax coarsely reticulate, the parapsidal furrows not very distinct anteriorly, posteriorly formed by triangular depressed areas which resemble scars, each with a single setigerous puncture; median lobe of mesonotum strongly emarginate at apex; scutellum at sides longitudinally striate, the apical portion reticulate, leaving the median basal area smooth; metathorax smooth, medially with two carinæ close together, lateral carinæ distinct; first segment of abdomen basally smooth, green, beyond this the abdomen purplish-black and finely punctured; legs green, the tarsi white, apically brown.

Male.—Unknown.

Habitat.—Japan.

Described from 8 specimens reared from cocoons of *Glyptapanteles japonicus* at the Gypsy Moth Parasite Laboratory, from material received from Prof. Trevor Kincaid and Prof. S. I. Kuwana.

Type.—Cat. No. 12976, U. S. National Museum.

Named in honor of Dr. L. O. Howard, under whose direction the parasite work is conducted.

Subfamily EULOPHINÆ Howard.

Tribe EULOPHINI Ashmead.

Genus DIMMOCKIA Ashmead.

DIMMOCKIA SECUNDUS, new species.

Female.—Length, about 2^{mm}. Bright green, the face and occiput covered with very fine, close striæ; antennæ brownish testaceous, the scape lighter colored; ring-joint distinct, pedicel shorter than first joint of funicle, about as long as joint 2; joints 2–4 subequal, only slightly longer than wide; club showing only 2 joints; mesonotum and metathorax between the lateral folds with fine thimble-like punctures, those of the scutellum finer than on the middle lobe of the mesonotum, those of the axillæ still finer and becoming in part fine striæ; scutellum with a median longitudinal line of punctures which are finer than the rest; median and lateral carinæ of metathorax very distinct; mesepisternum with thimblelike punctures; mesepimeron below finely reticulate, the upper part smooth; metapleuræ and metathorax laterad of lateral carinæ rugose; legs light yellow, the hind coxæ at base above with a small green spot; abdomen green, the apical margins of abdominal segments brownish; first and second segments smooth, the others with very fine lineolations.

Male.—Unknown.

Habitat.—Japan.

Described from 5 female specimens reared at the Gipsy Moth Parasite Laboratory from *Glyptapanteles japonicus*, from material received from Prof. Trevor Kincaid and Prof. S. I. Kuwana.

Type.—Cat. No. 12977, U. S. National Museum.

In this genus the funicle is 4-jointed and the club shows only 2 joints, so that the antennæ show 9 joints instead of 10 as given by Doctor Ashmead in his Classification of Chalcidoidea.

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TECHNICAL SERIES, No. 19, PART III.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

TECHNICAL RESULTS FROM THE GIPSY MOTH
PARASITE LABORATORY.

III. INVESTIGATIONS INTO THE HABITS OF
CERTAIN SARCOPHAGIDÆ.

By T. L. PATTERSON,

Assistant in Biology, Sheffield Scientific School, Yale University,

WITH AN INTRODUCTION

By W. F. FISKE,

In Charge of Gipsy Moth Parasite Laboratory, Bureau of Entomology.

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PREVENTING SPREAD OF MOTHS.

PARASITE LABORATORY.

W. F. FISKE, *in charge*; A. F. BURGESS, H. L. VIERECK, C. W. COLLINS, R. WOOLDRIDGE, JNO. D. TOTHILL, C. W. STOCKWELL, H. E. SMITH, *assistants.*

FIELD WORK.

D. M. ROGERS, *in charge*; H. B. DALTON, H. W. VINTON, D. G. MURPHY, I. L. BAILEY, H. L. MCINTYRE, *assistants.*

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TECHNICAL RESULTS FROM THE GIPSY MOTH PARASITE LABORATORY.

III. Investigations into the Habits of Certain Sarcophagidæ.

By T. L. PATTERSON,

*Assistant in Biology, Sheffield Scientific School, Yale University.*INTRODUCTION.¹

That there are among the Sarcophagidæ a number of species which, to all intents and purposes, are primary parasites of grasshoppers is a fact concerning which there is no ground left for argument. Whether the young larvæ of these flies bear a relation to the living host which is in any way comparable to the extraordinary intimacy which characterizes the relations between the tachinid parasites and their hosts is beside the present question. They assuredly do gain access to the living body of their host, and after a time destroy it, and by so doing qualify themselves to be considered among the insect parasites.

There are numerous species of the Sarcophagidæ which have been reared in association with the gipsy moth (*Porthetria dispar* L.). Each year after the caterpillars have pupated and when the moths are beginning to emerge, interested persons have found pupæ with the shell apparently unbroken, the contents in a state of decomposition, and an active sarcophagid larva luxuriating in the surroundings thus provided. The condition of the pupa containing the sarcophagid is always different from that of a pupa containing a tachinid maggot, but the distinction is not instantly apparent nor easily described. To the ordinary observer the pupa containing the sarcophagid answers perfectly to the description of a pupa destroyed by a tachinid, and each year it has been necessary to explain anew the difference between parasite and scavenger. That sarcophagid maggots found under these conditions are always scavengers and never parasites has never seriously been questioned.

It must be admitted, however, that in thus rather summarily consigning the whole group of sarcophagids to the rôle of scavengers, in so far as their relations to the gipsy moth were concerned, there has been an undercurrent of uneasiness lest among them should eventu-

¹ Introduction by W. F. Fiske, in charge of Gipsy Moth Parasite Laboratory, Bureau of Entomology, Melrose Highlands, Mass.

ally be found some which created rather than took advantage of the conditions under which they were encountered. It required hardly any stretching of the imagination to conceive of sarcophagid maggots deposited upon living pupæ, effecting an entrance, and eventually bringing about the death and decomposition of the host. From time to time tentative attempts to acquire more definite information were made, but without positive results one way or the other. Large numbers of gipsy-moth pupæ, apparently living, were collected in the open and upon one or two occasions sarcophagid maggots were subsequently found, but there were always very satisfactory explanations for their presence other than that they were parasitic, and it was increasingly evident that if such experiments were to be decisive, they would have to be conducted with exceedingly great care. Several attempts were also made to keep the adult sarcophagids reared from gipsy-moth pupæ imported from Europe or Japan until they reached their full sexual development and were ready to deposit their brood, but there were a good many things to learn about the best way of conducting an experiment of this sort and none of them was successfully concluded.

In the summer of 1910 the question of *Sarcophaga* in its relations to the gipsy moth was rather suddenly reopened as the immediate result of a study in parasitism conducted by Mr. P. H. Timberlake, of this laboratory, upon the "pine tussock moth" which was causing some injury to pine in northern Wisconsin. The results of his studies, which will be published in another part of this bulletin, were such as strongly to indicate the parasitic character of certain sarcophagids and to suggest that they were, in effect, of rather considerable importance in the control of this moth.

This, when taken in connection with the fact that a vastly larger number of sarcophagids were continually being received in shipments of gipsy-moth pupæ from Europe and Japan than would be secured from an equal number of similar pupæ collected in America, was a circumstance which could no longer be overlooked. The evidence was such as materially to support a contention that among the European sarcophagids occurred species which were primarily enemies of the gipsy moth. If, as did not seem so very improbable, there existed in Europe such an important group of dipterous parasites of gipsy-moth pupæ, no time should be lost in attempting to secure their introduction into America.

Most unfortunately it is impossible in this case, as in a great many others, to conduct the necessary investigations to the best advantage. Independent European entomologists can not, of course, conduct elaborate investigations along lines wholly outside of their own affairs, and the establishment of a European branch of the Gipsy Moth Parasite Laboratory has never been considered as practicable.

As usual we were forced to do what could be done with such opportunities as were offered. It was decided to institute at once a new series of studies upon the relations of the American sarcophagids to the gipsy moth, and to conduct them so carefully that if they did not produce positive results they would at least possess negative value.

Fortunately the services of Mr. Patterson were available at that time, and the affairs of the laboratory were in such condition as to permit him to give the work his undivided attention. For the first time it was possible to conduct the experiments, which he will describe himself, with the adequate attention to detail which is absolutely necessary if the results are to be considered as decisive. His results seem to justify the retention of the ideas previously held, in so far as they can be justified by a study of American conditions. It is sincerely to be hoped that in the very near future similar investigations may be conducted in Europe, since the only other additional studies which seem worth while in America will be of the sarcophagids in relation to other lepidopterous hosts, and the findings, whatever their character, would not be directly applicable to the problem of gipsy-moth parasite introduction.

GENERAL CONDITIONS.

Since the establishment of the Gipsy Moth Parasite Laboratory in 1905 considerable interest has been excited each year from the number of sarcophagids reared in connection with gipsy-moth pupæ, and even more from the larger percentage of sarcophagids received from gipsy-moth pupæ imported annually from Europe and Japan. It would seem probable from the above that certain species of sarcophagids had always been parasitic, or else that they had within recent years developed the parasitic habit, which is the more likely; hence, instead of having to depend wholly upon dead material as a host they had joined the ranks of certain of the Tachinidæ in waging war against one of the most injurious insect pests that has ever invaded New England, the gipsy moth. During the last few years certain tentative experiments have been made at the laboratory, but all this work, while it proved rather interesting, was not convincing, and gave neither positive nor negative results. In the summer of 1910 conditions again became favorable for further investigations into the habits of native Sarcophagidæ and the writer attempted to determine, by the series of experiments which follow, whether any of these flies are parasitic in habit, or whether they are scavengers on the gipsy moth.

COLLECTIONS OF GIPSY-MOTH PUPÆ FOR MAGGOTS OF SARCOPHAGIDÆ.

Collections were made of gipsy-moth pupæ from localities in towns within a radius of 10 miles of the laboratory. The smallest collection contained 225 and the largest 790 pupæ, each of which was care-

fully examined and placed into one of two separate lots, namely, the live and active, or the dead, abnormal, and inactive. A few small collections were also made of active prepupal larvæ which were kept separate from the other lots. All of these lots were placed in small pasteboard boxes about 8 by 5 by 4 inches, with tight covers, and were examined almost daily for either maggots or puparia of Sarcophagidæ, or parasites, and the moths as they issued from the pupæ were removed and killed. The small number of pupæ from which no moths issued was dissected for parasites at the close of the experiments. Three thousand two hundred and fifty-seven pupæ and prepupal larvæ were collected for the experiments, 300 of which were active prepupal larvæ, 591 were dead and inactive pupæ, and the remaining 2,366 were active pupæ. No sarcophagids were reared from the lots of active pupæ and active prepupal larvæ, but 2 puparia of the tachinid parasite *Compsilura concinnata* Meig. developed from one of the lots of the active pupæ and 14 were secured from the prepupal larvæ. This parasite of the gipsy moth and brown-tail moth was introduced from Europe and liberated in eastern Massachusetts. It has become so well established here, according to the best authorities and records, that it is now distributed over more than 200 square miles of the infested territory.

From the dead and inactive pupæ, as might have been expected, sarcophagids were obtained, as well as other species which work as scavengers or parasites. This material yielded 4 third-stage maggots and 1 second-stage (dead) maggot of the Sarcophagidæ; 4 puparia and 1 third-stage maggot (dead) of *Compsilura concinnata*; 1 *Exorista blanda* O. S.; 2 third-stage maggots and 1 second-stage tachinid maggot of an unknown species; 14 *Monodontomerus* adults and 2 pupæ of the same; 8 pupæ of *Gaurax anchora* Loew (?); and 1 adult and 4 pupæ of *Theronia* and 5 *Dibrachys* (dead) in 1 gipsy moth pupa. A special lot of 5 prepupal larvæ was collected, and on dissection 2 proved to be alive, 2 dead, and 1 had pupated while being brought in from the field. In one of the live prepupals a second-stage maggot of *Compsilura concinnata* was obtained, while the other was not parasitized. One of the dead prepupals produced 3 third-stage maggots of the Sarcophagidæ, while the other, as well as the freshly formed pupa, contained no parasites.

The above experiments not only uphold, but seem rather to strengthen the old belief that the sarcophagids are simply scavengers. Another point of interest in this line of investigation is that there are sometimes found in a single pupa more than one parasite, which often belong not only to entirely distinct and separate genera, but even to entirely distinct and separate families. This point was well illustrated in making one of the collections, when the posterior end of a

dead gipsy-moth pupa was accidentally broken off in removing it from the tree, thus disclosing within its almost empty case 2 third-stage maggots, one *Compsilura concinnata* and the other a sarcophagid. This may be very satisfactorily explained by the fact that this pupa, when in the caterpillar stage, was first parasitized by *Compsilura concinnata*, and after reaching the pupal stage the maggot within became large enough to kill the pupa. The decomposition which resulted furnished a favorable place for the oviposition of a female sarcophagid. In various other cases, when it appeared as an almost absolute certainty that maggots of the Sarcophagidæ came from living material, their presence could be accounted for in some such way as the above. The following experiments with the native sarcophagids will also go to strengthen and substantiate the above theory.

EXPERMENTS WITH ADULT SARCOPHAGIDÆ.

Collections were made of these flies for reproduction experiments from different localities in the infested area. Each collection was kept separate in cylindrical wire screen (one-twelfth-inch mesh) cages, 10 inches in height by about 4 inches in diameter. The top consisted of a circular piece of wood, to which was tacked the wire screen, while the lower edge of the screen fitted into a groove in the wooden base. This arrangement allowed the quick removal of the base and furnished easy access to the cage. A sprig of leaves, with the stem wrapped with cotton batting, was inserted in a tube of water attached to the inside of each cage, and this was sprayed with a solution of sugar and water twice daily, which furnished food for the flies. At first only active prepupal larvæ of the gipsy moth were placed in these cages. They pupated in a day or two and were allowed to remain there for several days, where the flies could have free access to them, before they were transferred to jelly glasses, which were covered with cheesecloth. These were kept under observation for sarcophagid maggots until the moths emerged or the pupæ died, in which cases they were always dissected. All these experiments gave negative results, showing almost conclusively that these flies did not oviposit on living pupæ. The writer then added some badly decomposed caterpillars to the living ones in the cages and observed in a short time that the female flies deposited tiny maggots on the dead material, but not on the living, although frequently they crawled over the live pupæ until these wriggled, which seemed to frighten the flies away. The living material from these experiments was also placed in jelly glasses, but all finally gave negative results. All dead material was now placed in the cages and first-stage maggots were obtained quite plentifully and appeared to be perfectly healthy.

EXPERIMENTS WITH FIRST-STAGE MAGGOTS ON LIVING AND DEAD MATERIAL.

Some of these maggots were placed on mature active pupæ, but in every instance they showed little, if any, desire to bore through the pupal cases. This would probably be an impossibility, as the exterior of the pupæ is tough and hard, but the maggots did not enter even the soft prepupal larvæ. In both cases the pupæ and prepupal larvæ were greatly disturbed and irritated when maggots were crawling on them, and they wriggled violently, dislodging the maggots. If they were placed on a soft, freshly formed pupa the maggots at once would make frantic attempts to bite into it, but without success; although, in one instance, when the membrane which holds the wing cover to the body of the pupa became ruptured, the maggot took advantage of this opportunity of concealment and crawled beneath, and although the maggot was still on the external surface of the pupa it caused such an irritation by its movements that a dark secretion oozed out, coming either from the pupa, maggot, or both, and in the course of a few hours the wing cover became sealed to the body of the pupa, so that only the anal stigmata of the maggot were left exposed. After the lapse of about 12 hours the pupa was found to be dead, and in 18 or 20 hours the maggot disappeared into the body of the pupa. A dissection was made the following day. The maggot was found dead midway in the body of the pupa. This would seem to indicate that the environment which the maggot found within the pupa was not favorable for its development.

To further illustrate the above idea the writer took active pupæ, making a puncture about midway in the body of each, and allowed a live maggot to crawl in, but in all cases the maggots died, showing that they can not live under such circumstances. However, a few came out of the pupæ and died on the outside. Similar experiments were made on dead material with entirely different results. In most cases the maggots went in without experiencing any difficulty and usually survived, which showed that they were in a natural environment.

RELATION OF DECOMPOSITION TO OVIPOSITION.

It was observed that the flies would not oviposit on freshly killed material in the cages, even though the females had been ovipositing previously on older decomposing caterpillars. This would seem to refute the parasitic theory and would tend to show that the material must reach a certain stage of decomposition before the females would oviposit. Selecting the only cage where females were ovipositing the writer removed all the old material and replaced it with a single freshly killed caterpillar. The flies at once ceased to oviposit,

although they would crawl about over it. Two days later the writer observed one of the female flies in this cage spending the most of her time crawling about over this caterpillar. A little later she began to make a buzzing noise with her wings and was feeling here and there with her proboscis over the body of the decomposing caterpillar. Proceeding to the anterior portion of the caterpillar a few segments back of the head she succeeded in puncturing the decaying skin with her proboscis, and then moving along far enough so that the end of her ovipositor was directly over this puncture she slowly deposited a maggot which immediately, true to its instincts, worked its way through this puncture into the body of the caterpillar. Several maggots were deposited by this fly, and later a second female was observed to oviposit on the caterpillar in the same incision. This not only indicates that a certain stage of decomposition must be reached, but that the skin of the caterpillar must be either broken, or in such a condition that the female fly can puncture it with her proboscis before she will oviposit, thus allowing an opportunity for the maggots to crawl into the dead host. There were a few living pupæ in this cage, and although the females not infrequently crawled about over them, they did not attempt oviposition. This was the case with a freshly killed caterpillar which was placed beside a dead specimen upon which flies were ovipositing, but when decomposition reached the proper stage, the flies began to oviposit freely. It must be stated here that the true source of the flies in the cage with which this last experiment was tried was unknown, and that they were selected only for the reason that they happened to be the only flies available that were ovipositing. They were secured from a jar containing dead European *Calosoma* beetles which had been exposed for several weeks to the attack of various species of sarcophagids. It is possible that these flies might have been imported from Europe, but this is extremely doubtful.

CONCLUSION.

These experiments indicate very conclusively that the sarcophagids in New England do not destroy living gipsy-moth larvæ or pupæ in the field. From a collection of 2,666 specimens not a single sarcophagid was reared.

In cages the flies would not oviposit on healthy or recently killed caterpillars or pupæ, but did so freely after they became slightly decomposed.

First-stage maggots, when placed artificially within living pupæ, failed to develop in every instance, showing that the conditions were not favorable for their growth.

When living and decomposing larvæ or pupæ were placed side by side in a cage, the flies selected the latter on which to oviposit, and normal larvæ developed.

In conclusion it must be understood that the writer has not attempted to work with any one species of the Sarcophagidæ, nor to separate them into species, but, on the other hand, he has worked with them only as a family, taking for granted that if any of these flies are ever parasitic on the gipsy moth, they would naturally be found in the infested localities. Although all the experiments have given negative results, yet they are nevertheless of economic importance, because in Europe and Japan, where sarcophagids are more commonly associated with the gipsy moth than in this country, it is possible that there may be several species that have the parasitic habit. If so, foreign investigations should be hastened, for if introduced into America these parasitic sarcophagids would be an important addition to the natural enemies of the gipsy moth.



TECHNICAL SERIES, No. 19, PART IV.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

TECHNICAL RESULTS FROM THE GIPSY MOTH
PARASITE LABORATORY.

IV. THE CHALCIDOID GENUS PERILAMPUS AND
ITS RELATIONS TO THE PROBLEM OF
PARASITE INTRODUCTION.

By HARRY S. SMITH,
Expert.

ISSUED APRIL 22, 1912.



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¹ Transferred to Cereal and Forage Insect Investigations.

² Transferred to Citrus Fruit Insect Investigations.

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TECHNICAL RESULTS FROM THE GIPSY MOTH PARASITE LABORATORY.

IV. The Chalcidoid Genus *Perilampus* and its Relations to the Problem of Parasite Introduction.¹By HARRY S. SMITH, *Expert*.

INTRODUCTORY.

Practical utilization of parasites in the control of noxious insects is becoming a more and more important means of warfare in economic entomology. For that reason accurate and detailed knowledge of the life history of the various parasitic groups is indispensable to an intelligent handling of the intricate problems which continually present themselves in work of this kind. It does not suffice merely to know that an insect is a primary parasite or a hyperparasite. Familiarity with the intimate details in its life and habits is of the utmost importance in order that it may be brought to its maximum of efficiency with the least possible delay; or, should it prove to be a hyperparasite, that an injurious insect may not thus be released unwittingly and irreparable damage be done. The great desirability of bringing this phase of economic entomology to a position of prominence has been the prime motive for a solution of some of the most perplexing problems which have confronted the student of insect parasitism; for example, the work of Marchal and Silvestri on the development of the hymenopterous, and of Townsend and Nielsen on the dipterous parasites. These men are economic workers and their discoveries of the extraordinary phenomenon of polyembryony or germi-nogony in the parasitic Hymenoptera and of the unusual habits of oviposition and larviposition in the tachinid parasites were made in connection with a study of the practical utility of these insects in the control of injurious species. Such investigations are interesting not only from the purely scientific standpoint, but are more than justifiable from that of applied entomology.

The few forms studied by these entomologists are among the most common species, which goes to show how limited the present knowledge of the biology of insect parasites really is. A fascinating field of study is open to those in a position to undertake research of this

¹ The writer is indebted to Mr. W. F. Fiske for valuable suggestions and criticisms throughout the course of his work on *Perilampus*.

kind, the requirements for investigating these most interesting phenomena, where the more common species are concerned, being, as stated by Dr. L. O. Howard, "simply good laboratory facilities and a skilled technique, together with trained powers of observation." These, as he points out, are to be found in many institutions and with many individuals in this country. The element of a chance discovery sometimes enters into consideration, however, even when a common insect is made the subject of study. Quite as often as not the discovery of the thread which will later lead to an unraveling of the complete life history is nothing more nor less than an accident, the clue being stumbled upon in a place and at a time altogether unlooked for. The investigations of the life history of *Perilampus hyalinus* Say received their initial impetus from just such an accidental discovery.

BIOLOGY OF PERILAMPUS HYALINUS SAY.

When time and opportunity have permitted, the parasites of certain among the native leaf-feeding caterpillars have been studied at the Gipsy Moth Laboratory in order to determine the part which parasitism plays in their natural control, and in an endeavor to arrive at a better understanding of the varied phases of the problem. Among others, the fall webworm (*Hyphantria textor* Harris) was selected as a promising subject, and, coming as it does at a season just after the summer's work on gipsy moth parasite importation and colonization is over, it has been possible to devote a larger share of our attention to it than to other even more interesting species which complete their transformations earlier in the season. Upon several occasions the young caterpillars have been brought in from the field, placed in insect-proof rooms and cages, and fed. In due time primary parasites, usually tachinids, species of the ichneumonid genus *Limnerium*, and occasionally *Apanteles*, emerged from these caterpillars, and the cocoons and puparia were removed to tightly stoppered vials and placed aside for the emergence of the adults. Later examination revealed the fact that adults of the species which formed the puparia or cocoons could not always be expected to emerge, for usually a certain percentage produced adults of *Perilampus* instead. How the adult female *Perilampus* obtained access to these puparia and cocoons in order to oviposit in them was a mystery inasmuch as especial pains had been taken to make the rooms and cages containing the caterpillars parasite-proof. But for a fortunate discovery during the spring of 1909 the true significance of these perplexing observations would doubtless have remained a mystery for some time to come.

While engaged in experimentation for developing a better technique in the preparation of hymenopterous larvæ for microscopical study, in which work the larvæ of the common *Limnerium validum* Cresson, an important parasite of the fall webworm, were used as subjects, a

strange little creature was discovered which was obviously the larva of an insect, but which differed very materially from any familiar form. It was impossible, from external characters, to assign it to any particular order with assurance, and consultation with several of the ablest entomologists of the country failed to throw any light upon the subject.

It was less than three-tenths of a millimeter in length, and therefore almost invisible to the unaided eye, oblong-ovate in shape and dark brown in color. Examination under the microscope showed it to be a highly organized being with well-defined mouth parts, strong, curved mandibles, conspicuous tracheal system, etc. The 13 segments were well differentiated, the first forming a distinct head, which was armed with several recurved hooks. The dorsal segments consisted of a series of heavy, chitinous, and overlapping plates, which nearly encircled the body. Most of these were furnished with one or two pairs of bristles. Ventrally the larva was furnished with several backward-projecting spines, which were evidently ambulatorial in function. An attempt to rear the adult from this larva was unsuccessful.

Among the minor projects under way at the laboratory at this time was a study of the biology of *Dimmockia incongrua* Ashmead, a rather common and important native chalcidoid parasite of tachinids. As a host for the rearing experiments with *Dimmockia* one of the most common native dipterous parasites, *Varichæta aldrichi* Townsend, also an important enemy of the fall webworm, was utilized.

In the course of an examination of the pupæ of this tachinid for the eggs and young larvæ of *Dimmockia* a second specimen of the remarkable creature referred to above, or to be more accurate one similar to it, was encountered. This second specimen, instead of being firmly attached to its host by its anterior end as was the former, was quite free and crawled about over the body of the tachinid pupa in a startlingly businesslike manner. This observation very naturally led to a further search through the abundant material at hand, and the presence of the strange parasite, for such it was now suspected of being, was found to be of not at all rare occurrence. An excellent opportunity was at once afforded for ascertaining the identity of the parasite and the subsequent rearings through the different stages were made with a great deal of eagerness. Immediately upon the completion of the first ecdysis it was seen that the larva resembled rather closely what was known to be the mature larva of *Perilampus*, and the further development of the specimens under observation confirmed that suspicion. The first-stage larva is of a very unusual type, which, with a single exception so far as known, has not been observed before. This exception is the larva of *Orasema viridis* Ashmead, described and figured by Dr. William Morton Wheeler.¹

¹ Bulletin of the American Museum of Natural History, vol. 23, Art. I, 1907.

A comparison of the peculiar first-stage *Perilampus* larva with the *Oraesema* material in Dr. Wheeler's possession indicated that while the two were very different in anatomical detail, they were of the same general character and constitute a type which, Dr. Wheeler has suggested, may be designated by the term "planidium."¹

The establishment of the identity of the planidium did not assist materially in clearing up the mysterious circumstance attending the rearing of the *Perilampus* from the *Limnerium*, *Varichæta*, and *Apanteles* parasitic on the fall webworm, and with the end in view of determining if possible the manner in which *Perilampus* gained access to its host, several thousand young caterpillars of *Hyphantria* were collected during the following fall, placed in rearing trays, and reared to maturity. At frequent intervals a large series of these caterpillars was killed and preserved in order that abundant material might be had for study during the winter.

Apanteles hyphantriæ Riley was found to be a fairly common parasite of the younger caterpillars, and *Varichæta aldrichi* and *Limnerium validum* of the older ones, as during the preceding summer. Examination of the puparia and cocoons of the parasites disclosed the fact that the planidia of *Perilampus* were even more common than they were during the preceding year, and as large quantities of material in all stages had been preserved an excellent opportunity was afforded for working out the life history of this remarkable parasite.

As has been mentioned on a preceding page, *Perilampus* was frequently reared from puparia and cocoons formed in tight rooms or breeding cages into which it was thought impossible for an adult parasite to gain entrance. Consequently in seeking an explanation of the presence of the planidia of *Perilampus* in the puparia and cocoons of these primary parasites of *Hyphantria*, it seemed most plausible that the female oviposited in or on the caterpillar containing the parasite which was later to become the host of the young *Perilampus*. Acting upon this hypothesis, maggots of the tachinid which had emerged from the caterpillar were examined and found to contain the planidia internally. The planidium, by reason of its dark color, was easily visible through the semitransparent integument of the maggot, and even after the latter had ceased activity and had formed its puparium the *Perilampus* larva could be seen through the shell until it had changed color and had become quite opaque. Dissection of the fully developed caterpillars revealed the fact that the tachinid maggots *while still within the caterpillar* contained these planidia, and going back still further, to the younger caterpillars, the planidia were found to be present here irrespective of whether the caterpillar was infested by a primary parasite or not.

¹ From the Greek *πλανητης*, a wanderer, and *ιδιον*, diminutive.

Examination of a considerable number of the *Hyphantria* caterpillars showed that the planidium could be found in almost any portion of the caterpillar's anatomy, although they generally "floated about" freely in the body cavity. Occasionally specimens attached to the larval organs, such as the alimentary canal or silk glands, were encountered. Further study of still younger caterpillars revealed the most interesting and significant feature of the whole life cycle, namely, the presence of the planidia *upon the exterior* of the caterpillars. These were apparently about to make their way through the integument to the interior in a search for suitable hosts upon which to complete their development. The less heavily chitinized portions of the caterpillar's skin, that is, the portion between the different segments, offered the most vulnerable point of attack and almost invariably this was the place selected by the parasite for making an entrance. Individuals which had not yet started an opening were found quite as frequently upon the middle of the segments as between them. Just how these planidia came to be located upon the skin of the caterpillars and how, when, and where the adult female *Perilampus* places her eggs, we have been unable to ascertain up to the present time, and any statement in regard to this portion of the life cycle must take the form of mere conjecture.

OVIPOSITION.

There have been made, so far as published records go, at any rate, no observations upon the oviposition of members of the genus *Perilampus*. It is known, however, that oviposition does not occur in the normal way, or in the manner we are accustomed to regard as the normal method of oviposition among the parasitic Hymenoptera, and for this reason speculations on what may actually occur are rather interesting.

In the first place it is obvious from the facts recorded in the preceding pages that *Perilampus* does not oviposit directly in or upon its host. In the second place, it does not oviposit within the caterpillar of which its host is a primary parasite, which is equally obvious from observations already made. That it places its eggs *upon* the young caterpillar is improbable, the adult *Perilampus* being too slow and clumsy to be capable of accomplishing this act with any degree of certainty.

There are two plausible methods which *Perilampus* might adopt for the deposition of its eggs, and the writer is strongly inclined to the view that one of these methods is in part at least correct. As in the case of some of the parasitic beetles, it may deposit its eggs upon flower heads or upon leaves of plants not in the immediate vicinity of the caterpillar colony, the planidia hatching from these

eggs being conveyed to the caterpillars by means of some intermediate carrier. In the Coleoptera cited above the carrier is frequently a parasitic bee upon which, by means of their claws, the triungulins attach themselves and are conveyed to the nest of their host. With *Perilampus*, should this method prove to be the one which really takes place, the intermediate carrier might be any of the primary parasites which attack *Hyphantria*; that is, the hymenopterous parasites *Limnerium* or *Apanteles*, or the tachinid *Varichæta*. The planidium seems more or less fitted for this sort of a life and is apparently analogous to the triungulin of the coleopterous parasites. The chitinous plates with which it is armored are especially serviceable in preventing injury of various kinds, and the mandibles and hooks and spines would serve it very well as a means of clinging to its conveyer.

Varichæta as a conveyer of the planidia would expose the young *Perilampus* to one more vicissitude, as it does not oviposit upon the caterpillars, but deposits young maggots upon the leaves of the food plant of its host. These maggots, should they by good fortune happen to have been placed upon a leaf which is later crawled over by a caterpillar, fasten themselves upon their host when the opportunity offers. *Perilampus* then would twice be subjected to the same conditions as these maggots, and their success in finding a host would depend entirely upon whether or not caterpillars came within their reach.

The other method, which seems much more plausible, is that of oviposition upon the food plant *in the vicinity of a colony* of the caterpillars. This would do away with the necessity of an intermediate carrier, but would expose the delicate eggs to great danger unless they hatched immediately after deposition.

Both theories have their faults and it may easily be that neither is correct. They are offered simply as suggestions to anyone who has the opportunity to make observations upon this parasite, in the hope that they will be of assistance in completing the knowledge of this strange life cycle. The former hypothesis has the advantage of a parallel in the parasitic Coleoptera, while something similar to the latter is known to occur in certain of the tachinid parasites (notably *Varichæta*, as mentioned above) which deposit young maggots upon the leaves, the maggots attaching themselves to the caterpillar as it crawls over the leaf upon which they are located.

While the eggs of *Perilampus* have not been observed after deposition, those contained in the ovarian tubes, in one case apparently mature, have been examined. They are of the usual elongate-oval shape, not stalked, and whitish in color.

REPRODUCTIVE CAPACITY.

It is a well-known fact that insects which are subject to very high mortality in their younger stages must have a high potential rate of reproduction in order to offset this loss and still prevent the species from becoming extinct; and conversely, we may say that insects laying a great number of eggs must of necessity experience a very high death rate or else they would in time increase beyond all bounds. We have found by the dissection of adult female *Perilampus* that the eggs are very numerous, the abdomen containing as high as 250 fully developed eggs at one time. It is therefore apparent that in some stage or stages before maturity many of the young die. As *Perilampus* is eminently well fitted to withstand the vicissitudes encountered in its later existence, the logical place to find this high death rate is during the planidium stage, while the tiny larva is wandering about either within or outside the caterpillar in search of its host. That this wandering habit of the younger, pre-eruciform stages of parasitic larvæ is accompanied by great mortality is well exemplified in the case of the Strepsiptera. Newport, in his "History and General Anatomy of Meloë and Its Affinities,"¹ records the production of more than 7,000 triungulins by a single female of the genus *Stylops*. *Perilampus* is apparently not only subject to a considerable mortality by reason of its wandering habit, but large numbers meet their death through a failure to find a proper host within the caterpillar and through the operations of superparasitism after they do find their host.

Whatever be the real method by which the planidium becomes affixed to the caterpillar, the life history from this point on has been worked out by actual observation in the laboratory, with an abundance of material for study.

DESCRIPTION OF PLANIDIUM OF PERILAMPUS HYALINUS.

(Figs. 24, 25.)

Length about 0.3 mm., depending on the amount of distension; diameter at widest place about 0.06 mm. Shape obovate; composed of 13 distinct segments or rings which are dark brown and heavily chitinized, and which "telescope" into each other more or less.

Head heavily margined, both laterally and posteriorly above, the rim strongly emarginate or indented posteriorly, where it is also strongly elevated in life and darker than other portions of the head. Mandibles well developed, hook-shaped, situated in a buccal cavity, and crossing at tips; bases broad, with a rather large area for muscular attachment. Immediately back of the mandibles are two flattened, heavily chitinized organs, which are probably homologous to the

¹ Proceedings of the Linnean Society of London, vol. 1, pp. 317-320, 368-370.

maxilla, but the minute character of which makes it impossible to determine their nature without considerable uncertainty. Head heavily armored with two powerful hooks or horns on the anterior margin, projecting laterally, about the size of the mandibles; above are seen two rather strong hooks at about the middle, both curved backward at tips; just back of hooks on dorsal portion of head are several semitransparent round spots, which probably bear small bristles, and may be sensory in function.

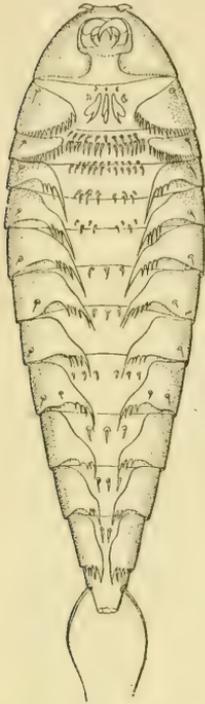


FIG. 24.—*Perilampus hyalinus*: Planidium, ventral view. Magnified about 350 diameters. (Original.)

Body segments as follows: First segment (excluding head) provided dorsally with two very minute semitransparent round spots, with dark spot in center, which is probably a minute spine, but which is rendered practically invisible by the clearing action of the balsam; ventrally the same segment is provided with two other similar spots, but which bear very distinct curved spines, one in the center of each. The heavy chitinous ring does not join beneath the body, each side ending instead with the ventro-posterior margin, which is serrated or fringed with long teeth, about 30 in number, becoming gradually shorter as they approach the lateral margin of the planidium. Between these fringed margins, situated in the center of the ventral portion of the segment, are three peculiar appendages which apparently function as ambulatory organs; these are somewhat flattened pyriform, with the broad end heavily notched somewhat at one side and attached at small end; at the bases of these are several small irregular appendages. The second segment is provided with the dorsal, backwardly curved spines, much closer together than on preceding segment and rather larger, and two ventral smaller spines; the teeth are slightly smaller. Between the serrate margins, as in preceding segment, are several hooks or motor appendages, but of quite a different type, these latter being simply plain hooks projecting backward, there being two transverse rows, about 10 in first row and about 16 in second. Between first and second segments on the

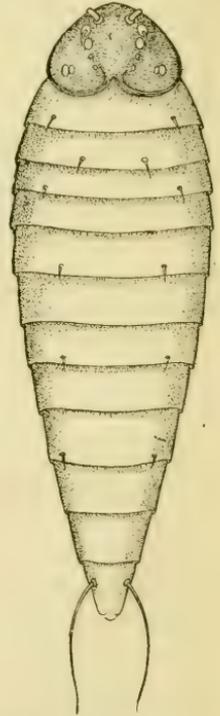


FIG. 25.—*Perilampus hyalinus*: Planidium, dorsal view. Magnified about 350 diameters. (Original.)

ventral side, situated in the elastic integument connecting the chitinized plates, are two stigmata, apparently the only spiracular openings in the whole tracheal system. Third segment similar to preceding, the two dorsal spines being considerably farther apart; the ends of the chitinous plate, however, are of quite a different type; instead of ending in a serrate margin the inner margin is smooth, but the posterior corner terminates in a long tapering projection considerably longer than the width of the chitinous sclerites; laterad of the long tapering projection referred to above are two or three much smaller ones, also situated on the apical margins of the segment; between the ends of the chitinous plates, as in preceding segments, are several hooklike motor appendages, smaller and fewer in number, however, than in the second segment; an additional series of hooks which is not provided in preceding segments is situated just laterad of these. The fourth segment seems to have no dorsal spines; there are two ventral ones, however, situated at the extreme outer margin of the ring; the chitinous plate terminates as in the third segment; motor appendages as in third segment but fewer in number. The fifth segment differs from the fourth apparently only in the possession of a pair of dorsal spines and in the smaller number of ventral motor appendages. The sixth segment does not have the dorsal spines but in other respects is similar to the fifth; the seventh segment possesses the dorsal spines; the eighth does not, nor does the tenth, eleventh, or twelfth; these latter, however, are similar in other respects, excepting that they become gradually less in size. The last segment is provided with an unjointed stylet on each side attached at about the middle of the segment, this stylet about twice the length of the segment itself.

HABITS OF PLANIDIUM.

Starting with the planidium upon the skin of the caterpillar, this makes its way through the thinner portion of the integument found at the junctures of the segments, this passage being effected by means of its well-developed mouth parts and specially armored head. Just how the search for the host parasite is conducted is not known excepting as it may be deduced from dissections of preserved material. The planidium has been found in almost every part of the caterpillar and it appears that its search for a host is rather thorough and extensive. The time of its attack upon the host larva has not been very definitely determined, although from the data at hand it seems most likely that this follows at once upon the finding of another parasite within the caterpillar. This supposition is substantiated by the fact that the planidium is found within the very young tachinid larvæ which have just completed their first molt. In this stage the disparity in size between the larvæ of *Perilampus* and of *Varichæta* is very much less than it is later, and it seems remarkable that the

tiny tachinid maggot can, without inconvenience apparently, continue in its development with the *Perilampus* larva boring about within its body, and sometimes with not only one but five or six.

What becomes of the planidium in case the caterpillar does not contain a primary parasite is a question which has not yet been answered, and to do so would require considerable care and patience. There are two courses open to the *Perilampus* in case it has selected an unparasitized caterpillar. It may either wander about within the body of the latter until it dies from starvation and exhaustion, or it may make its way to the outside again and continue the search for a host in another caterpillar. That it might possibly develop upon the caterpillar itself is not to be considered. Even should it remain within the caterpillar until the latter pupated,¹ it is not likely that it could make its way through the hard pupal shell of *Hyphantria*, and if this were possible the older *Perilampus* larva is very much too delicate a creature to be able to feed externally unprotected.

In case the former alternative is what actually takes place, there must be a great percentage of mortality due to the lack of a proper host, for relatively only a small proportion of the caterpillars hatching from the eggs ever reach an age sufficient to nourish a host for *Perilampus*. Of those that do reach that age a great many are never attacked by primary parasites and hence would not be available for *Perilampus*.

Just what is the effect upon the caterpillar itself which is infested by *Perilampus* but which contains no primary parasite is a matter for conjecture. It seems likely, however, that its presence would not prevent the caterpillar from reaching its full development and it is probably only slightly inconvenienced if affected at all.²

Having followed the *Perilampus* planidium to its host within the caterpillar it is now necessary to trace out the slightly different modes of development upon the various parasites of *Hyphantria* which are subject to its attack.

LIFE AS A PARASITE OF VARICHETA.

Varicheta aldrichi Townsend³ has been by far the most common of all of the parasites of the fall webworm in Massachusetts during the past two years. As stated on a preceding page, it belongs to that group of tachinids which deposit living maggots upon the stems and foliage in the vicinity of the caterpillars of their chosen host, a habit first discovered by Mr. C. H. T. Townsend in the course of his work

¹ Later dissection of *Hyphantria* pupæ, made in the spring of 1911, by Mr. H. E. Smith, discovered the planidium alive and still "waiting for something to turn up." In one instance the planidium was embedded in the gonad of the *Hyphantria*.—W. F. FISKE.

² The occurrence of the planidium in the gonad, as noted in preceding footnote, suggests that partial castration might possibly result.

³ Determination furnished by Mr. W. R. Thompson.

at this laboratory and briefly described by him in an earlier bulletin of this bureau.¹ The maggots rarely leave their host until after it has become full fed and prepared for pupation in the fall. The tachinid maggots pupate soon after emerging from their hosts, the pupæ remain unchanged during the winter, and the subsequent transformations are accomplished quite early in the spring.

In case the planidium chooses a maggot of *Varichæta* as its host, it remains endoparasitic until the puparium is formed. During the process of histolysis the *Perilampus* either orients itself in such a manner that it will be external to the tachinid pupa when pupation is completed, or it emerges from the pupa immediately after pupation; in either case, of course, it remains within the puparium. When parasitic upon this host the planidium, so far at least as the writer has been able to learn, normally hibernates in this stage and probably without nourishment.

It is quite likely, however, that a late warm fall would start the development of the planidium on *Varichæta* at once. This would without doubt result in the death of the secondary parasite, as it would scarcely be able to pass the winter in the normal larval stage. In fact dead second-stage *Perilampus* larvæ have occasionally been found upon the pupæ during the winter, and this would seem to be evidence in corroboration of the above statement. It is probably an attempt to go through two generations per year, as this insect does, without much doubt, farther south, and the individual specimens found in the second stage during the winter in New England are probably those from the puparia which emerged as larvæ from the caterpillars earliest in the fall, although we have no absolute evidence that this is the case. The development, or rather the conduct, of the planidium up to and including its change from endoparasitism to ectoparasitism, as stated on a previous page, seems entirely dependent upon the development of its host, such are the intimate relations between the two. After the planidium has emerged from its host development takes place in the usual way.

AS A PARASITE OF *LIMNERIUM VALIDUM* CRESSON.

Of the primary hymenopterous parasites attacked by *Perilampus* probably the most common one is *Limnerium validum* Cresson, an ophionine parasite emerging from the older caterpillars in the fall and hibernating as larva in a silken cocoon. The larva of this parasite, like that of *Varichæta aldrichi*, does not reach full maturity until its host has prepared for pupation, and the cocoons are to be found in the same situations as the pupæ of *Hyphantria* and are afforded the same protection. In this respect it differs radically from the other species of *Limnerium* parasitic upon the fall webworm.

¹ Technical Series, No. 12, Part VI, p. 103.

Perilampus hyalinus in this case always remains endoparasitic throughout the winter, at least so far as our observations go, and several hundred cocoons have been examined to date. At first it seemed rather puzzling that the same species should pass the winter ectoparasitically upon tachinids and endoparasitically upon *Limnerium validum*, but dissections of hundreds of the puparia and cocoons brought to light the fact that the habit of *Perilampus* in this regard was dependent entirely upon the life cycle of the host parasite, that is to say, the planidium lives internally in its host until histolysis takes place, when it changes its mode of life from an internal parasite to an external parasite. *Varichæta* pupates in the fall, so the planidium makes its exit at this season of the year and hibernates externally. *Limnerium validum* hibernates as a larva and pupates in the spring, hence the planidium in this case remains internal until spring, when it emerges by means of its efficient mandibles and spined head, completing its development in precisely the same manner as those individuals which happen to have chosen *Varichæta* as their host. The internal disturbances which take place in the body of the host at the time of histolysis probably act as a stimulus to the activities of the planidium, and the condition of the integument is such as to make the exit of the secondary parasite especially easy at this time. The development of the host, so far as our observations have gone, invariably ceases at the time of the exit of the planidium. Whether or not it is actually killed at this time is not evident. In any case decomposition does not take place immediately, the host being left in a condition somewhat comparable to that of the prey of certain aculeate Hymenoptera.

AS A PARASITE OF SUMMER-ISSUING HYMENOPTERA.

The other primary parasites of *Hyphantria* from which we have reared *Perilampus* are two additional species of *Limnerium*, differing from *L. validum* in that they spin their cocoon within the skin of the caterpillar and emerge in the fall, and the braconids *Apanteles hyphantriæ* Riley and a *Meteorus* (probably *M. communis* Cresson). In all four of these species the *Perilampus* completes its development at once. Whether or not these individual specimens manage to survive the winter is open to question. It is quite possible that many of them remain within the cocoon of their host throughout the winter. This is quite strongly indicated by the result of an experiment in which a collection of old webs containing cocoons of the several parasites was made on October 20, 1908, from which several adult *Perilampus* issued between 6 and 10 days later. The material was kept in a warm room; had it remained out of doors it is very unlikely that emergence would have occurred so soon, and probable that it would have been deferred until spring.

We know that the adult of one of the European species of *Perilampus* hibernates in the puparium of certain tachinids parasitic on the gipsy moth and brown-tail moth. Most of these tachinids, like the summer-issuing hymenopterous parasites, pupate comparatively early in the fall, thus making the two cases similar. For this reason the writer feels justified in surmising that the same thing occurs in the case of *Perilampus hyalinus* parasitic on the summer-issuing Hymenoptera.

AS A PARASITE OF OTHER HOSTS.

There is another group of parasites of the fall webworm which hibernate either as partially grown or as full-fed larvæ within the pupæ of their host. These include certain large solitary ichneumonids, *Anomalon ambiguum* Norton, *Ichneumon cincitarsis* Provancher, and *Melanichneumon* sp. At least one species of Tachinidæ has also been found hibernating in this manner in Massachusetts. We have not actually found *Perilampus* to be a parasite of any of the ichneumonids named above, but only a very small number of the larvæ of these parasites have been seen.¹ There seems to be no good reason why the secondary should not attack these hibernating hymenopterous larvæ, and it is practically certain that the examination of a considerable number would show the planidium to be present.

We have absolute proof, however, that it does attack the hibernating tachinids,² having found the planidium actually within the maggot of this species within the pupa of *Hyphantria*. Whether or not the adult *Perilampus* is able to make its way through the pupal shell of the fall webworm (presuming that the tachinid completes its larval development and pupates internally) we are unable to state definitely, as no record has been made of *Perilampus* having issued from these pupæ. There seems to be little doubt as to its ability to do this, as it has very powerful jaws. Specimens in the laboratory will eat away quite a large quantity of cork in attempting to escape from a vial in which they have been confined.

LATER LARVAL STAGES.

On the return of warm weather in the spring, the winter having been passed upon the various hosts in the manner indicated in the preceding pages, the planidium begins feeding by sucking the juices of its host. Growth takes place gradually and first becomes apparent through the planidium taking on a banded appearance due to the

¹ It has since been found by Mr. H. E. Smith within the larvæ of *Ichneumon* (which attacks the pupa of the host) and that of *Erochilum*, which hibernate in what must be considered as an embryonic state within the *Hyphantria* pupæ.—W. F. FISKE.

² Probably *Compsitura concinnata*, the recently imported parasite of the gipsy and brown-tail moths.

separation of the chitinous rings or plates by a stretching of the intersegmental membranes which are transparent. (See fig. 26, *d, d'*.) The underside of the planidium also gradually fills out until the larva has attained a bulk several times greater than that of the hibernating planidium and presents the appearance of an ovate semitransparent sack with dark median crossbars dorsally.

After a short resting period, ecdysis takes place. The skin of the planidium breaks transversely just back of the second thoracic segment, the posterior segment slips backward, and the old head and first two thoracic segments are shed at the anterior end of the larva. Just how long the planidium feeds before ecdysis has not been ascer-

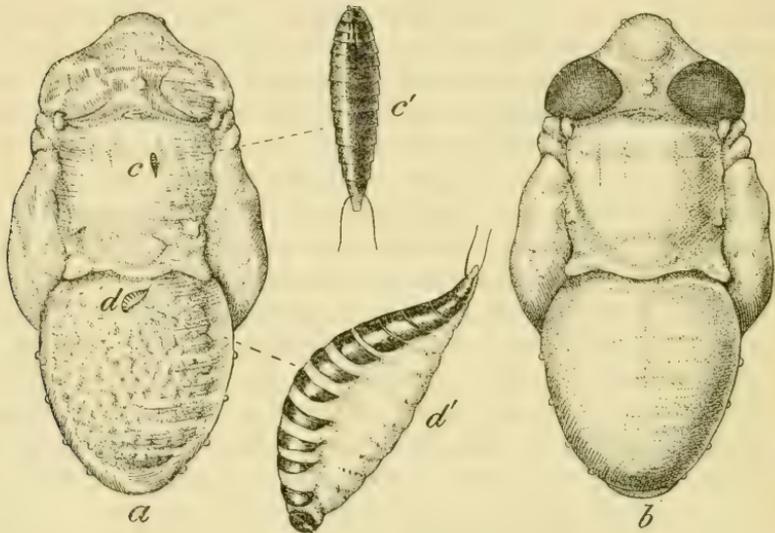


FIG. 26.—*a*, Pupa of *Varichata aldrichi* parasitized by *Perilampus hyalinus*; *b*, unparasitized pupa of *Varichata aldrichi*; *c*, planidium of *Perilampus hyalinus* before feeding; *c'*, same, more enlarged; *d*, planidium of *Perilampus hyalinus* after feeding; *d'*, same, more enlarged. (Original.)

tained. The period probably varies greatly in accordance with the prevailing temperature. Usually, though not always, the larva crawls away a short distance before it resumes feeding.

After settling down the second time it is likely to remain stationary for the rest of the larval and the pupal life. The larva in the second stage is of a whitish color, with the tracheal system showing through the transparent skin. The body is ovate in shape, with the head bent underneath the anterior portion. The growth during this stage is little compared to that accomplished in the third, and after feeding a short time the second ecdysis takes place.

Growth now becomes quite rapid and the larva assumes a very different appearance. (See fig. 27.) The mandibles have not increased in size to any great extent, but the mouth as a whole and the head

change quite materially. The mouth parts are in this stage situated in a triangular basinlike depression which is bounded on two sides and parts of the third by a strong chitinous carina or rim. Besides the mandibles there are two bulblike appendages just beneath, which are probably homologous to the maxillæ of the adult. Immediately above the oral opening are situated two large rounded elevations which may be called larval antennæ. The segments forming the head are now separated by a more or less distinct neck from the remaining segments and are bent beneath them with face downward, as in the second stage. The first two thoracic segments are each provided laterally with a raised tubercle at about the middle of the segment, viewed from the side, and just above this tubercle is another more or less distinct one, one also occurring on the third thoracic segment in a corresponding location. The next three segments each bear a pair of much larger tubercles or projections which give the larva a very unusual appearance. These tubercles, if they may be called such, correspond to those described and figured by Dr. Wheeler as occurring in *Orasema*, but are somewhat differently arranged. Just posterior to these there occurs an abrupt declivity, the segments becoming much smaller toward the posterior end of the larva. Beneath, the larva is smooth and free from constrictions, but the segmental sutures are visible to some extent. Dorsally through a transparent median line formed by a break in the corpus adiposum may be seen a large number of white urate masses, which pulsate slowly back and forth as the larva feeds. The tracheal system is rather conspicuous and is of the normal holopneustic type.

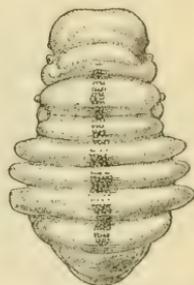


FIG. 27.—*Perilampus hyalinus*: Mature larva. Greatly enlarged. (Original.)

PUPATION.

(Figs. 28, 29.)

As soon as the larva is full fed, pupation takes place. The meconium is discharged, leaving the larva scarcely more than half its former bulk, and creamy white instead of translucent gray-white in color. Beneath the larval skin the imaginal appendages and the head gradually appear, and the tubercles so characteristic of the larva become less conspicuous. Finally the larval skin is discarded, and the pupa assumes its own distinctive shape.

The pupa is short and robust, corresponding very closely, of course, to the form of the adult. The abdomen bears five or six transverse carinæ or ridges, one for each segment, which are interrupted on the disk. These are very similar to those occurring on the ant parasite *Orasema viridis*, but differ in that they are not continuous dorsally

At first the pupa is white or yellowish white, but the eyes soon become pigmented with reddish, then the thorax becomes black, later changing to a metallic green. In about two days the head and abdomen assume the same metallic hue as the thorax, with the sculpture of the adult insect showing through, and soon after this the pupal skin is shed and the adult insect issues.

FOOD HABITS OF THE ADULT.

No observations upon the food habits of the adult *Perilampus* have been made in connection with this work, excepting that in confinement they will consume, in common with many other chalcidoid parasites, comparatively large quantities of sweetened water upon banana peelings. During June, 1905, the author found specimens of this genus in abundance upon the leaves of *Ambrosia*, *Helianthus*,



FIG. 28.—*Perilampus hyalinus*: Fresh pupa. Greatly enlarged. (Original.)

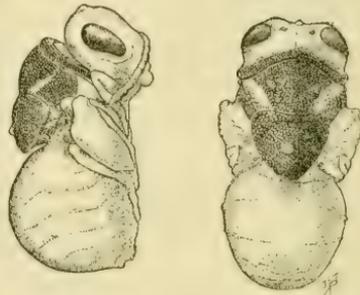


FIG. 29.—*Perilampus hyalinus*: Pupa just previous to eclosion. Greatly enlarged. (Original.)

and other vegetation at West Point, Nebr., where they were apparently feeding upon the honeydew secreted by aphides.

Dr. S. Graenicher, of the Public Museum of Milwaukee, has in the course of his extensive studies upon the pollination of Wisconsin flowers¹ recorded two species of *Perilampus*, *hyalinus* Say and *cyaneus* Brullé, as visitors of the following Compositæ: *Eupatorium perfoliatum*, *Solidago juncea*, *S. canadensis*, *Achillea millefolium*, *Tanacetum vulgare*, and *Erigeron canadensis*. In considering the insect visitors to the last named flower he has the following to say:

It is noteworthy that the chalcid-flies *Perilampus cyaneus* and *P. hyalinus* seem to have a certain preference for these flowers. They were regular attendants, day after day, at Cedar Lake, and were also present at Milwaukee.

Dr. Graenicher in a recent letter kindly informs me that he has also taken *P. cyaneus* at flowers of *Angelica atropurpurea*, *Pastinaca sativa*, and *Sium cicatæfolium*.

¹ Bulletin of the Wisconsin Natural History Society, vol. 7, Nos. 1 and 2, pp. 19-77, April, 1909.

LONGEVITY AND OÖGENESIS.

While the *Perilampus* adults as a usual thing are very short-lived in the laboratory, there is no doubt that they live for a considerable period when out of doors under natural conditions. This is indicated by the fact that the females, when newly emerged, never contain eggs within the ovarian tubes, as do those insects which oviposit at once upon emerging.

In one instance a female was kept alive from April 6 to May 12, a period of 36 days, at the end of which time she was apparently ready to oviposit. Upon dissection approximately 250 eggs, nearly all of which seemed to be ready for deposition, were found. It is probable that many more would have developed had the individual remained alive under natural conditions.

LENGTH OF LIFE CYCLE AND INFLUENCE OF TEMPERATURE.

The time required for *Perilampus* to develop from egg to adult is dependent upon several factors, one of the most important of which is the host. When parasitic upon *Varichæta*, the planidium begins to feed early in the spring. On *Limnerium validum*, however, the planidium must wait until its host begins pupation before it can become external, thus throwing it several days or even weeks behind the individuals infesting *Varichæta*.

There are no complete data at hand concerning the development upon *Limnerium*, owing to the failure of any individual to complete its transformations upon this host after removal from the cocoon. Its progress has been followed beyond the first ecdysis several times in the laboratory. In an apparently typical instance a larva of *Limnerium* containing two planidia was brought into the laboratory from out of doors on January 28 and placed in an incubator kept at a temperature of 78° F. On the morning of February 4 histolysis had begun, and during the evening of February 5 both planidia had made their exit. Two days later the host larva was apparently dead and the planidia were feeding. February 11 one had molted its first-stage skin, but died a short time later.

With *Varichæta* as a host it is a much simpler matter to carry the *Perilampus* through to maturity. When a single individual is watched through its development more time is required than in undisturbed puparia, owing to the fact that it is impossible to keep the host pupa from deteriorating somewhat. A typical instance of the development upon *Varichæta* under laboratory conditions follows: On January 28 a pupa of *Varichæta* with a single planidium was brought in from out of doors and placed in the incubator. On the next day the planidium had started to feed and filled up rapidly. February 1 the distance between the dorsal plates of the planidium

was rather greater than the width of the plates themselves. Three days later the first ecdysis was completed and the second-stage larva had moved some distance away from its original feeding place. The next day it had become very much distended and glistening. On February 7 it had apparently molted a second time and was very strongly tuberculate. On the 9th it was again feeding freely. Five days later it had reached full growth and ceased feeding. The next day pupation had taken place, but the pupa was still pale in color and covered with little "perspirationlike" globules. On the 19th the thorax of the pupa had begun to turn dark and the sculpture of the adult to show, and three days later it had become entirely dark colored. On February 25 the adult *Perilampus* emerged. The time required for development from start of external feeding to maturity was 28 days. The incubator was kept at a constant temperature of 78° F.

In the unopened puparia brought in at the same time *Perilampus* required about 25 days from the time they were placed in the incubator until they emerged as adults, but the period of development is dependent somewhat upon how much time they have been left out of doors, and there is some variation among the individuals themselves. From puparia brought in and placed in the incubator November 22 to 28 *Perilampus* began emerging December 27, about a month later, and continued coming out intermittently until approximately February 13, covering a period of about 48 days. Puparia brought in December 13 to 19 produced *Perilampus* first on January 17 and continued producing until February 6, a period of about 20 days. Puparia brought in January 17 to 23 produced adult *Perilampus* first on February 14 and continued until March 3, a period of about 17 days. From the above data it is seen that the later in the winter the puparia are brought in and placed under conditions favorable for the development of *Perilampus*, the shorter is the period during which the adults emerge. It is also evident that when infested puparia are brought in early in the winter a longer period of time elapses until the first adult *Perilampus* emerges than when left for a more extended period out of doors. Whether bringing the planidium in later in the winter causes it to develop more rapidly or whether it simply does not require so much time before becoming ready to begin feeding under these conditions is not known, but the latter explanation seems more reasonable.

The relative time of emergence of the adult *Perilampus* and adults of the host insect of the same lot is of considerable interest and will be given more study later. In September, 1908, a lot of *Varichæta* were placed in cold storage and kept there until January 18, when they were brought into the laboratory. From these puparia *Vari-*

chæta adults issued from February 2 to February 14. *Perilampus* adults issued from the same lot April 1 to April 6, approximately two months later.

In this instance the puparia were not kept at an even temperature. During the night, especially, it was frequently cool. Another lot of puparia collected at about the same time but *not* placed in cold storage or exposed to frost produced *Perilampus* adults November 30 to January 30 and adult tachinids January 22. Under these conditions the first *Perilampus* issued a month *earlier* than its host, as opposed to two months *later* when kept in cold storage until about the middle of January. It is apparent from the above that *Perilampus* adapts itself to changed conditions much more readily than does *Varichæta*. Indeed it is a necessity that it should be able to do this, being a parasite of other parasites which normally complete their development during either spring, summer, or fall, as the case may be.

EFFECT OF PARASITISM UPON HOST.

(Fig. 26.)

The *Perilampus* planidium, even before it begins to feed, exerts a very marked effect upon its host, especially in case the host is a tachinid. As mentioned on a preceding page, these planidia while living internally within the host larva do not seem to cause it the slightest inconvenience, and it is impossible to distinguish between a parasitized and an unparasitized larva before the planidium emerges, excepting, of course, where the secondary parasite itself is visible. Immediately pupation takes place in the host and the planidium becomes ectoparasitic, the effect of the parasitism becomes evident, especially after the host pupa has been subjected to warmth. Instead of responding to the increased temperature in the usual way—that is, instead of developing pigment in the imaginal eyes and bristles upon the body—it takes on a peculiar transparent appearance, principally in the cephalic and thoracic regions. The eyes and appendages develop very slightly and the imaginal head reaches scarcely one-half the size of that attained in the unparasitized pupa. These pupæ now present a very characteristic appearance (see fig. 26), and in opening a series of puparia one may recognize the parasitized individuals at a glance, even before *Perilampus* has begun to feed. This peculiar effect is noticeable to a considerably less extent where *Limnerium* acts as a host.

The pathological nature of this unusual condition of the parasitized pupæ has not been investigated as yet. It is apparently an arrested histogenesis, but in what manner this is brought about we can not say. Only a single case has come under observation where

the host pupa developed the characters of the adult to any extent. During March, 1909, a puparium of *Varichæta* was dissected and found to contain a very small pupa of *Perilampus*, only about three-fourths natural size but fully developed and apparently healthy in every way. The astonishing thing in this instance was the fact that the tachinid pupa had developed to a stage where it had taken on the characters of the adult. Even the bristles were well formed. This is the only case out of several hundred puparia examined where development had not ceased soon after the formation of the pupa and is rather difficult to explain. It is possible that for some reason the planidium did not respond to the usual stimulus, histolysis, and remained internal within the pupa, giving the tachinid an opportunity to develop considerably further than normally before the secondary parasite changed its mode of life to external feeding. There were many other puparia subject to the same conditions and they all responded in the usual way, so that the above case must be considered as abnormal.

The retardation of development in the parasitized hosts is of course brought about by the presence of the planidium, but whether indirectly or directly has not been ascertained. That it may be due to a glandular secretion is not impossible, but this hardly seems to be an adequate explanation, as nothing resembling glands of this kind have been found, although a careful study of the planidium has been made with the oil-emersion objective. In the opinion of many zoologists an insect during the process of pupation is in a very critical condition and is more susceptible to injury at this time than during any other period of its life. It does not seem improbable that in this supposition lies the explanation of the condition brought about in its host by *Perilampus*. The larva or maggot is able by reason of its great vigor to withstand the presence of the secondary parasite, but immediately histolysis and histogenesis begin to take place the weakened condition of the host makes itself apparent in the form of a cessation of development of pupal or imaginal organs and appendages and occasionally in certain instances death ensues. The development of *Limnerium* invariably ceases soon after the exit of *Perilampus*, although the latter does not emerge until the host larva has discharged its meconium and the formation of the pupa has begun. In one instance the planidium was observed located in the imaginal eye of its host, which becomes visible as a darker spot some time before the larval skin is discarded.

PERCENTAGE OF PARASITISM.

The percentage of parasitism of *Varichæta* and *Limnerium* by *Perilampus* in 1908 was not very high. Large numbers of the cocoons and puparia were opened, or reared through in the laboratory,

but accurate counts were kept in only a single instance, in which 35 out of a lot of 164 puparia, or 21.4 per cent, were found to be parasitized by *Perilampus*. This is known to be above the average, taking the material which was reared or studied as a whole.

The results of several counts given in Table I are indicative of parasitism in 1909.

TABLE I.—Percentage of parasitism of *Varichæta* by *Perilampus*, 1909.

Number of puparia.	Number attacked by <i>Perilampus</i> .	Per cent of parasitism.
29	16	55.0
244	58	23.3
57	28	49.1
100	54	54.0
100	23	23.0
Total.....530	179	.....
Average.....	.....	41.0

The variation between the individual lots is due to their having been collected in different localities. Although it may be stated with assurance that the average was much higher than during the previous year, exact comparisons are impossible, since parasitism varies in different nests in the same locality, and in different localities. A long series of careful calculations would be required in order to secure accurate results.

As might be expected, the cocoons of *Limnerium validum* were parasitized to an approximately equal extent, and in these cocoons were found a few planidia of another species, which has been designated in the notes as "Species A." The summer-issuing *Limnerium* and *Apanteles* were not so heavily parasitized as a rule, probably because many of the planidia did not enter the caterpillars until a part of those afflicted by these parasites had died.

The percentage of healthy caterpillars of *Hyphantria* bearing the planidia, either internally or externally, ought to be, and apparently is, approximately the same as the percentage of *Varichæta* and *Limnerium* parasitized.

SUPERPARASITISM.

PERILAMPUS VERSUS PERILAMPUS.

The extent to which *Varichæta* or *Limnerium* is parasitized by *Perilampus* may be easily determined by opening the puparia or cocoons before the planidia have begun to develop, and in this manner the prevalence of superparasitism may be easily calculated. Upon several occasions as many as five planidia have been found upon one host, and four, three, and two are of frequent occurrence. In not a

single instance out of hundreds has more than one adult *Perilampus* issued from any cocoon or puparium under observation.

In a recent discussion of this phase of parasitism by Mr. W. F. Fiske¹ an attempt was made to classify its varied manifestations in accordance with the manner in which the parasites interested are ultimately affected. Superparasitism by *Perilampus* appears to fall in "I, b." of the scheme, i. e., one parasite lives and the other or others die, and the survivor brings about the destruction of the others by causing the premature death of the host. Several planidia may begin to feed at about the same time, but one invariably molts for the last time a little in advance of the others, and even though the difference is but a few hours it quickly devours the host, or else reduces it to such a condition as to render it unfit food for the next in succession. In no case has one larva been known to make a direct attack upon another.

In the article referred to above an attempt was made to indicate diagrammatically the probable amount of superparasitism accompanying a given amount of parasitism provided its prevalence was governed by chance alone. Whenever opportunity has permitted, the validity of the calculations which served as the basis for this diagram has been tested, and in nearly every instance, to date, the results have tended to confirm the contention at the time that "in the field * * * superparasitism would be distinctly more prevalent in proportion to the percentage of total parasitism" than these calculations demanded. This has proved to be true of *Perilampus*, as will be seen by Table II, which gives the results of a series of counts to determine the point.

TABLE II.—Prevalence of superparasitism of *Perilampus* on *Varichæta*, 1909.

	Lot 1.	Lot 2.	Lot 3.
Puparia examined.....number..	100	100	57
<i>Perilampus</i> planidia found.....do....	28	87	47
Supernumerary planidia.....do....	5	33	19
Puparia parasitized.....do....	23	54	28
Parasitism.....per cent..	23	54	49
Loss in efficiency through superparasitism:			
Actual.....do....	5	33	33
Theoretical ¹.....do....	3.3	28.8	26.6
Losses sustained by <i>Perilampus</i> through superparasitism:			
Actual.....do....	17.9	37.9	40.2
Theoretical ¹.....do....	11.8	33.1	32.4

¹ In accordance with calculations upon which the diagram published in the Journal of Economic Entomology (loc. cit.) was based.

It will be noted that in each instance the numerical loss sustained by *Perilampus*, and the decrease in its efficiency as a parasite, is greater than is theoretically called for.

PERILAMPUS VERSUS DIBRACHYS.

Another exceedingly curious complication was observed in the winter of 1908-9 in an instance where a cocoon of *Limnerium validum* had been attacked by *Perilampus* and later by *Dibrachys boucheanus* Ratzeburg. The larvæ of the latter parasite fed externally and gregariously, and hibernated without transforming to pupæ. So soon as its original host was destroyed, the *Perilampus* planidium, not to be outwitted, calmly proceeded to take up a position internally in one of the *Dibrachys* larvæ. The particular larva bearing this planidium was killed and preserved, but in another instance a very small *Perilampus* adult issued from a puparium of *Varichæta* from which a number of *Dibrachys* adults had emerged some time before, and there is no doubt that it completed its transformations as a parasite on this host. With the exception of *Melittobia*, which from its very small size would likely prove unsuitable as an ultimate host, there is no known hymenopterous hyperparasite likely to attack the puparia of *Varichæta* or the cocoons of *Limnerium* which might not serve as well as *Dibrachys* as a host for *Perilampus*. The planidium is admirably fitted to triumph over adversity, and shows the part of wisdom in not causing the death of its host until it is ready to complete its transformations. If, for example, it had the habit of killing its host in the fall, and of hibernating as a full-fed larva, after the manner of *Dibrachys*, the latter might easily turn the tables and emerge victorious from the conflict.

PERILAMPUS, "SPECIES A."

(Figs. 30, 31.)

In the course of the investigations upon the genus *Perilampus*, two kinds of planidia have been found parasitic upon *Limnerium validum*, which, while belonging to the same general type, are quite different in structural detail and apparently represent different species. One of these, the commoner one, is *Perilampus hyalinus*, which has been treated rather fully in the preceding pages. The other species we have never succeeded in rearing through to the adult, so are unable to give it a specific name at this time. In length it is rather shorter than *hyalinus*, measuring on the average about 0.24 mm., but is comparatively greater in diameter through the anterior segments. The color is usually somewhat darker than that of *hyalinus*. In *P. hyalinus* the head of the planidium is notched or emarginated and elevated posteriorly, but in this species the posterior margin is continuous. The mandibles are heavier and considerably less curved, and the recurved hooks on the top of the head are also considerably larger. The ambulatorial spines are very much less developed than

in *hyalinus* and the ends of the chitinous bands which surround the body are simple, not terminating in long teeth or serrate as in the other species. The dorsal and ventral bristles, however, are stronger and more numerous, and somewhat differently arranged.

Considerable difference in habit in these two species has also been noted. *P. hyalinus*, we have reared from many different hosts, but the other species has been found only upon the larva of *Limnerium validum*. Instead of remaining internal within the *Limnerium* larva until it attempts to pupate in the spring as does *P. hyalinus*, this

species, if it ever feeds endoparasitically, must emerge from its host soon after the cocoon is spun, for it is found externally upon its host during the fall and winter before the *Limnerium* has any intention of pupating, and has never been found internally. In only one instance have we succeeded in getting this species to feed, and even that did not terminate satisfactorily. During the spring of 1909 a specimen of the planidium of this species was placed on a larva of *Limnerium* in a glass cell for observation. Six days later the planidium had not fed and was noted as be-

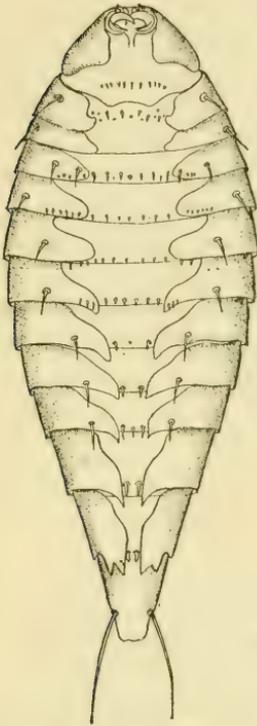


FIG. 30.—*Perilampus*, "species A." Planidium, ventral view. Magnified about 400 diameters. (Original.)

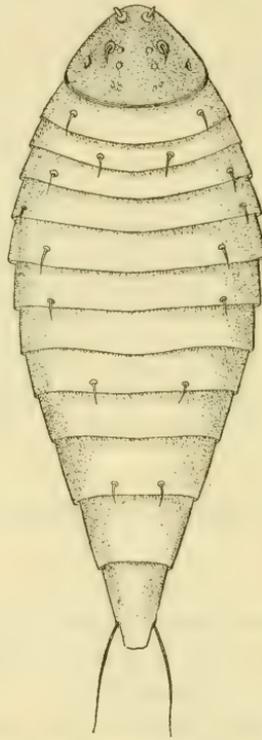


FIG. 31.—*Perilampus*, "species A." Planidium, dorsal view. Magnified about 400 diameters. (Original.)

ing apparently dead, but on the next day it was seen to have been feeding, although its host was still alive and active. Five days later the planidium had molted its skin and had taken on the globular form of the second-stage larva but was apparently not in very good condition and died two or three days later. At no other time were we able to get this species to feed. There is a possibility that it is of purely accidental occurrence upon *Limnerium*, and this may account for our inability to rear the adults. This belief is strengthened by the fact that a large percentage of the specimens of this planidium are

dead when found upon the *Limnerium* larvæ in the fall. Out of 11 specimens found during an examination of some 55 cocoons, 10 were dead and shrunken. These cocoons had been kept under perfectly natural conditions out of doors, so that it is obvious that there was something radically wrong between parasite and host. The fact that it has never been found upon *Varichæta* suggests the possibility of its being of ectoparasitic habits entirely, and that it attaches itself to the *Limnerium* larva after the latter emerges from the caterpillar, but prior to the spinning of its cocoon. This would of course preclude its being a parasite of a tachinid, as the formation of the puparium would naturally leave it outside of the hardened shell and death would inevitably result. The data on hand concerning this species, however, are too limited to warrant an attempt to draw any conclusions, and with the recording of the above facts we leave it until further investigations have thrown more light upon its habits.

DEVELOPMENT OF ORASEMA.

Dr. William Morton Wheeler, in the article referred to on page 35, gives an exceedingly interesting account of the life history and economy of the chalcidoid genus *Orasema*, of the family Eucharidæ. A comparison of the habits of representatives of the so-called families Eucharidæ and Perilampidæ is of unusual interest at this time and may assist in clearing up certain doubtful points in the economy of the former. *Orasema* is parasitic principally upon the harvesting ant *Pheidole instabilis* Emery, but also occurs not uncommonly upon representatives of other ant genera in the southwestern United States and Mexico. In view of the close relationship existing between the two genera and the general similarity of development so far as is known in the two forms, it would seem permissible at this time to draw certain conclusions in regard to *Orasema* which have been suggested by the investigations upon *Perilampus*. In regard to the oviposition of *Orasema* Dr. Wheeler has the following to say:

I have not seen the eggs of *O. viridis* after oviposition, but only the very young larvæ. Dissection of the female shows that, as we should expect in a parasite, the eggs are extremely numerous and minute. The mother insect, when she comes to oviposit, exercises a very careful selection among the ant brood. In the first place she has nothing to do with the *instabilis* larvæ, but directs her attention to the pupæ. In the second place she selects, as a rule, only the pupæ of the soldiers, males and females. The small worker pupæ would not furnish sufficient food for her larvæ. In the third place she selects only pupæ at the very critical moment when they have been stripped of their larval skin by the workers and are, therefore, little more than semipupæ, for obviously at this moment the cuticle is thinner and will be more easily pierced by the young *Orasema* larvæ than during the preceding or succeeding stages; and in the fourth place she does not lay her eggs at random anywhere on the body of the semipupæ, but carefully selects one of four regions near the head. Usually she places the egg on the sternal surface just beneath the very short, incurving legs of the

semipupa, but occasionally it is placed on the back of the neck between the head and the prothoracic segment or on the right or left side of the neck beneath the corresponding prothoracic leg. These regions would seem to be singularly appropriate, both because the cuticle is extremely thin and readily punctured by the parasitic larva at these points, and also because the egg or resulting larva, especially when it is covered with the overlapping appendages of the semipupa, is not so readily brushed or licked off by the *instabilis* workers.

If we may judge from the habits of *Perilampus*, the explanation of Dr. Wheeler's failure to find the eggs of *Orasema* in the ant nest is possibly that they are not deposited there. It is possible that oviposition might take place outside the nest, perhaps upon flowers or other vegetation visited by both the *Orasema* adults and the worker ants; and that from the eggs deposited upon these plants the planidia hatch, in some manner attach themselves to the worker ants, and are in that way conveyed to the nest, where they leave their carrier and attack the larvæ. Several points in the economy of *Orasema* as noted by Dr. Wheeler tend to substantiate the belief that oviposition takes place outside the nest. In the first place the large number of eggs deposited by *Orasema* (Dr. Wheeler found by dissection of the adults that they were very numerous and minute) indicates that somewhere in its early life cycle there is prevalent a very great mortality. That this mortality actually takes place was observed by Dr. Wheeler, and he thought that it might be explained in the following manner:

I believe that the danger of detaching the egg is very great, and this, together with the other special requirements enumerated above, may account for the fact that comparatively very few of the great number of *Orasema* eggs ever complete their development.

The number of eggs deposited by a single female *Orasema*, should they all become effective, would probably be sufficient to annihilate a whole colony of the *Pheidole*, and not one but many female *Orasema* are usually found in the infested nests. It would seem, therefore, that there would be little likelihood that such great mortality would occur if only the causes enumerated by Dr. Wheeler were operative. It is possible that the *Orasema* planidia attack the larvæ of *Pheidole*, not the pupæ, and that the seemingly sudden appearance of the young *Orasema* larvæ upon the pupæ of *Pheidole* immediately after the last larval ecdysis is similar to that which has been noted on a preceding page as occurring in *Perilampus*. In other words, the *Orasema* planidium may be endoparasitic within the *Pheidole* larvæ, making its exit to the exterior at the time of histolysis and feeding ectoparasitically thereafter. Dr. Wheeler's observation of the fact that the *Orasema* planidia appear upon the pupæ only at this critical time would tend to substantiate this theory.

It seems improbable that insects as highly positively phototropic as Dr. Wheeler has observed *Orasema* to be should return to the interior of an ant's nest to oviposit after having escaped and lived in the sunlight for a considerable time.

PLANIDIUM OF ORASEMA VIRIDIS ASHMEAD.

Length about 0.16 mm. General shape like that of *Perilampus*, but comparatively broader and much more simple in structural detail. Color dark, as in *Perilampus*. Head more elongate than that of *P. hyalinus*, the recurved hooks, if present, very small; there are two pairs of organs in a location similar to that of the hooks upon the head of *Perilampus*, but their extremely minute size makes the nature of these objects difficult to define even under the oil-immersion objective. Mouth parts indefinable, considerably retracted into head. Anterior margin of head much roughened. First dorsal segment short, with a pair of distinct bristles situated along the apical margin, the base of each within a transparent spot. Second segment broader, with two apical spines farther apart than on preceding. Next segment much like second, but broader, with similar spines. Remaining segments apparently without dorsal spines. Ventral ends of the chitinous plates simple, not ending in a serrate margin or with long teeth as in *Perilampus*. Seventh segment with a pair of spines ventrally. Last segment with a pair of stylets comparatively shorter and stronger than in *Perilampus*.

Dr. Wheeler's account of the effect of parasitism by *Orasema* upon *Phcidole* tallies very well with our observations upon parasites attacked by *Perilampus*, the same microcephalic characters are present in the host pupæ in both cases, with the peculiar transparent appearance, as noted upon a previous page of this article.

Other points in the economy of *Orasema* brought up by Dr. Wheeler and which at the time seemed very puzzling are apparently rather easy of explanation in the light of our present knowledge of *Perilampus*. It is hardly within the province of this bulletin, however, to take these up in detail, and it is merely suggested here that anyone desirous of doing further work upon the development of *Orasema*, and perhaps other members of the chalcidoid family Eucharidæ, would perhaps do well to bear in mind the similarity of the life cycle, so far as known, to that of *Perilampus*.¹

RELATIONSHIP OF EUCHARIDÆ AND PERILAMPIDÆ.

The great similarity of development in the genera *Orasema* and *Perilampus* can not fail to have considerable bearing upon the taxonomic relationship of the so-called families Eucharidæ and Perilampidæ. Francis Walker, in 1846, placed the two groups together under the family name Eucharidæ. Ten years later, however, the German hymenopterist, Arnold Förster, decided that the differences

¹ During the winter of 1909-10 an extraordinary planidium was found on the hibernating larva of the larch sawfly (*Nematus erichsonii* Hartig), within the cocoon. This parasite was not reared, but was *Perilampus* in all probability.

were sufficient to justify him in splitting the group into two distinct families. In this move he was later supported by Dr. William H. Ashmead. It is of course impossible to come to any definite conclusions in a case of this kind until more has been learned concerning the larval development in the other genera of the two groups, and also in the related families. If it is found that this type of development is characteristic of these two groups and no others, it should certainly be an argument of considerable weight in support of Walker's views.

RHIPIPHORUS AND OTHER COLEOPTEROUS PARASITES.

Anyone at all familiar with the life histories of certain of the parasitic Coleoptera, *Meloë*, *Sitaris*, and more especially the hornet parasite *Rhipiphorus*, will be reminded of these genera by a perusal of the preceding pages. The similarity in development, life cycle, and habits even to certain minute details is so striking that one in reading the excellent description of the life history of *Rhipiphorus paradoxus* given by Dr. T. A. Chapman¹ could scarcely tell whether it belonged to that insect or to *Perilampus* were the names omitted. A brief comparison of the two may be of interest.

So far as we know, the place of oviposition of *Rhipiphorus paradoxus* has not been observed, but other members of the family, notably *Myodites*, oviposit commonly upon flowers of various kinds. From the eggs hatch the triungulins which are not only analogous to the planidium of *Perilampus* and *Orasema* but, except for the legs and antennæ, are strikingly similar in anatomical details. The dark chitinous rings which encircle the triungulin for protective purposes during its adventurous search for its host, the backward-pointing spines with which these are provided, the pair of stylets on the last segment and the "comma"-shaped mandibles retracted into the buccal cavity all forcibly remind one of the planidium of *Perilampus*. The writer is aware that the resemblance is mainly a superficial one, but it is very unusual, superficial though it be. The similarity does not end here, however, but is carried out even to the details of the life cycle. It is more comparable to *Orasema* than to *Perilampus* inasmuch as the *Perilampus* is a secondary while the others are primary parasites. The *Rhipiphorus* triungulin, after gaining entrance to the nest of its host, conducts itself almost exactly as we have reason to suspect *Orasema* does; that is, it enters the young host larva, emerges at the time the host larva attempts to pupate, and feeds ectoparasitically thereafter. It differs, however, in the fact that the *Rhipiphorus* triungulin feeds and grows to 8 or 10 times its original length while *within* the host larva, while *Orasema* and *Perilampus* apparently do

¹ Annals and Magazine of Natural History, 4th series, vol. 6, pp. 314-326, 1870.

not grow at all until they emerge and begin feeding outside. This resemblance is not altogether lost in the later stages. Even the large dorsal tubercles or projections of *Orasema* and *Perilampus* are reproduced in the third-stage larva of *Rhipiphorus*. There is a slight difference in the method of pupation, the *Rhipiphorus* larva leaving the host to pupate while *Orasema*, when not interfered with by the worker ants, and *Perilampus*, transform *in situ*.

We have then in *Perilampus* and *Orasema* an instance of hypermetamorphism as defined by Packard, belonging to the same type as that occurring in the Rhipiphoridae. The planidium exists as such because of the wandering and perilous life it is obliged to lead in its search for a host, but soon after that host is found, the protection of the chitinous plates or the use of the ambulatorial spines no longer being necessary, these accessory structures are discarded. As the parasite now has easy access to an abundance of rich nutritious food without the necessity of putting forth the slightest effort it becomes a mere grub—a perfect adaptation to the new mode of life.

HOST RELATIONS OF THE GENUS PERILAMPUS.

REARING RECORDS OF PERILAMPUS HYALINUS AT THE LABORATORY.

We have found the native species *Perilampus hyalinus* to attack the primary parasites of two species of Aretiidae, *Hyphantria textor* Harris and *Euchætiæ egle* Drury; a single notodontid, *Melalopha inclusa* Hübner; and a saturniid, *Samia cecropia* L.

The species *hyalinus* has shown an adaptability in the matter of food habits which is quite unusual in an insect with such a complicated life history. We have absolute records of this species from 10 different primary parasites belonging to 2 different orders and 6 or 7 different genera. A diversity of host relations as exhibited by *hyalinus* would not be considered at all remarkable in species of a great many chalcidoid genera, but when we consider the circumscribed method by which access to the host is gained, it seems, on first thought, to show a quite unusual versatility. When we come to analyze the habits of the parasite more closely, however, it is at once seen that the versatility is only apparent. The diversity of host relations is due more to a lack of discrimination than to any especial adaptability. Precisely the same efforts are put forth by the planidium on the occasion of its attack upon any and all of its hosts. The conditions under which it develops are somewhat variable, but even here the actual stimulus which causes the change from endoparasitism to ectoparasitism is the same, namely, that of histolysis in the host larva.

We have reared *P. hyalinus* from the following hosts:

PARASITES OF HYPHANTRIA TEXTOR HARRIS.

Tachinidæ:

- Varichæta aldrichi* Townsend.
Compsilura concinnata Meigen.

Ichneumonidæ:

- Limnerium validum* Cresson.
Limnerium fugitivum Say.
Limnerium pallipes Provancher.

Braconidæ:

- Apanteles hyphantriæ* Riley.
Meteorus communis Cresson.

Pteromalidæ:

- Diabrachys boucheanus* Ratzeburg (on *Varichæta*).

PARASITE OF EUCHLETIAS EGLE DRURY.

Tachinidæ:

- Genus and species undetermined.

Braconidæ:

- Apanteles* sp.

PARASITE OF MELALOPHA INCLUSA HÜBNER.

Ichneumonidæ:

- Limnerium validum* Cresson.

PARASITE OF SAMIA CECROPIA LINNÆUS.

Tachinidæ:

- Frontina frenchii* Williston.

OTHER AMERICAN REARING RECORDS OF PERILAMPUS.

Through the courtesy of Dr. L. O. Howard the rearing records have been obtained from the collection and biological notes of the Bureau of Entomology. The species of *Perilampus* have not been determined. The hosts are all lepidopterous and are as follows:

- Dasyphyga alternosquamella* Ragonot.
Acrobasis caryæ Grote.
Eucosma scudderiana Clemens.
Eucosma desertana Zeller.
Phlyctænia extricalis Guenée.
Apatela haustulifera Smith and Abbot.
Harrisina americana Guerin-Ménéville.
Retinia sp. (?)

Prof. C. V. Riley records ¹ *Perilampus platygaster* Say as a parasite of *Harrisina americana* in the State of Missouri.

A species of *Perilampus* was reared, according to the labels in the United States National Museum, by Mr. D. W. Coquillett from the cocoon of a *Chrysopa* at Los Angeles, Cal. Dr. Ashmead also reared

¹ Second Report on the Noxious and Beneficial Insects of Missouri, p. 87, 1870.

a species from *Chrysopa* at Utica, Miss., this record being the one referred to in his Monograph of the Chalcidoidea.

In a paper entitled "A list of the parasites known to attack North American Rhynchophora,"¹ Mr. W. D. Pierce records *Perilampus* as a parasite of the cotton boll weevil (*Anthonomus grandis* Boheman) in cotton squares in Louisiana. Mr. Pierce in a recent letter regarding this record states that it is open to question. A cotton square from which a weevil had emerged forms an excellent retreat for another insect that might be inclined to secrete itself in this manner. It may be that in this case a *Chrysopa* larva parasitized by *Perilampus* crawled into the square to pupate and from this the *Perilampus* emerged later. That *Chrysopa* is prone to do just this thing is a well-known fact. Dr. Howard described the chalcidoid parasite *Isodromus iceryæ* as a parasite of the scale *Icerya*. He later found that *Isodromus* was instead a parasite of *Chrysopa*, which in this instance had crawled beneath the *Icerya* scale, through which the *Isodromus* later emerged.

In 1897 Mr. W. F. Fiske reared a single specimen of *Perilampus hyalinus* from the cocoon of *Limnerium fugitivum* Say as a parasite of *Hyphantria*. This fact was recorded in his paper on the parasites of the American tent caterpillar,² and probably constitutes the first published record of *Perilampus* as a secondary parasite on Hymenoptera.

Quaintance and Brues in their study of the cotton bollworm³ found this species to be a rather uncommon parasite of *Microplitis nigripennis* Ashmead, a braconid parasite of *Heliothis obsoleta* Fabricius in Arkansas and Texas.

Dr. L. O. Howard, in a paper entitled "The biology of the hymenopterous insects of the family Chalcididae,"⁴ makes the statement that *Perilampus* has been reared from Tachinidæ, but none of the details of the rearing was given. Dr. Howard, in a recent letter in regard to this, says that he is unable to find any record upon which this statement was based, but that he is of the opinion that it was reared from tachinid puparia in the office of the Entomologist at Washington prior to 1892. This is the first published record, so far as we are aware, of *Perilampus* as a parasite of Diptera.

Prof. M. H. Swenk⁵ records having reared *Perilampus hyalinus* from a sarcophagid which in turn was reared from *Melanoplus bivittatus* Say.

¹ Journal of Economic Entomology, vol. 1, p. 383, 1908.

² New Hampshire College Agricultural Experiment Station, Technical Bulletin 6, p. 206, 1903.

³ Bulletin 59, Bureau of Entomology, U. S. Department of Agriculture, p. 122, 1905.

⁴ Proceedings of the U. S. National Museum, vol. 14, p. 574, 1892.

⁵ Journal of Economic Entomology, vol. 4, p. 286, 1911.

EUROPEAN REARING RECORDS OF PERILAMPUS.¹*Perilampus angustatus* Nees.

This species was reared by Rondani² from the wood-boring larva of *Anobium molle*. Gaulle³ records *angustatus* as a parasite of *Dryophilus pusillus*.

Perilampus auratus Panzer.

According to Gaulle,³ this species has been reared from the crabronid wasps *Solenius rubicola* and *S. vagus* by Lichtenstein.

Perilampus levifrons Dalman.

Rondani² has reared *levifrons* from the larvæ of the tortricid *Coccyx buoliana* and also from the codling moth (*Carpocapsa pomonella* L.). Gaulle³ gives an additional host in *Exocentris punctipennis*. Dour⁴ mentions the first two records, crediting the first to Gouraud.

Perilampus micans Dalman.

This parasite was reared by Rondani² from the larvæ of *Lyctus canaliculatus* and *Hister picipes*.

Perilampus ruficornis Fabricius.

Gaulle³ records this insect as a parasite of *Hylophila bicolorana*. Rondani² has reared it from the lepidopterous *Halias quercena*. Dalle Torre regards *violaceus* Fabricius as a synonym of this species.

Ratzeburg⁵ refers to a *Perilampus* which he calls *violaceus* as follows:⁶

Herr Reissig was so fortunate as to rear a female of this species. The host was not determined definitely, but it was without doubt a forest insect. On an oak leaf he found the dried remains of a tortricid larva. The parasitic larva had come out of this and had hung itself by a spun thread. The cocoon has the compact form of those of *Campoplex*, is two lines long, transparent (but nevertheless of close texture), dark brown, with a somewhat lighter band. The large opening through which the *Perilampus* had gnawed its way is at one end and appears as an irregularly torn circle.

There seems to be little doubt that Ratzeburg was incorrect in his surmise that this species was primary upon the tortricid. *Perilampus* of course does not spin a cocoon, or even a thread. The cocoon which he describes was almost certainly that of *Campoplex*, which he says it resembles, and with which his description agrees.

¹ The author is indebted to Dr. L. O. Howard for examining literature which was inaccessible.

² *Bulletino della Società Entomologica Italiana*, vol. 4, pp. 57-58, 1872; vol. 8, pp. 241-242, 1876.

³ *Catalogue systematique et biologiques des Hyménoptères de France*, in *La Feuilles des Jeunes Naturalistes*.

⁴ *Catalogue synonymique des Hyménoptères de France*, in *Mémoires de Société Linnéenne du Nord de la France*.

⁵ *Ichneumonon der Forstinsekten*, vol. 3, p. 221.

⁶ Translation by the author.

This *Campoplex* was probably parasitic on the tortricid, and the *Perilampus* destroyed it as a secondary parasite.

There is almost certainly more than one species under the name *ruficornis*, as the records indicate that it has been reared from moths as a primary parasite, and from an ichneumonid as a secondary. That this would occur in a single species seems hardly probable in view of its highly specialized life cycle.

Perilampus italicus Fabricius.

Recorded by Gaulle¹ as a parasite of the sawfly *Athalia colibri*.

Of course there is always the possibility that the specimens recorded from Lepidoptera really came from tachinids or ichneumonids which transform within their host. It is difficult to understand how the *Perilampus* larva, being an external feeder for the greater part of its life, could feed and develop externally upon the pupa of an ectophagous lepidopteron, taking for granted that the mode of development is similar in all the species of the genus. It might, however, be able to do so upon a lepidopterous host which feeds within stems or galls, the *Perilampus* in this case being protected from injury.

EUROPEAN SPECIES OF PERILAMPUS REARED AT THE LABORATORY.

Perilampus cuprinus Förster.

In 1906 several individuals of *Perilampus cuprinus* were reared by Mr. Titus from puparia of imported tachinids parasitic upon the gipsy moth and brown-tail moth. Occasionally a few more were secured under similar circumstances, but never in numbers sufficient to indicate that the species was of any particular importance as a secondary parasite. Neither were there any records which indicated that any species of the genus was of more than incidental interest in connection with lepidopterous hosts.

The tachinids acting as hosts were not identified in every instance, but among those species attacking the gipsy moth are *Blepharipa scutellata* Robineau Desvoidy, *Compsilura concinnata* Meigen, and *Tricholyga grandis* Zetterstedt, and among the brown-tail moth parasites are *Pales pavidata* Rondani and *Paraxorista chelonix* Rondani. It is practically certain that all of the tachinids and probably some of the ichneumonids and braconids preying upon this host are liable to attack by *Perilampus*. It is also possible, but not proven, that it is at times an enemy of sarcophagids which usually and probably always attack pupæ which have died from other causes.

In no instance has the planidium of this species been seen but there is hardly a doubt that this stage exists and that in its essential

¹ Catalogue systematique et biologique des Hyménoptères de France, in La Feuilles des Jeunes Naturalistes.

characteristics it resembles the planidium of *P. hyalinus* and others described in the preceding pages. It is also probable that the later larval development is analogous to that of *P. hyalinus* and that the beginning of development of the pupa is the signal which stirs the planidium into activity.

Varichæta, as has been shown, hibernates as a pupa which has not begun to show the color or characteristics of the adult, and the *Perilampus* planidium remains dormant throughout the winter and feeds in the spring. Among the European tachinids known to act the part of host to *P. cuprinus*, *Compsilura*, *Tricholyga*, and *Pales* issue in the summer, much as do the summer-issuing hymenopterous parasites of the fall webworm, and *P. cuprinus* completes its transformations and hibernates as an adult without leaving the puparium. *Blepharipa*, unlike *Varichæta*, develops imaginal characters in the fall and is, so far as external evidences indicate, ready to emerge before winter. *Perilampus* as a parasite of *Blepharipa* acts exactly as it would had its host actually emerged in the fall, and hibernates as an adult within the puparium. *Parexorista* hibernates like *Varichæta*, and if the parallel between *P. hyalinus* and *P. cuprinus* is as close as is believed, the planidium hibernates as such and becomes active when its host begins to develop in the spring.

Perilampus inimicus Crawford.

A relatively small number of this species, recently described in Part II of this bulletin, was reared in 1908 from the cocoons of *Apanteles fulvipes* var. *japonica* Ashm., imported that year from Japan as a parasite of the gipsy moth. It has not been reared as a parasite of Japanese tachinids, but it may well be that it resembles *P. cuprinus* in habits, and that it will be reared when larger importations of tachinids from Japan have been made.

The specimens reared issued in the late summer, coincidentally with the emergence of the other more common chalcidoid parasites of the same host.

Perilampus sp.

Another species of *Perilampus*, as yet undetermined, has been reared from the cocoons of a European *Apanteles* parasitic upon the young brown-tail moth caterpillars. The circumstances are interesting and suggestive but the incident will be discussed more at length in another connection.

RÉSUMÉ OF HOST RELATIONS OF THE GENUS.

Species of the genus *Perilampus* have been reared¹ from insects belonging to five different orders, Hymenoptera, Diptera, Lepi-

¹ This is according to the published records, although some of them are almost certainly incorrect.

doptera, Coleoptera, and Neuroptera, in Europe, Japan, and America. Table III shows the number of each group from which *Perilampus* has been reared in those regions where the gipsy moth is found:

TABLE III.—*Classification and distribution of the known hosts of the genus Perilampus.*

	America.	Europe.	Japan.	Total.
Hymenoptera parasitica.....	8	2	1	11
Hymenoptera phytophaga.....		1		1
Hymenoptera aculeata.....		2		2
Diptera (Tachinidæ).....	4	5		9
Lepidoptera.....	8	5		13
Coleoptera.....	1 (?)	4		5
Neuroptera.....	1			1
Total.....	22	19	1	42

THE ECONOMIC ASPECTS.

In 1906 Mr. E. S. G. Titus, at that time in charge of the Gipsy Moth Parasite Laboratory, reared a few cocoons of *Apanteles vimenatorum* Wesmael¹ from caterpillars of the brown-tail moth which had been imported in the hibernating nests. From them there emerged a very few specimens of a species of *Mesochorus*, different from any known American secondary upon *Apanteles* and apparently but not certainly European. The circumstances under which the *Apanteles* were reared were not such as absolutely to protect them from the attack of the native hyperparasites, but there was good reason to believe that the *Mesochorus*, as well as the *Apanteles*, had attacked the very small caterpillars of the brown-tail moth in Europe the fall before. This was the first instance encountered in the course of the work of parasite introduction in which a secondary parasite was known or suspected to attack a primary parasite before the death of the primary host.

In 1907 this record was confirmed, and it was demonstrated beyond possibility of error that there were some secondary parasites which had this habit. The fact was of the greatest significance, since it was one of the fixed policies of the laboratory to introduce the primary parasites of the gipsy and brown-tail moths and to exclude the secondary. It had been supposed that this could be accomplished by importing the living caterpillars and pupæ of the gipsy and brown-tail moths and rearing the parasites. The fact that the primaries might be attacked before the death of their host altered the situation materially and made the strictest supervision of imported material necessary in order to meet the ideal which had been set.

That the relative importance of hyperparasitism has diminished rather than increased as a result of a better understanding of the

¹ As determined by Schmiedeknecht.

subject affects the matter scarcely at all. We know now that the primary parasites of the gipsy and brown-tail moths, if they become established, will be subjected to the attack of native hyperparasites to a varying degree in accordance with the closeness of their resemblance in natural affinities and habits to American species, but there are among them a few which are so different from any American species as to make it probable that they will largely escape undue parasitism in America, much as the gipsy and brown-tail moths have themselves escaped. This does not lessen the force of the original contention at all materially. It has simply served to separate the secondary parasites into bad, worse, and worst, and has left them as a group with about the same degree of odium attached as before.

The separation of the several secondary parasites into groups in accordance with their capabilities for evil has not always been easy. As with the primary parasites, the importance of which can not be inferred from the numbers which chance to be reared from the imported material, the secondary parasites, which are the least frequently encountered, may easily be the most to be feared.

Perilampus has never been abundant as a parasite of tachinids in any of the imported material. So far as is directly indicated by our notes and breeding records there is nothing in its life or habits which would separate it from the minor and inconsequential secondary parasites, of which there are many species.

These opinions, formerly held, have been changed as a result of the investigations into the life and habits of the native *Perilampus hyalinus*. It was not known or suspected, in spite of the considerable study which the fall webworm has received at various times and by various entomologists, that this secondary was of any more interest or importance than any other, but it is now evident that species of this genus may become of the greatest importance as hyperparasites. It is further indicated as a direct result of these studies that the different species of *Perilampus* are likely to concentrate their attack upon the parasites of some particular primary host instead of scattering their attack upon all of the very numerous species of hymenopterous and dipterous parasites suitable in other respects. Thus *Perilampus hyalinus* appears to be particularly a parasite of the parasites of the fall webworm. It is possible that it will never attack the parasites of the gipsy moth or the brown-tail moth. *Perilampus cuprinus*, for all that is positively known to the contrary, may similarly concentrate its attack upon the parasites of the gipsy moth and the brown-tail moth and might become a factor of as much importance in the natural control of these insects as *Perilampus hyalinus* undoubtedly is in the control of *Varichæta*.

It is not probable, but it is conceivable, that the establishment of *P. cuprinus* in America might make all the difference between success and failure of the whole work of parasite introduction, in so far as the gipsy moth is concerned, because, in the first place, *Blepharipa scutellata* is one of the most important parasites of the gipsy moth and the success or failure attending the attempts to introduce it into America might easily tip the scale one way or the other, and *Perilampus*, so far as known, is the most important parasite of *Blepharipa* and might in a similar manner determine whether or not its host reached the necessary state of efficiency.

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TECHNICAL SERIES No. 19, PART V.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

TECHNICAL RESULTS FROM THE GIPSY MOTH
PARASITE LABORATORY.

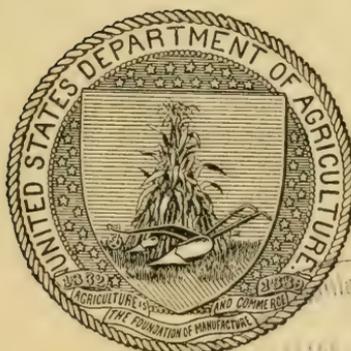
V. EXPERIMENTAL PARASITISM:

A STUDY OF THE BIOLOGY OF *LIMNERIUM VALIDUM* (CRESSON).

By P. H. TIMBERLAKE, A. M.,

Agent and Expert, Gipsy Moth Parasite Laboratory.

ISSUED MAY 29, 1912.



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1912.

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¹ Transferred to cereal and forage insect investigations.

² Transferred to citrus fruit insect investigations.

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TECHNICAL RESULTS FROM THE GIPSY MOTH PARASITE LABORATORY.

V. Experimental Parasitism: A Study of the Biology of *Limnerium Validum* (Cresson).

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INTRODUCTION.

The biology of none of our American parasitic Hymenoptera is too well known to demand an apology for the appearance of this article, and it is the hope of the author that the results of the studies here set forth will call to the attention of our professional and amateur entomologists this exceedingly rich but almost untouched field for investigation. A little of the ecology, especially of the host relationship, of many of our parasites has been recorded, but the various and interesting adaptations in the larval structure and habits of our different species are almost unknown.

In connection with the practical work at the Gipsy Moth Parasite Laboratory of importing and liberating parasites of the gipsy and brown-tail moths, considerable attention is paid to the habits and biology not only of the imported parasites, but also of our native parasites of caterpillars that resemble the gipsy moth or brown-tail moth in habits or destructiveness. In this way considerable knowledge has accumulated which, besides its intrinsic and theoretical value, has been useful in perfecting the methods of handling the imported species and in showing which of our American species, if any, may be expected to become contributing factors in the control of these pests.

It was especially with this latter idea in mind that in the spring of 1910 a series of experiments was undertaken to work out the biology of our native *Limnerium validum* (Cresson) (fig. 32) and its behavior toward unusual hosts. The experiments grew out of a successful attempt to foster oviposition on small brown-tail moth caterpillars (*Euproctis chrysorrhæa* Linnaeus), which yielded such unexpected complications that the work was continued on other hosts as they became available in the course of the spring.

Limnerium validum proved to be an excellent subject for experimentation for several reasons, but chiefly on account of its docility in

confinement and the readiness with which it attacks any suitable species of caterpillar and because the heavily chitinized chorion of the egg is remarkably durable. This last fact was an advantage in determining the number of eggs deposited in a caterpillar, even when considerable time had elapsed after the hatching of the larva. Fortunately for the success of the experiments an abundance of adults of this species was at hand, reared from cocoons obtained the preceding fall from its usual host, *Hyphantria cunea* (Drury).

This *Limnerium* is one of the hymenopterous parasites affecting the fall webworm (*Hyphantria cunea*); and although not so important as *Meteorus* and *Apanteles*, it is frequently found. In the northern States it emerges from the fall webworm and spins its cocoon mostly during the month of September. Unlike *Limnerium pilosulum* (Provancher), another species common on *Hyphantria*, it hibernates in

its cocoon until late the following spring or summer, and consequently it has been considered to have only a single generation a year. Farther south, however, as pointed out by Dr. L. O. Howard (1897) in his bulletin on the white-marked tussock-moth (*Hemerocampa leucostigma* Smith and Abbot), of which it is an unimportant parasite, it probably hibernates

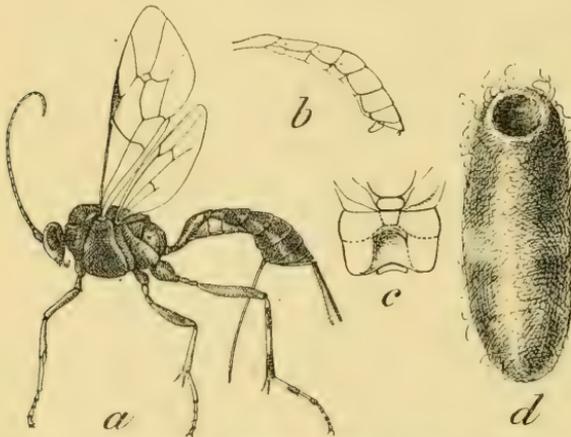


FIG. 32.—*Limnerium validum*: a, Adult female, side view; b, abdomen of male; c, metascutum from above; d, cocoon. Enlarged. (a, b, d, Redrawn from Howard; c, original.)

as an adult, as its empty cocoons were found associated with "spun-up" larvæ of the *Hemerocampa* in the middle of December. Dr. Howard also records rearing the adult as early as the middle of July, so that in the vicinity of Washington, D. C., two generations, if not more, occur annually. Besides its favored host, *Hyphantria cunea*, and the *Hemerocampa*, it probably attacks other caterpillars, but so far as the author is aware no other rearings have been recorded.

EXPERIMENTS.

GENERAL METHODS OF EXPERIMENTATION.

In most of the experiments undertaken with *Limnerium validum* the parasites and caterpillars were confined together in large glass cylinders covered at the top with cheesecloth, and resting on cloth-covered frames. When it was desirable, however, to have a large

number of caterpillars, a small, flat tray was used, wire screened on the bottom and covered with glass. A small hole in the side of the tray was found useful in introducing fresh foliage sprayed with sweetened water, as food for the caterpillars and parasites. In the first experiments several females of the *Limnerium* were confined with a limited number of caterpillars, but later, when it was discovered how readily the parasites attacked the hosts, the number of the latter was proportionately increased. Dissection of the caterpillars was chiefly relied upon in working out the results of each experiment.

BEHAVIOR OF LIMNERIUM VALIDUM (CRESSON) IN CONFINEMENT.

This species did not become overrestless in confinement, and hardly betrayed the excitement that some parasites are said to do when in proximity to their hosts. This tranquility may possibly be explained by the fact that the *Limnerium* was always confined with species of caterpillars that do not naturally serve it as hosts, and it might have been stimulated, perhaps, to greater activity by fall webworms. The females, however, readily oviposited in 4 of the 6 species of caterpillars with which they were confined. The postero-dorsal part of the host was usually chosen as the most suitable point for attack, and there seems to be a more or less well-developed instinct in this as well as other parasites to keep away from the head of the caterpillar in ovipositing. This instinct is not so necessary for large, strong parasites like *Limnerium validum*, but may be of great advantage to small, weak species like *Meteorus* or *Apanteles*. These frequently attack caterpillars that are many times their size, and might easily fall a victim to one vicious sweep of the host's head, or become so daubed up by juices exuding from the mouth of the excited caterpillar that they could not escape. As circumstantial evidence of the existence of this instinct, comparatively few eggs were found near the head in dissected caterpillars, and by far the greater number was found in the posterior half of the body. A favored site for them was in the extreme tip of the postero-dorsal part of the body cavity just beneath the integument.

The males of *Limnerium* were slightly more active than the females in running about the cage, but they paid no attention to the caterpillars, and but little attention to the females. None was ever seen attempting to mate.

LIMNERIUM VALIDUM AS A PARASITE OF EUPROCTIS CHRYSORRHICEA (LINNÆUS).

Three experiments were undertaken during February and March, 1910, to determine whether *Limnerium validum* would successfully attack brown-tail caterpillars, and to collect data, if possible, on the early stages.

FIRST EXPERIMENT.

In the first experiment, on February 2, 5 females of *Limnerium* were confined in a small glass cylinder with 10 active brown-tail caterpillars about 8 mm. long. The experiment was closed on February 15, at which time the last of the caterpillars died. Nine of the caterpillars were carefully dissected and a count made of the easily discovered eggs and larvæ of *Limnerium*. The largest number found in one caterpillar was 23 eggs and 11 larvæ with the empty eggshells, dissected from one that died on February 11. The smallest number was 4 eggs and 5 larvæ taken from a dead caterpillar on February 15. One hundred and forty-six eggs and 72 larvæ were found in all, making a total of 218 eggs deposited by the 5 females in the course of the 4 to 6 days that they remained alive, or an average of nearly 44 eggs for each female, and about 24 to each caterpillar.

With this unusual number of eggs and larvæ present, it is no wonder that the caterpillars failed to survive. As the caterpillars in every case died before the larvæ had grown to any appreciable extent and even before all the eggs had hatched, it is not probable that they were killed by the feeding of the parasites. It is much more probable that they succumbed to the mechanical irritation produced by so many eggs and larvæ, which not only may have caused a violent disturbance or pathological condition of the body tissues, but also tended to keep them from feeding.

SECOND EXPERIMENT.

A second experiment was started on February 5, with 5 females and 13 active brown-tail caterpillars. By February 9, all the parasites were dead, and 3 caterpillars were found dead on the 11th and 5 more on the 19th. In the 8 dead caterpillars 61 unhatched and 5 hatched eggs were found, but only 1 larva, which had grown to be about five times the size of newly hatched larvæ, although still in the first stage. About 8 eggs, on an average, were thus found in each caterpillar, and they were undoubtedly at least a strong contributing factor in causing the death of the latter.

Three of the 5 living caterpillars were dissected on February 19 and the remaining two on March 4. In these 5 caterpillars only 1 unhatched egg and 12 eggshells with only 4 larvæ were found. This, on an average, is only 2 or 3 to each caterpillar, for although 1 had been victimized 8 times, 1 had escaped altogether. Only 4 larvæ were found, and of these 3 had died shortly after hatching before growing to any extent, whereas 1 had managed to live and increase in size about five times. In the 13 caterpillars dissected, 72 unhatched eggs, 17 hatched eggs, and 5 larvæ were found, or nearly 7 to a caterpillar and 18 for each female *Limnerium*.

AMŒBOCYTOSIS AS A PROTECTIVE REACTION OF THE HOST.

The remarkable fact in the array of figures just given is the disparity between the number of eggshells or cast choria found and the number of larvæ. The latter were large enough so that they could not have been overlooked, and the only explanation is that they had been killed by the host and absorbed by the blood tissues, or destroyed, in other words, by amœbocytosis. The chitinous choria, on the other hand, escaped unharmed. In the preceding experiment, in one of the dead caterpillars dissected on February 15 the dead larvæ and some of the eggs and eggshells were found inclosed in a firm, thick, homogeneous-appearing, transparent capsule of tissue. The significance of this was not realized at that time, but when on February 19 the same phenomenon was noticed in the dissection of living caterpillars, the mystery of the missing larvæ was explained, for when the capsule was stained in methyl green and mounted in glycerin, it was resolved under the high power of the microscope into innumerable, densely packed, minute, roundish and spindle-shaped cells. These were undoubtedly blood-tissue cells or amœbocytes, and whereas they were not true phagocytes, yet their function must have been to break down and absorb the tissues of the parasites, for within the capsules larvæ were found in several stages of dissolution.

Later experiments with the same and other hosts, such as *Malacosoma* and *Notolophus*, brought to light the fact that this amœbocytic reaction takes place regularly when the *Limnerium* occurs in these hosts to which it seems to be unaccustomed and unadapted. In most cases it was found that the parasite was able to hatch from its egg, but that it perished generally soon afterwards before growing to any extent. Many times the larva was found to have disappeared entirely through the action of the amœbocytes, yet the story of its death and dissolution was told by the encapsulated remains of the much more resistant eggshell. Whether the amœbocytes gathered around and killed the living larvæ and eggs or attacked only parasites that had been killed by some other factor was not certainly determined; but the former supposition is probably correct, as unhatched eggs containing embryos in different stages of dissolution were found sometimes inclosed in sheaths of these cells. In one instance, also, a larva that had grown to be about six times the size of newly hatched larvæ, was found entirely inclosed except for its head in a characteristic sheath. This larva was probably living when its host was killed for dissection, or at least, judging from its fresh and uninjured condition, it could not have been dead for more than a few hours.

An extended series of dissections of *Hyphantria cunea*, on the other hand, made by J. D. Tothill during the fall of 1910, showed that the

larvæ of *Limnerium* are free from the slightest trace of amœbocytic attack when occurring in their natural host.

Other phases of this so-called "phagocytosis" have been studied by several European investigators, especially by Cuenot (1896), Janet (1906, 1907), and Pantel (1910). The latter author has given a summary of those cases of amœbocytosis that were known to him in his excellent "*Recherches sur les Diptères a Larves Entomobies.*" He concludes that this defensive reaction of the host is aroused not only by bacterial infection but also by sick or dead parasitic larvæ and by molt skins, and states that free and healthy larvæ are regularly exempt.

The only cases of sick larvæ that Pantel seems to have observed are larvæ of Tachinidæ that have fallen accidentally from their breathing holes, generally during the molting of the host. Such larvæ do not affix themselves anew, but wander about in the body cavity of the host until overcome by suffocation. Pantel further observes that the anal sheaths of such larvæ begin to turn brown and become inclosed by a great number of amœbocytes, which finally almost completely cover the larva.

In the case of dead larvæ which have perished in the struggle for the possession of the host, Pantel observes that their bodies only exceptionally become encapsulated by amœbocytes. The molt skins, on the other hand, he furthermore states, are attacked, not always, but most frequently by amœbocytes.

The similar action of amœbocytes in breaking down the wing muscles of queen ants has been described by Janet (1906, 1907). The muscles are not devoured in small fragments by phagocytes, but are disintegrated gradually and absorbed by amœbocytes, which creep in among the fibrillæ in large numbers.

We have seemingly in this amœbocytic reaction a manifestation of the protective faculty of the host in guarding against the attack of entoparasites. As shown by Pantel (1910) and confirmed by our own observations of various species of parasitic Diptera and Hymenoptera, normal or adapted parasitic larvæ, when healthy, rarely if ever arouse this defensive reaction, or, in other possibly more correct words, they are able to repel the amœbocytes by some curious adaptation. Unadapted parasites, on the contrary, being unable to repel the amœbocytes, may regularly succumb to their agency. The instinct of parasites under ordinary conditions well fits them for choosing their accustomed hosts, but in the millions of instances where this instinct comes into play, an egg may be placed occasionally in an unsuitable host. In such cases the resulting larva seems to be doomed to a lingering death, and its tissues are absorbed by the amœbocytes with no ultimate detriment to the host.

ADAPTATION OF PARASITE TO HOST.

The phenomenon of amœbocytosis, on the other hand, brings up the question. Why do not all parasites suffer the same fate, and what

constitutes adaptation? We begin here to sink deep into the quagmire of speculation and doubt. We may say that the parasitic larva is so similar to the host in its effluvia or physical being, that its presence is not felt or resented, and that it bears much the same relation to the host that the fetus within the uterus does to the mammalian mother; or we may conclude that it secretes substances into the blood which paralyze the protective reactions of the host. We are more inclined to accept the latter view, for we have observed several phenomena in the course of other dissections which are difficult to explain except by a secretion hypothesis.

In dissecting various parasitized insects we have often noticed pathological changes in the body tissues, and especially that the flaky fat bodies are often converted into a number of comparatively gigantic, globular cells which are unattached and float freely about in the blood of the insect. In dissecting brown-tail moth caterpillars imported from Europe we have seen small first-stage larvæ of *Meteorus* exert a strange and fatal influence over the larvæ of *Zygobothria nidicola* Fallen, when occurring together in the same host. The larvæ of *Meteorus* live free in the body cavity of the host at the extreme posterior end of the body on the dorsal side, whereas the maggot of *Zygobothria* is normally found encysted in the wall of the crop or œsophagus. In the few cases in which both were found in the same caterpillar, the maggot of *Zygobothria* had left its cyst in the crop, and was either wandering about in the body cavity of the host or had already died. How can we explain this strange and untimely reaction of the maggot, unless we consider that it had been stimulated to activity by some unusual substance in the blood tissues of the host, either secreted by the larvæ of *Meteorus*, or by the host itself in reaction thereto?

FURTHER EXPERIMENTS WITH EUPROCTIS CHRYSORRHŒA.

A third experiment was started on February 15 with about 100 brown-tail moth caterpillars that had been feeding for 20 days and were consequently about 10 mm. long. These caterpillars were placed in a small tray, and 15 females of *Limnerium* were confined with them between the 15th and 27th of February, fresh females being added as the first ones died.

Dissection of living caterpillars was undertaken on the 4th of March and continued on the 14th. Thirty-four caterpillars in all were dissected and 15 were found to be parasitized by *Limnerium*. Not more than 2 larvæ or eggs were found, on an average, in a single caterpillar, and the larvæ were in most cases dead. Only one larva, in fact, had obtained any size, and it was only about six times as large as the newly hatched larvæ. Although incrustated with a capsule of amœbocytes it may have been still alive, but could not have survived

much longer. All the other larvæ that were found were newly hatched, or had been killed soon after hatching, and were commonly inclosed in a sheath of amœbocytes.

The rest of the caterpillars were kept alive as long as possible in the hope that one or two of the *Limnerium* might be able to pass through their transformations, but none was reared. The experiment therefore furnished data similar to those obtained in the preceding experiments, and conclusively confirmed the belief that *Limnerium validum* is unable to live as a parasite within brown-tail moth caterpillars.

LIMNERIUM VALIDUM AS A PARASITE OF MALACOSOMA AMERICANA
(FABRICIUS).

On April 20 an experiment was started with *Limnerium validum* as a parasite of the common tent caterpillar (*Malacosoma americana* Fabricius). Three females were confined in a large, flat, tangle-footed tray, with three nestfuls of caterpillars, mostly in the second stage, collected in the open at Melrose Highlands, Mass. A fourth nest was added on the 21st to insure an abundance of caterpillars for the *Limnerium* to attack. By the 26th the *Limnerium* had all died, but 2 more females were placed in the tray on the 28th. Many of the caterpillars at that time were passing into the third stage.

RESULTS OF EXPERIMENTS AS DETERMINED BY DISSECTION.

On May 3 dissections were made of 6 second-stage and 11 third-stage caterpillars, of which all of the former and 9 of the latter were found to be parasitized. The results of the dissections are given in Table I.

TABLE I.—Results of dissections of caterpillars of *Malacosoma americana* parasitized by *Limnerium validum*.

Stage of host.	Number of eggs laid.	Number of eggshells found.	Number of larvæ found.	Condition of larvæ.	Other data.
Third.....	1	1	1	Living.....	
Do.....	1	1	1	do.....	
Do.....	3	3	2	1 living.....	Dead larva only partially enclosed.
Do.....	1	1	1	1 dead.....	1 larva already destroyed.
Do.....	1	1	1	Living.....	
Second.....	1	1	1	Living.....	1 dead egg covered with amœbocytes.
Do.....	1	1	1	do.....	
Do.....	1	1	1	do.....	Eggshell not found.
Do.....	1	1	1	do.....	
Third.....	2	2	1	do.....	1 larva already destroyed.
Second.....	2	1	1	do.....	1 dead egg covered with amœbocytes.
Do.....	1	1	1	do.....	
Do.....	1	1	1	do.....	
Do.....	1	1	1	Living.....	Host not parasitized.
Do.....	1	1	1	do.....	Eggshell not found.
Do.....	1	1	1	do.....	
Do.....	1	1	1	Living.....	Host not parasitized.
Do.....	1	1	1	Living.....	
Total (17 hosts).....	19	15	15		

According to the dissections 19 eggs were deposited in the 17 caterpillars, distributed as follows: One caterpillar was parasitized three times, 2 twice, 12 once, and 2 escaped parasitism altogether. Of the 19 eggs deposited, 2 failed to hatch and became covered with amœbocytes, as did also the eggshells except in one doubtful instance, and in case of a third the embryo or larva was killed during the process of eclosion, becoming also densely encapsulated with amœbocytes. Two other larvæ were killed after hatching, and were entirely destroyed by the action of the amœbocytes, but their former presence was revealed by the empty eggshells. The remaining 14 larvæ were in a living and apparently healthy condition. Some were recently hatched, but others had grown to an appreciable extent. They lay free in the body cavity of the host, generally in the posterior half of the body, either above or below the digestive tube, and with the head directed caudad in respect to the host.

On the 7th of May, 5 caterpillars in the fourth stage were dissected, and in 2 of them was found a living first-stage larva; on the 11th, 10 more caterpillars were dissected, but none was parasitized; again on the 19th 2 caterpillars out of 10 in the fourth and fifth stages were found to be parasitized. One contained a living, first-stage larva of *Limnerium*, the other a living larva in the second stage, each host being about 20 mm. long.

EMERGENCE OF ADULTS OF LIMNERIUM FROM REPRODUCTION.

On the 21st of May, 2 unspun, full-grown larvæ of *Limnerium* were discovered in the tray, and between that time and the 1st of June, 29 in all were found, 6 of which died before spinning cocoons. The rest spun perfect cocoons, and 6 passed through their transformations to the imagos, in every case males, from June 7 to June 14. The remaining 17 cocoons remained unissued up to December 13, when they were cut open and examined. All were found to contain dead larvæ, some perfectly dry and shriveled, although 4 seemed only recently dead, as they were still plump although much discolored.

In all cases in this experiment where remains of the host were found associated with the larva or cocoon, the *Limnerium* issued from half-grown caterpillars, which were mostly in the fourth stage, although a few appeared to be small and stunted specimens of the fifth stage. On May 28 the remains of a host were examined. This caterpillar was killed by the parasite when about 25 mm. long, while still in the fourth stage. It had a large, round hole in the integument on the ventral side, just back of the head, through which the larva escaped, after destroying all of the internal organs. The integument inside was left perfectly dry and bare, except for a small amount of broken-down tissue at the extreme posterior tip of the body.

LENGTH OF THE STAGES IN THE LIFE HISTORY OF *LIMNERIUM*.

From this and the preceding experiments we may estimate that the duration of the embryonic development of *Limnerium validum*, or the time from oviposition to the hatching of the egg, is about 6 to 8 days; that the larval developmental period lasts for about 24 to 33 days; and that the pupal period, or, more exactly, the time from the spinning of the cocoon to the eclosion of the adult, is about 13 to 22 days, or much longer. The length of the larval period within the cocoon before pupation was not determined, but, judging from the cocoons examined on December 13, it may be extended several months. The minimum time from egg to imago is thus about 7 weeks, or 50 days, whereas the maximum time to the eclosion of the adult may be many months, due to quiescence within the cocoon. This species hitherto has been considered to have a single generation a year, but this last experiment seems to indicate that under certain conditions at least it is able to pass through two generations annually. Under normal conditions, however, there is much doubt whether more than one generation actually occurs in the Northern States.

A POSSIBLY NORMAL PARASITE OF MALACOSOMA.

This experiment shows that *Limnerium validum* is a possibly normal parasite of the tent caterpillar, although it has never been found attacking that species in the field. The reason for this is obvious: The tent caterpillars hatch early in the spring, long before the *Limnerium* leaves its cocoon, and therefore are not in season for this parasite. From the fact, however, that nearly one-half of the caterpillars dissected in this experiment were found to be parasitized, and that comparatively few were killed by *Limnerium*, we may conclude that *Limnerium validum* is only partially adapted to this host. In the dissecting work only 5 dead larvæ or eggs were discovered, but many more without much doubt succumbed to the defensive reactions of the host. In the 42 caterpillars dissected, 23 eggs or larvæ were found, and 29 other larvæ were successful in passing through their larval development, making a total of only 52 parasites that came under observation. If the 5 females used in this experiment oviposited as freely, however, as those in the preceding experiments, and there is no reason to believe otherwise, some 100 to 200 eggs or even more were probably laid. Taking 100 as a conservative estimate, and with due allowance for the destruction wrought by the dissections, we may thus figure on a mortality of at least about 37 per cent. The cast eggshells were almost invariably found thickly ensheathed with amoebocytes, and the function of the latter was without doubt the same as in the case of the brown-tail moth caterpillars, to disintegrate if not to kill the young larvæ. In the present instance,

however, a few of the larvæ were able to withstand the action of the amœbocytes and reach maturity. This immunity of the few is of theoretical interest, as it would furnish a basis under proper conditions for the evolutionary development of complete host relationship. It is not difficult to conceive that this parasite in the course of not many generations might adapt itself so as to insure a minimum mortality, and thus become an effective enemy of the tent caterpillar.

LIMNERIUM VALIDUM AS A PARASITE OF NOTOLOPHUS ANTIQVUS
(LINNÆUS).

One of the most interesting of the experiments was started May 9, 1910, with the rusty vaporier moth (*Notolophus antiquus* Linnaeus) as the host. One unfertilized female *Limnerium* was confined with 25 small, third-stage caterpillars. The female remained alive for 12 days and oviposited freely in the caterpillars.

Dissection work was commenced on June 17 and was continued at intervals until June 30. In all, 10 caterpillars, 1 pupa, and 7 moths were dissected. In the 10 caterpillars, a total of 40 eggs and eggshells was found, and 8 larvæ which were all dead; in the 1 pupa, 1 eggshell was found; and in the 7 moths, a total of 16 dead eggs and eggshells was discovered, making a total of 57 eggs laid by the single female in only 18 of the hosts. The results of the dissections are given more in detail in Table II.

This experiment proved conclusively that this parasite is not at all adapted to live at the expense of *Notolophus*. The larvæ, even if they were able to hatch, were killed by the host soon afterward, and at least 6 of the eggs were unable to hatch. Two other eggs were found with the dead larva only partially out of the shell. The larvæ in most cases were entirely destroyed by the host, so that all trace of them was lost, except for the cast eggshell, yet a few resisted total disintegration for a long period. The body tissues of the latter, however, were broken down, so that nothing was left but the integument. The eggshells, or dead eggs with the embryo inside, resisted destruction, on the other hand, to a remarkable degree, and were found practically unharmed for a month or even longer after they were laid, not only in the body cavity of the caterpillar and pupa but even in that of the adult moth, and invariably well incased in a sheath of amœbocytes. The eggshell in the single pupa dissected was found adhering to the ovarian tubules of the host; in the case of the moths, the eggs or shells were found many times just beneath the integument of the abdomen, or among the ovarian tubules. One female moth, which was in perfect condition and in no way inconvenienced, carried 6 of these eggshells.

TABLE II.—*Results of dissections of caterpillars and later stages of Notolophus antiquus parasitized by Limnerium validum.*

Date of dissection.	Stage and sex of host.	Number of eggs laid.	Number of unhatched eggs.	Number of eggshells.	Number of larvæ.	Remarks.
May 17...	Fourth-stage caterpillar.	2	2	.....	.....	Embryos not noticed within eggs.
Do.....	do.....	5	5	.....	.....	Do.
May 30...	Fifth-stage caterpillar.	3	.....	3	.....	No trace of larvæ.
Do.....	do.....	2	.....	2	2	Larvæ much broken down.
June 14...	Sixth-stage caterpillar.	2	.....	2	1	Larva killed before complete eclosion.
Do.....	Male moth.....	1	.....	1	.....	No trace of larva.
June 15...	do.....	1	1	.....	.....	Egg contained dead embryo.
Do.....	Female pupa.....	1	.....	1	.....	Shell among egg tubes of host.
June 17...	Sixth-stage caterpillar.	7	2	5	1	Larva broken down. Host dead.
June 18...	Male moth.....	1	.....	1	.....	No trace of larva.
June 20...	Fifth-stage caterpillar.	8	.....	8	1	Larva killed before complete eclosion. Host dead.
Do.....	do.....	.....	.....	.....	.....	Host dead, not parasitized.
Do.....	do.....	6	.....	6	2	Larvæ broken down; killed soon after eclosion. Host dead.
Do.....	Female moth.....	6	.....	6	.....	No trace of larvæ.
June 30...	do.....	1	1	.....	.....	Egg contained dead embryo.
Do.....	do.....	5	2	3	.....	Two eggs contained dead embryos.
Do.....	Male moth.....	1	.....	1	.....	No trace of larva.
Do.....	Sixth-stage caterpillar.	5	.....	5	1	Larva all destroyed except skin.
	Total.....	57	13	44	8	

LIMNERIUM VALIDUM AS A PARASITE OF PORTHETRIA DISPAR (LINNÆUS).

Two experiments were undertaken to determine whether this species of *Limnerium* can parasitize successfully the caterpillars of the gipsy moth (*Porthetria dispar* Linnaeus). Both were, unfortunately, unsatisfactory in that the caterpillars were subject to disease and soon died in confinement. The second experiment only gave any results at all, and was started June 10, when 1 female *Limnerium* was confined with 20 caterpillars in the third and fourth stages, collected at Melrose Highlands, Mass.

On June 17 the female *Limnerium* was dead, and 19 of the caterpillars had succumbed to disease. These dead caterpillars were carefully dissected, and in 4 of them were found 18 eggs of *Limnerium*, occurring 2, 3, 5, and 8 in number, respectively. The eggs were all unhatched, the embryos undeveloped, and in some of the eggs the contents appeared to be broken down, such eggs being undoubtedly dead. Whether they had died through contact with dead and diseased tissues of the caterpillars or had been killed previously by some reaction of the host is not clear. In experiments with brown-tail moth caterpillars earlier in the season, living eggs and even larvæ were found within dead hosts; but in that case the caterpillars had not died from disease, but were killed by superparasitism.

On the 21st of June, 6 more of the caterpillars had died. They were dissected, and in one 5 eggs of *Limnerium* were found still unhatched. By June 31 the remaining 5 caterpillars had succumbed

to disease, and the experiment was closed without any conclusive evidence being gained, although the inference may be drawn that *Limnerium validum* is not adapted to the gipsy moth.

EXPERIMENTS WITH OTHER HOSTS.

Several experiments were also started with caterpillars of the common tussock moth (*Hemerocampa leucostigma* Smith and Abbot) and of the mourning-cloak butterfly (*Euvanessa antiopa* Linnaeus), but for various reasons they furnish no satisfactory evidence to show whether these hosts can be parasitized successfully by *Limnerium validum*. It is rather unfortunate that the experiment with the *Hemerocampa* did not give any results on account of disease prevalent among the caterpillars, in view of the fact that this species of *Limnerium* has been reared by Dr. L. O. Howard from the tussock moth at Washington, D. C. In Massachusetts, however, it has never been surely reared from this host, although large numbers of the tussock moth have been collected in various parts of the State and carefully studied at the Gipsy Moth Parasite Laboratory. It seems likely, therefore, that the *Limnerium* varies in habits in different parts of the country, or this apparent difference in host relationship



FIG. 33.—*Limnerium validum*: Egg. Enlarged about 120 times. (Original.)



FIG. 34.—*Limnerium validum*: Eclosion of larva. Enlarged about 120 times. (Original.)

may be ascribable merely to changes in its seasonal history brought about by a colder climate.

NOTES ON DEVELOPMENT AND ANATOMY OF THE LARVA.

THE EGG.

The egg (figs. 33, 34) of *Limnerium validum* is elongate kidney-shaped or subcylindrical and rather convex on the dorsal side, slightly concave ventrally, with both poles bluntly rounded. The chorion is heavily chitinized, comparatively thick and resistant, and with a perfectly smooth surface. Its color is pale brown, or sometimes nearly white in the case of freshly deposited eggs, but not always, as fully colored eggs may be found in the oviducts of dissected females. In size the egg is about 0.35 to 0.41 mm. long and 0.13 to 0.14 mm. in transverse diameter.

Adult females freshly issued from cocoons were dissected on several occasions, and fully developed eggs to the number of 15 to 20 were found in the oviducts ready for oviposition. The female of this species therefore may perpetuate its kind almost immediately after its eclosion from the cocoon (fig. 32). It may also be parthenogenetic at times, as eggs that were laid by unfertilized females in the preceding experiments hatched freely. Not enough evidence was gained to state positively whether unfertilized eggs always produce males, but this is probably true.

THE FIRST-STAGE LARVA.

DESCRIPTION OF THE NEWLY HATCHED LARVA.

The first stage of the larva of *Limnerium* is characterized by 13 segments, including the comparatively heavily chitinized head, and a long tapering ventral appendage of the last body segment. In the

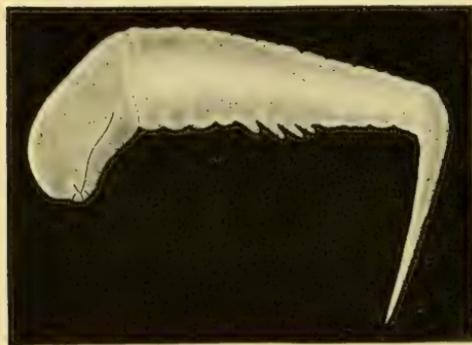


FIG. 35.—*Limnerium validum*: First-stage larva, newly hatched. Enlarged about 120 times. (Original.)

case of newly hatched larvæ (fig. 35) the head is about one-half as long as the body, excluding the tail appendage, and is bent to the axis of the body at an angle of about 45° . Its dorsal margin is strongly curved, especially anteriorly; the ventral margin is much shorter and only slightly curved. The integument of the head is rather heavily chitinized and is slightly pigmented with

brown. It has a slight ridge on each side running backward from the insertion of the mandibles, and separating the gula from the cheeks. The gula seems to be but slightly hollowed out and is as heavily armored as the rest of the head.

The mouthparts (fig. 37) consist of prominent, curved and sharply pointed mandibles, crossing each other at the tips, and projecting somewhat downward into the large mouth cavity. The aperture of the mouth is surrounded by a raised, chitinized, circular rim, about 0.037 mm. in diameter, and with a broad inner margin. The posterior inner margin is a heavily chitinized plate, with two prominent teeth separated by an angular median indentation.

The body in the thoracic region is nearly as broad as the head but rapidly tapers posteriorly. The thin, delicate, transparent integument is thrown into folds on the dorsum and venter, but appar-

ently not on the sides. Each fold on the venter represents a body segment, though some may be more or less double; the folds on the dorsum, however, are plainly double, as two occur on each segment. The body is thus found to be 12-segmented, excluding the tail appendage which is plainly a ventral outgrowth of the last segment.

The appendage itself sometimes appears to be distinctly ringed, due undoubtedly to the folding of the integument. It is slender, tapering, and about four-fifths as long as the body. During embryonic development it is bent sharply forward and appressed to the venter; after eclosion it is bent to the axis of the body for a short period at an angle of about 90° , though later in life it extends straight backward. Its color and that of the body is transparent whitish.

The total length of the newly hatched larva is about 0.64 mm.; without tail, only 0.41 mm.; the width of the head is 0.11 mm. and that of the thorax 0.10 mm.

FUNCTION OF THE TAIL APPENDAGE.

In case of larvæ observed immediately after hatching, the tracheal system could be made out easily, and was filled with air without doubt, though necessarily of the closed or pneumatic type. Only one fine tracheal branch could be distinguished in the tail, and it was clearly not important enough to indicate that the tail is a tracheal gill. The function of the tail, however, is probably respiratory, and the organ might properly be termed a blood gill. There is nothing in its structure to contradict this view, as it is a simple, hollow tube lined with hypodermal cells, and undoubtedly filled with blood a greater part of the time. Since the larva lies free in the body cavity of the host it is constantly bathed in blood and lymph fluids, from which the oxygen of its own blood must be derived through the delicate integument of the tail, or other parts of the body, especially while still small.

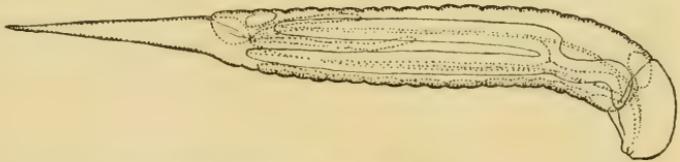


FIG. 36.—*Limnerium validum*: First-stage larva of large size, showing silk glands and nervous system. Enlarged 50 times. (Original.)

APPEARANCE OF OLDER LARVÆ.

The larva makes its escape from the egg by bursting open the chorion irregularly at the anterior pole (fig. 34), possibly with the aid of the mandibles. After hatching it develops rapidly if located in a suitable host, and molts for the first time in probably about 7 to 10

days. Before molting it attains a length of nearly if not quite 2 mm., for some larvæ were found, evidently nearly full-sized, about 1.7 mm. long. It now differs considerably in appearance from newly hatched larvæ, as a comparison of figures 35 and 36 will indicate. The head, being heavily chitinized, has remained the same size, but the body has grown until it is about five times as long as the head instead of only twice as long, as at first. The tail has also increased in size, but not proportionately to the growth of the body. Because of this rapid growth the folds of the integument so noticeable in newly hatched larvæ have largely disappeared, but are still discernible as slight creases, and afford the only means whereby the segments of the body may be distinguished.

NOTES ON THE ANATOMY OF THE LARVA.

The development of the viscera as made out in stained and mounted specimens is not without interest. Toward the end of the first instar the sericteries become the most conspicuous organs in the body, thus forecasting the prime importance of the cocoon-spinning habit as a protection during the pupal period. There is a pair of these silk glands which seem to start blindly in the first body segment and extend backward after branching once to the eleventh or twelfth segment. In reality, however, they are connected anteriorly with a minute tube which runs forward to the mouth. The glands themselves are also tubular and composed of comparatively enormous cells, with large oval nuclei.



FIG. 37.—*Linnæum calidum*: Mouth-parts of first-stage larva. Enlarged about 250 times. (Original.)

The proctodæum is also conspicuous and extends forward only to the anterior end of the twelfth body segment. It is a thick-walled, ovoid organ, and although contiguous with the posterior end of the mesenteron, it does not communicate therewith. At the anterior end it gives rise to four large Malpighian tubules which extend forward into the ninth or even the eighth segment. The anus appears as a distinct opening at the end of the twelfth segment on the dorsal side, thus proving that the tail is a ventral outgrowth of the last segment. As the anus is distinctly open, there is no reason why the secretions of the Malpighian tubules may not be passed off into the blood of the host.

The brain toward the end of the first instar is crowded partly out of the head and becomes a conspicuous organ of the first body segment. The same phenomenon takes place in regard to the infræ-sophageal ganglion. Twelve ventral ganglia may be distinguished, of which the first 5 are closely united to each other and to the infræ-sophageal ganglion, the following 5 being separated by commissures, but the last 2 are also conjoined.

THE SECOND-STAGE LARVA.

The larva after the first molt differs conspicuously from the first-stage larva in respect to the soft, unarmored head, and the much shorter tail appendage (fig. 38). The mouth and its parts are also considerably changed.

The head is still large and prominent and has much the same general shape as in the first stage, although considerably shorter. Its



FIG. 38.—*Limnerium validum*: Second-stage larva. Enlarged about 30 times. (Original.)

integument is soft and pliable like that of the body. The mouth-parts (fig. 39) consist of a slightly bilobed, simple labium, and two strong, curved mandibles, which project downward into the large funnel-shaped mouth cavity. The body is distinctly cylindrical and tapers but little behind. Twelve segments in the body may be easily distinguished, the last one of which is prolonged ventrally into a short, conical tail appendage.

Only a few larvæ in this stage were found, and they were all about 2.2 mm. long. The duration of this stage is probably short, perhaps not more than from 5 to 7 days.

THE THIRD-STAGE LARVA.

DESCRIPTION OF THE FULL-GROWN LARVA.

When the larva has obtained its full size and leaves the host it is from 9 to 10 mm. long, and pinkish white in color. It is like the usual hymenopterous type of larva (fig. 40), and the body is rather deeply twelve-segmented. The head is comparatively small and inconspicuous, and the tail appendage, so characteristic of the first stage and still persistent in the second stage, is now entirely lacking.

The mouth parts (fig. 41) are decidedly different from those in the preceding stages. They consist of strong mandibles, supported by two short, longitudinal, heavily chitinized ridges, and two long, transverse ridges that extend nearly to the lateral margins of the



FIG. 39.—*Limnerium validum*: Mouthparts of second-stage larva. Enlarged about 100 times. (Original.)

head. Below the mandibles is a more or less circular labium with heavily chitinized margins, supported by two short transverse ridges. The mouth opening is small and hardly distinguishable, but probably lies directly beneath the tips of the mandibles, toward which



FIG. 40.—*Limnerium validum*: Third-stage larva. Enlarged about 8 times. (Original.)

point there is a gentle declivity. Just in front of the deeply concave, anterior end of the labium, in fact at the bottom of this concavity, is located the external opening of the sericteries. Above the mandibles are two large, circular, slightly pigmented spots, which undoubtedly mark the place where the compound eyes of the adult are beginning to develop.

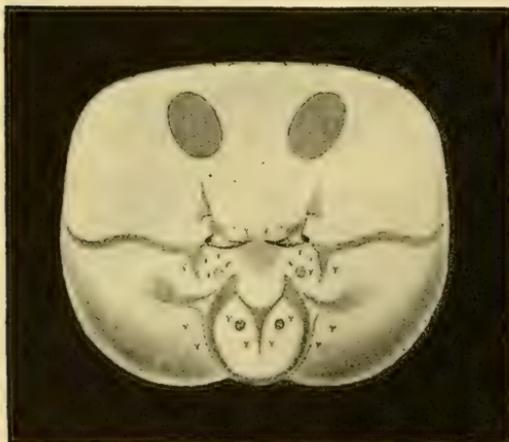


FIG. 41.—*Limnerium validum*: Anterior view of head of third-stage larva, showing mouthparts. Enlarged about 60 times. (Original.)

FEEDING HABITS OF THE IMPRISONED LARVA.

With a clear understanding of the mouth structures in the three stages, we may briefly consider the feeding habits of the imprisoned larva. The old accepted theory up to the time of Ratzeburg was that internal parasitic larvæ feed upon the fat-body of the host. Ratzeburg (1844),

however, was forced to replace this theory with one that is probably more nearly correct. He concluded that such larvæ feed upon the lymph and blood of the host rather than upon any of the solid tissues. This view seems especially applicable to the feeding habits of *Apanteles* and related genera, which often leave the host in a living though comatose condition, but as the mandibles are

well developed in all three larval stages in the case of *Limnerium*, we hesitate to apply it in entirety to this species. We do not believe, however, that the larvæ of *Limnerium* while small actively attack and devour any of the solid tissues of the host including the fat-bodies, but rather institute pathological changes whereby these tissues become available for food. The first tissues to be broken down are the fat-bodies, whereas the vital organs, including the digestive tube, resist dissolution until the last. The very apparent, early disappearance of the fat-body in parasitized caterpillars probably accounts for the old theory that the parasite consumes it directly. The parasite certainly does consume the fat-body, but only after it has been broken down. We have often noticed this condition of the fat-body in apparently healthy caterpillars that harbored the early stage of almost any hymenopterous parasite. In such cases the fat-bodies were broken down more or less completely into their component parts, and the blood of the host was filled with the perfectly globular fat cells of varying sizes, and sometimes of a truly enormous size for individual cells. These small, solid particles, we believe, are as readily eaten by the larvæ of *Limnerium*, at least, as the fluid medium in which they float about within the body of the host. The mouthparts in the first and second stages of *Limnerium* are admirably adapted for this purpose, being in fact a sucking apparatus, with strong, pointed mandibles, so placed as to aid in swallowing small, solid particles. In the third stage the mouthparts are still essentially sucking, but as the mouth opening is surrounded by chitinized, supporting or possibly rasping ridges, there is some ground for believing that even solid tissues may now be taken in, even before they have been wholly disintegrated. When the parasite reaches this stage, the host has become somewhat weakened, its fat-body having been almost entirely, and its body fluids greatly, depleted. Unlike the condition produced by some larvæ of tachinids at this stage in their development, the remaining tissues never dissolve into a putrid or semiputrid mass, but at all events remain clear and wholesome. To just what extent the tissues are broken down before being consumed has not been definitely determined, but we believe usually to a semiliquid condition in the case of *Limnerium*. A caterpillar forsaken by a larva of the *Limnerium* was closely examined, and a small amount of tissue was found at the posterior end of its body. This tissue was probably the remains of the muscles of that region, and appeared to be of a mucilaginous consistency.

RESPIRATION OF THE LARVA IN THE THIRD STAGE.

The shortening of the tail appendage in the second stage and its entire disappearance in the third stage must necessitate a gradual change in the respiratory habit of the larva, if, indeed, the tail is a

truly respiratory organ, as we think it must be. This change is perhaps correlated with the more ravenous appetite of the parasite in the last two stages of its larval life, and also with the gradual disappearance of the blood and lymph of the host. With the disappearance of the fluids of the host, the tail as a blood gill must necessarily become useless, as it is fitted for life in a fluid medium only. Nor does it seem possible, for much the same reason, that the larva's whole supply of oxygen is gained by osmosis through the integument of the body itself, for as the larva grows older the integument becomes thicker and tougher, especially in the last stage. The only alternative left is to consider that the oxygen is derived from the comparatively enormous amount of food taken in during this period, and that it is absorbed by the blood of the larva through the walls of its digestive tube. In other words, if the larva stopped feeding it would not only starve but also suffocate. Toward the end of the third stage, however, when the host is nearly or possibly not entirely consumed the stigmata become open, and the larva is able to breathe air directly, as it certainly does after leaving the host to spin its cocoon.

THE COCOON.

The cocoon has been aptly described by Dr. L. O. Howard (1897) in his bulletin on the parasites of the white-marked tussock moth, and we take the liberty of transcribing his words here: "The cocoon is rather long ellipsoidal, averaging 7.5 mm. in length by 2.8 mm. in greatest diameter. It is composed of two distinct coverings, the outer one of weak, close-spun, crinkly, gray, or grayish-brown silk, readily peeling off in a sheet, and the inner one close, tough, parchmentlike, dark brown in color, with golden reflections, of the type common among the Ophioninae."

RESULTS OF THE DISSECTIONS OF HYPHANTRIA DURING THE FALL OF 1910.

During the late summer and the fall of 1910 a large series of collections of the fall webworm (*Hyphantria cunea* Drury) was brought together at the Gipsy Moth Parasite Laboratory, and an extensive study made of its parasites by means of dissection and rearing work. Most of the work was conducted by Mr. J. D. Tothill, who kindly turned over to the writer, together with his notes, the series of larvæ of *Limnerium* that were found during the course of the dissections. Inasmuch as another species of *Limnerium* is found attacking the fall webworm in Massachusetts rather abundantly, the collection of larvæ may have included *L. pilosulum* as well as *validum*, but the most careful scrutiny of the larvæ, all of which were mounted in balsam and in the first stage, failed to reveal any characters to sepa-

rate the series into the two species, so that some doubt remains whether *L. pilosulum* was actually represented.

The two most important lots of the larvæ were obtained respectively on August 18, from third-stage hosts collected the day previously at Reading Highlands, Mass., and on September 6 to 9, from mostly sixth-stage hosts collected near the laboratory at Melrose Highlands. The former lot may have been *L. pilosulum*, as this species spins its cocoon inside of the skin of small hosts and issues therefrom throughout the month of September. The latter lot of larvæ seems to have been *L. validum* without any doubt, as they were in the first stage when *L. pilosulum* was already beginning to issue as imagos, and inasmuch as they were found in rather large sixth-stage hosts. It seems reasonable to conclude, therefore, that the first-stage larvæ of these two species are practically identical in structure and appearance.

The disposition of the larvæ in their natural host is not without interest. According to Mr. Tothill's notes, they were found free in the body cavity, between the walls of the body and the alimentary canal, either inferior or superior to the latter. No indication of amœbocytosis was encountered during the course of the dissections.

GENERAL SUMMARY.

Limnerium validum (Cresson), a common parasite of the fall web-worm (*Hyphantria cunea* Drury), readily attacks the caterpillars of the brown-tail moth, gipsy moth, and rusty vaporers moths, and also the tent caterpillar, when placed in confinement with these hosts, but is able to complete its transformations in the last species only and even then in but a small percentage of cases. Its larvæ seem to be totally unadapted for life in the caterpillars of the three former species, and fail to survive the protective reactions of the host, which are visibly manifested by an accumulation of active blood cells or amœbocytes around the larvæ, the cast eggshells, and even the eggs themselves. The amœbocytes presumably attack the living eggs and larvæ, or at least ultimately efface the latter entirely. The same reaction takes place in the case of the tent caterpillar, but a few of the larvæ are able to complete their transformations. Adaptation here is partially in evidence, and may be due to larval secretions which ward off the protective reactions of the host.

The egg of *Limnerium* has a thick, chitinized chorion, which resists decomposition in the body fluids of the host to a remarkable degree. The first-stage larva is characterized by a long, tapering tail appendage, evidently adapted for a respiratory function and acting as a blood gill. The second-stage larva has a much shorter appendage, and the third-stage larva has none, so that respiration very likely occurs through the walls of the digestive tube, oxygen

being absorbed from the constantly ingested supply of fresh tissues of the host.

The larva while still small assumes a more or less definite position in the body cavity of the host, and generally lies toward the posterior half of the body, either above or below the digestive tract and with its head directed caudad in respect to the host. During its whole life the larva feeds on blood and lymph and on small solid particles which result from the disintegration of the host's tissues, probably pathologically induced by some larval secretion. There is no evidence to show that such definite organs of the host as the digestive tube and muscular tissue can be consumed by the larva unless they are broken down, inasmuch as the mouthparts of the larva throughout life are essentially sucking.

Under artificial conditions the minimum time needed for the development of the insect from the egg to the adult was found to be about 50 days, but the maximum time may be extended many months. Under natural conditions in the Northern States as a parasite of *Hyphantria*, the females are probably active in parasitizing the caterpillars throughout the month of August and the first part of September. The larvæ issue from the caterpillars and spin their cocoons during September and the first part of October, but the cocoons always overwinter, and the adults emerge the following summer.

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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

TECHNICAL PAPERS ON MISCELLANEOUS
FOREST INSECTS.

CONTENTS AND INDEX.

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BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

TECHNICAL PAPERS ON MISCELLANEOUS
FOREST INSECTS.

I. CONTRIBUTIONS TOWARD A MONOGRAPH OF THE BARK-WEEVILS
OF THE GENUS *PISSODES*.

By A. D. HOPKINS, *In Charge of Forest Insect Investigations.*

II. THE GENOTYPES OF THE SAWFLIES AND WOODWASPS, OR
THE SUPERFAMILY TENTHREDINOIDEA.

By S. A. ROHWER, *Specialist in Forest Hymenoptera.*

III. A REVISION OF THE POWDER-POST BEETLES OF THE FAMILY LYCTIDÆ
OF THE UNITED STATES AND EUROPE.

By E. J. KRAUS, *Expert Preparator, Forest Insect Investigations.*

APPENDIX. NOTES ON HABITS AND DISTRIBUTION
WITH LIST OF DESCRIBED SPECIES.

By A. D. HOPKINS, *In Charge of Forest Insect Investigations.*

IV. STUDIES IN THE SAWFLY GENUS *HOPLOCAMPA*.

By S. A. ROHWER, *Specialist in Forest Hymenoptera.*

V. A PRELIMINARY SYNOPSIS OF CERAMBYCOID LARVÆ.

By J. L. WEBB, *Entomological Assistant.*

VI. CHALCIDIDS INJURIOUS TO FOREST-TREE SEEDS.

By S. A. ROHWER, *Specialist in Forest Hymenoptera.*



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PREFACE TO BULLETIN.

It is the purpose of this bulletin to include such miscellaneous technical papers on insects, other than the scolytid beetles, as are either injurious or beneficial and of more or less importance in their relation to American forests. These papers are based largely, if not entirely, on original observations and investigations, supplemented by material in the United States National Museum, and serve as a necessary basis for the nontechnical papers on the same insects. As they are intended to be of service especially to the economic entomologists and to the student of forest entomology, they are, as a rule, presented in a somewhat less formal style than if intended for the systematist only.

A. D. H.

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ERRATA

- Page 7, line 12, for *cembræ* read *cembra*.
Page 34, line 16, for *deodaræ* read *deodara*.
Page 36, line 37, for *Le Conte* read *Randall*.
Page 74, line 29, after *Can. Ent.* insert *vol. 40*.
Page 102, line 29, after *n.* insert *n.*
Page 131, line 23, for *cinerius* read *cinereus*.

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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

TECHNICAL PAPERS ON MISCELLANEOUS
FOREST INSECTS.

I. CONTRIBUTIONS TOWARD A MONOGRAPH
OF THE BARK-WEEVILS OF THE
GENUS *PISSODES*.

BY

A. D. HOPKINS, Ph. D.,

In Charge of Forest Insect Investigations.

ISSUED JANUARY 7, 1911.



WASHINGTON:
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TECHNICAL SERIES, No. 20, PART I.

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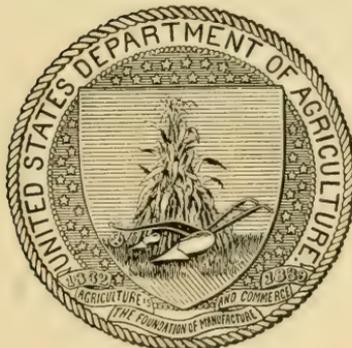
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., July 25, 1910.

SIR: I have the honor to transmit herewith manuscript of the first part of a bulletin of the technical series to be entitled "Technical Papers on Miscellaneous Forest Insects. I. Contributions Toward a Monograph of the Bark-weevils of the Genus *Pissodes*," by Dr. A. D. Hopkins. Although the bark-weevils are among the most important enemies of coniferous forest trees, and especially of the young growth, comparatively little has been known heretofore of the species; hence the special need for this contribution as a basis for economic investigations and publications. It embodies the results of extensive systematic work by Doctor Hopkins on new material contained in the collections of the Bureau of Entomology and the United States National Museum and includes the descriptions of twenty-three species new to science.

I recommend the publication of this manuscript as Technical Series No. 20, Part I, of the Bureau of Entomology.

Respectfully,

L. O. HOWARD,
Entomologist and Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

PREFACE TO BULLETIN.

It is the purpose of this bulletin to include such miscellaneous technical papers on insects, other than the scolytid beetles, as are either injurious or beneficial and of more or less importance in their relation to American forests. These papers are based largely, if not entirely, on original observations and investigations, supplemented by material in the United States National Museum, and serve as a necessary basis for the nontechnical papers on the same insects. As they are intended to be of service especially to the economic entomologist and to the student of forest entomology, they are, as a rule, presented in a somewhat less formal style than if intended for the systematist only.

A. D. H.

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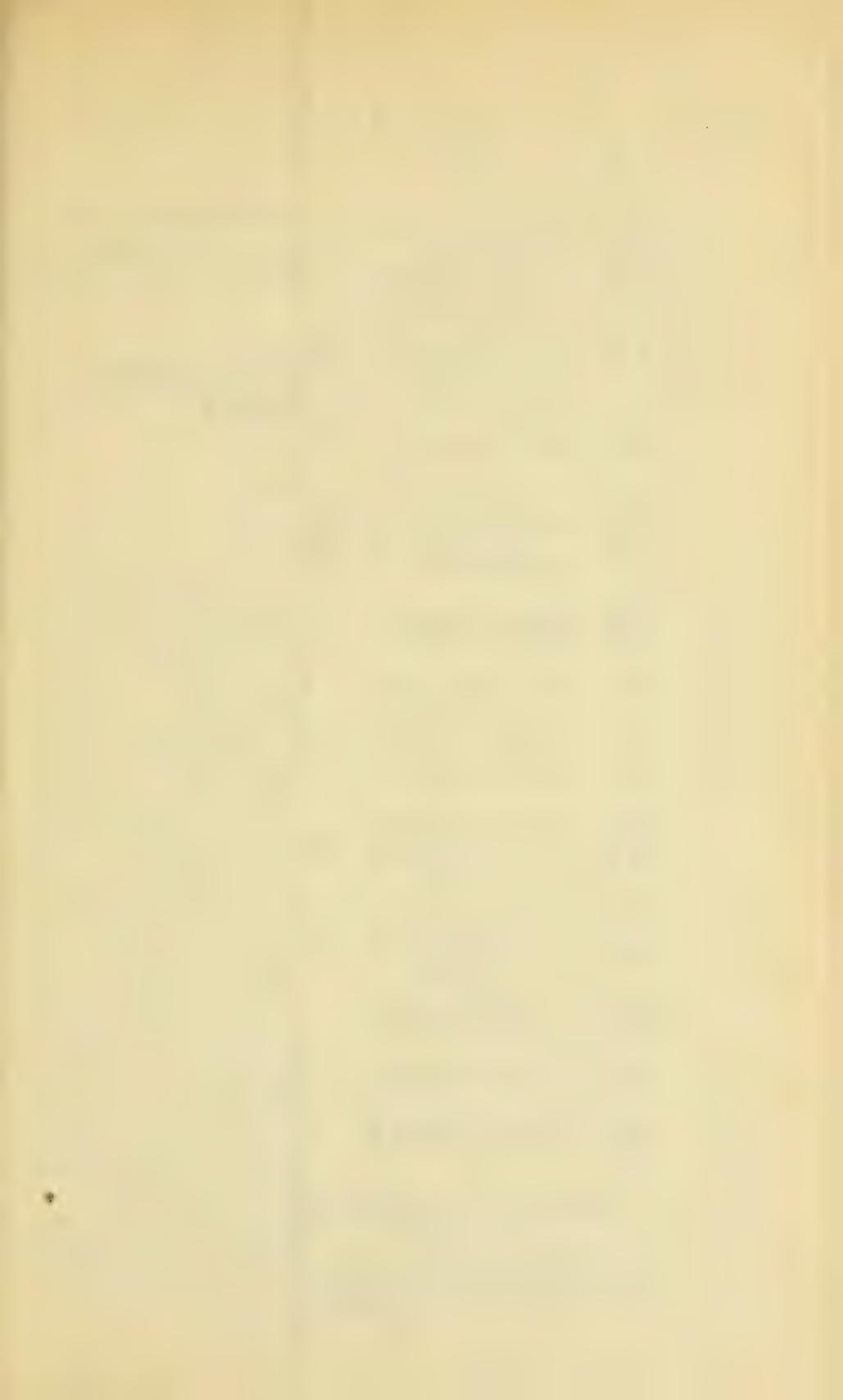


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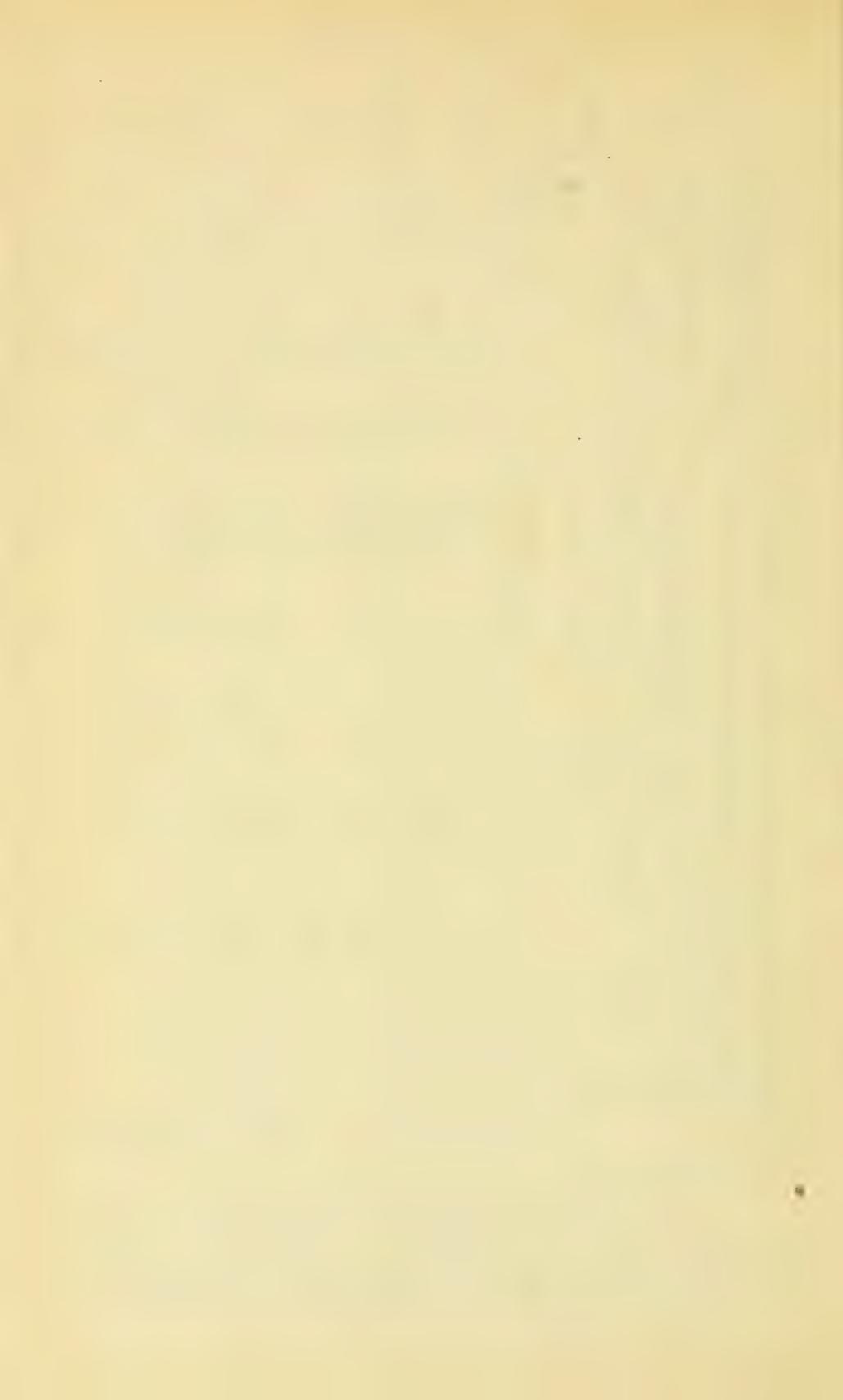
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Classification of the Genus *Pissodes*, Showing Technical and Common Names and Species Numbers. (Original.)

This diagram will enable the reader to refer at once to the technical and common names of any species number mentioned in the text, and will show at a glance the position and relations of the divisions, subdivisions, sections, subsections, series, subseries, minor series, and species into which the genus is divided.



TECHNICAL PAPERS ON MISCELLANEOUS FOREST INSECTS.

I. CONTRIBUTIONS TOWARD A MONOGRAPH OF THE BARK- WEEVILS OF THE GENUS *PISSODES*.

By A. D. HOPKINS,

In Charge of Forest Insect Investigations.

INTRODUCTORY.

The bark-weevils of the genus *Pissodes* represent an important class of enemies of pine, spruce, and fir trees. For this reason, in the future management of federal, state, and private forests there will be a demand for information on the species and on practical methods of preventing or reducing the damage from their attacks. Heretofore comparatively little has been known about the North American species, and consequently there has been much confusion in collections and in published information, due to the possession of insufficient facts relating to the destructive characters and habits of the described species, and especially because of the number of undescribed species which have not been recognized or have been wrongly identified.

It is the object of this contribution to revise the generic and specific descriptions, to describe the species recognized by the author as new to science, and to record some of the results of the more technical features of the investigations. This is part of a manuscript on the genus *Pissodes* which was prepared by the author in 1905, but which, owing to the pressure of other duties, was not completed.

The study of this group of beetles has made it plain to the author that there is urgent need for special work on the rhynchophorous beetles of the world, with a view to determining the more important characters on which to base a satisfactory classification of this important division of the Coleoptera. This is, however, too great a task to be undertaken by any one systematist until the principal genera have been thoroughly studied and monographed by specialists.

For a number of years the writer has given special attention to the family Scolytidae, with a view to monographing it, and in connection

with this work the genus *Pissodes* has been studied in some detail and many other genera of the Rhynchophora and other Coleoptera have received attention in order that a broader knowledge of the order, and of the division to which the Scolytidæ belong, might be acquired, but there has been no idea of specializing on any but the Scolytidæ and possibly a few genera, like *Pissodes*, which are of special interest in connection with forest entomology.

The material which has served as a basis for this bulletin is that collected by the writer between 1890 and 1902, that collected by him and by the assistants in forest insect investigations, Bureau of Entomology, between 1902 and 1907, and that found in the collections of the United States Department of Agriculture and United States National Museum, especially in the Hubbard and Schwarz collection. Studies were made also of good series of specimens of 5 European species sent to the Bureau through the kindness of Dr. R. Heymons and Prof. H. Kolbe, of the Royal Zoological Museum of Berlin, and 3 European species represented in the United States National Museum collection.

The abbreviations adopted in this publication in referring to material in the different collections examined and that identified by the writer are as follows:

D. A.—Division and Bureau of Entomology, United States Department of Agriculture, Washington, D. C., other than *Hopk. U. S.*

Hopk. U. S.—Branch of Forest Insect Investigations, Bureau of Entomology, United States Department of Agriculture, Washington, D. C.

Hopk. W. Va.—West Virginia Agricultural Experiment Station, Morgantown, W. Va.

U. S. N. M.—United States National Museum, Washington, D. C.

H. & S.—H. G. Hubbard and E. A. Schwarz collection in the United States National Museum.

A. M. N. H.—American Museum of Natural History, New York, N. Y.

The author desires to acknowledge in this connection the assistance of Messrs. W. F. Fiske, H. E. Burke, and J. L. Webb in the collecting of material and recording of field observations, to Messrs. C. B. Dyar and E. J. Kraus for assistance in compiling the bibliography, and to Mr. J. F. Strauss for assistance in the preparation of the illustrations.

HISTORICAL REFERENCES.

The name *Pissodes* (pitch-colored) was first proposed by E. F. Germar (1817, p. 340) without description, but to include *Rhynchænus bufo* Fab., *Lixus notatus* Fab., and *Rhynchænus pini* L. Later (Germar, 1824, pp. 316-319) he described the genus, part of which was based on the mouth parts of *Pissodes pini* and *P. notatus*, but among the 10 species described only one, *P. nemorensis*, has been retained. A copy of the original description of the genus and of this species follows:

COPY OF ORIGINAL DESCRIPTION OF THE GENUS.

PISSODES. Genus novum.^a*Character generis.*

[p. 316] Rostrum thoraci subaequale aut longius, teres, scrobe sensim subtus flexa. Antennae pone medium rostri insertae, breves, funiculo septemarticulato, articulis subaequalibus. Oculi distantes, immersi. Thorax subtus integer. Scutellum distinctum. Coleoptera oblonga, abdomen et alas obtegentia. Pedes fortes, sub [p. 317] aequales, tibiis apice unco inflexo armatis, tarsis brevibus, latis, articulo penultimo bilobo.

Pissodis corpus oblongum, obscurum, maculis squamosis variegatum. Rostrum thoraci subaequale aut longius, tenue, arcuatum, teres, apicem versus planiusculum, scrobe lineari, sensim subtus flexa, basi rostri subtus connivente.

Antennae pone medium rostri insertae, breves, fractae, scapo recto, parum clavato, funiculo septemarticulato, articulis lenticularibus, 1. 2. sublongioribus, obconicis, clava ovali.

Caput parvum, rotundatum, oculis rotundis, lateralibus, immersis.

Mandibula valida, cornea, tridentata. Maxilla membranacea, intus biloba: lobo majore ovato, ciliato, denticulato, altero parvo, ensiformi, basali. Palpi quatuor aequales, conici. Glossarium corneum, oblongum, basi angustatum, intergerio parvo, basali, ciliato. Inveni instrumenta cibaria in *P. pini* et *P. notato*.

Thorax transversus, convexus, apice subito angustatus, coarctatus, subtus pone gulam leviter emarginatus, canali pro receptione rostri nullo praeditus.

Scutellum distinctum.

Coleoptera basi thorace parum latiora, oblonga, convexa, postice callosa, apice rotundata, abdomine haud breviora, alas obtegentia.

[p. 318] Pedes fortes, subaequales, antici approximati. Femora clavata, plerumque dentata, tibiae parum compressae, apice intus angulatae, extus unco magno introrsum flexo armatae, tarsi breves lati, articulis 1. 2. trigonis, penultimo latiore bilobo, ultimo clavato, biunguiculato.

Degunt species indigenae in truncis arborum resinorum, captivi hostem tibiarum unco arte complectuntur.

([No.] 456) PISSODES NEMORENSIS: femoribus muticis, piceus, thorace punctato rugoso, punctis duobus albis, elytris fulvo-subfasciatis, macula infra medium alba. Habitat in America boreali. (Kentucky.)

Affinis certe *P. notato*, paullo minor et macula elytrorum alba apici propius. Rostrum thorace longius, punctulatum, piceum. Thorax lateribus parum rotundatus, apice coarctatus, rugoso-punctatus, obsolete carinatus, piceus, punctis duobus disci albo-squamosis. Scutellum albidum-squamosum. Coleoptera thorace paullo latiora, et latitudine sesqui longiora, lateribus recta, apice obtuse rotundata, utrinque impressa; convexa, striato-punctata, interstitiis alternis latioribus, elevatioribus, picea, brunneo parum squamosa, fasciis utrinque duabus obsoletis fulvis, posteriore juxta suturam macula alba terminata. Corpus subtus piceum, [p. 319] griseo-squamosum. Pedes picei, femoribus muticis, ante apicem griseo-annulatis.

[TRANSLATION OF ORIGINAL DESCRIPTION.]

PISSODES. New genus.

Generic characters. Beak not quite as long or longer than the prothorax, cylindrical, scrobe noticeably flexed under. Antennae

^aFrom "Insectorum species novae," by E. F. Germar, vol. 1 (Coleoptera), pp. 316-319, 1824.

inserted behind the middle of the beak, short, funiculus 7-segmented, the segments subequal. Eyes separate, sunken [impressed]. Thorax entire below. Scutellum distinct. The elytra oblong, covering the abdomen and wings. Feet strong, subequal, tibiæ armed at apex with an incurved hook, tarsi short, broad, the penultimate segment bilobed.

The body of *Pissodes* is oblong, obscure, variegated with spot-covered scales. The rostrum not quite equal to or longer than thorax, slender, curved, cylindrical, somewhat flattened toward the apex, scrobe linear, noticeably flexed under, in close approximation to the base of the rostrum below.

Antennæ inserted posterior to the middle of the beak, short, elbowed, scape straight, somewhat clavate, funiculus 7-segmented, the segments lenticular, 1 and 2 somewhat longer, obconical, club oval.

Head small, rounded, eyes round, lateral, sunken [margin impressed].

Mandibles strong, corneous, tridentate. Maxilla membranous, bilobed internally: the larger lobe ovate, ciliate, denticulate, the other small, ensiform, basal. Palpi four, equal, conical. Glossarium [labium] corneous, oblong, narrowed at base, intergerium [ligula] small, basal, ciliate. I have examined the mouth parts in *P. pini* and *P. notatus*.

Thorax transverse, convex, the apex slightly narrowed, coarctate, slightly emarginate below behind the gula, not provided with a canal for the reception of the rostrum.

Scutellum distinct.

Elytra slightly broader than the thorax at base, oblong, convex, posteriorly calloused, rounded at apex, not shorter than the abdomen, covering the wings.

Feet strong, subequal, approximate anteriorly. Femora clavate, frequently dentate,^a tibiæ hardly compressed, angulate interiorly at the apex, exteriorly armed with a large hook flexed inward, tarsi short, broad, segments 1 and 2 triangular, the penultimate broader, bilobed, the last clavate, with two claws.

The indigenous species live in the trunks of resinous trees; they are able to hold on to the host by the curved hook of the tibia.

[No.] 456. *PISSODES NEMORENSIS*: Femora shortened, piceous, thorax rugosely punctate, with two white spots, elytra subfasciate with yellow, a white spot below the middle. Lives in North America. (Kentucky.)

It is certainly similar to *P. notatus*, a little smaller, and the white spot of the elytra near the apex. Beak longer than the thorax, punctulate, piceous. Thorax with the sides somewhat rounded,

^a Relates to *Hylebius* and *Hilipus*.

coarctate at apex, rugosely punctate, obsoletely carinate, piceous, with two disklike spots of white scales. Scutellum with white scales. Elytra slightly broader than thorax and half again longer than wide. Sides straight, obtusely rounded at apex, impressed at either side; convex, striato-punctate, the alternate interspaces broader, more elevated, piceous, lightly clothed with brown scales, each with two obsolescent fulvous bands, posteriorly close to the suture terminated with a white spot. Body piceous below, with gray scales. Feet piceous, the femora shortened, annulated with gray before the apex.

Following are the names of the other species described and the genera and species to which they were later referred.

No. 457. *Pissodes macellus* = *Hylobius pales* Boh., Sch. Curc., II, 340.

No. 458. *Pissodes choicus* = *Hilipus choicus* (Germar).

No. 459. *Pissodes onychinus* = *Hilipus onychinus* (Germar).

No. 460. *Pissodes flammiger* = *Hilipus flammiger* (Germar).

No. 461. *Pissodes picturatus* = *Hilipus picturatus* (Germar).

No. 462. *Pissodes polymitus* = *Hilipus polymitus* (Germar).

No. 463. *Pissodes erythrorhynchus* = *Hilipus erythrorhynchus* (Germar).

No. 464. *Pissodes prodigialis* = *Hilipus prodigialis* (Germar).

No. 465. *Pissodes trachypterus* = *Hilipus trachypterus* (Germar).

Schoenherr (1826, pp. 225-226) was the first to subdivide the genus and to designate *Pissodes pini* (L.) as the type and *P. piceæ* (Ill.), *P. harcyniæ* (Herbst), *P. notatus* (Fab.), *P. piniphilus* (Herbst), and *P. nemorensis* Germ. as cotypes. Therefore, according to the rules of nomenclature (Stiles, 1905, pp. 26-27), *Pissodes pini* (L.) must stand as the type of the genus.

It appears that up to 1909 the genus was represented by 21 authentically recognized species, 7 from North America, 9 from Europe, 3 from eastern Siberia, and 2 from Japan, as follows:

LIST OF SPECIES OF PISSEDES DESCRIBED PREVIOUS TO 1909, WITH RECORDED DISTRIBUTION AND HOST TREES.

Species of Pissodes.	Reference to original description in bibliography.	Distribution.	Host.
NORTH AMERICA.			
<i>affinis</i> Randall.	1838, p. 24.	North America.	<i>Pinus</i> .
<i>costatus</i> Mannerheim.	1852, p. 363.	Sitka.	Pine?
<i>dubius</i> Randall.	1838, p. 24.	North America.	<i>Abies</i> .
<i>fasciatus</i> Le Conte.	1876, p. 143.	Oregon.	
<i>strobi</i> Peck.	1817, p. 205.	Maine to North Carolina.	<i>Pinus strobus</i> .
<i>nemorensis</i> Germar.	1824, p. 318.	Kentucky.	
<i>rotundatus</i> Le Conte.	1876, p. 143.	Lake Superior.	
EUROPE.			
<i>gyllenhalii</i> Gyllenhal, in Schoenherr.	1836, p. 260.	North Germany, Sweden, eastern Siberia.	
<i>harcynix</i> Gyllenhal.	1813, p. 68.	Sweden.	
<i>harcynix</i> Herbst.	1795, Käf., VI, p. 294.	Middle northern Europe.	<i>Picea</i> .
<i>interstitiosus</i> Sahlberg.		Finland.	
<i>quadri-notatus</i> Panzer.	1801?	Germany.	
<i>notatus</i> Fabricius.	1787, p. 103.	Europe—Russia to Greece, Spain, Italy, Madeira, England.	<i>Pinus sylvestris</i> , <i>Pinus strobus</i> , <i>Picea</i> , <i>Larix</i> .
<i>var. castaneus</i> De Geer.	1775, p. 231.	Germany.	
<i>var. brunneus</i> Panzer.	1801?	Germany.	
<i>var. palmaris</i> Herbst.	1795, Käf., VI, p. 169.	Germany.	
<i>fabricii</i> Stephens.	1829, p. 88.	England.	
<i>pini</i> Olivier.	1807, p. 116.	France.	
<i>strobili</i> Redtenbacher.	1874, p. 417?	Germany.	
<i>piceæ</i> Illiger.	1807, p. 309.	Mountains of middle Europe; Caucasus.	<i>Abies pectinata</i> .
<i>fabricii</i> Leach, MSS, in litt.		England.	
<i>notatus</i> Sturm.	1826, Catalogue, p. 184.	Germany.	
<i>pini</i> Panzer.	1801?, 42, 1.	Germany.	
<i>piniophilus</i> Megerle, MSS, in litt.		Hungary.	

- pini Linnæus.....1798, p. 379.....Europe.....*Pinus sylvestris*, *Pinus strobus*,
 Picea, *Larix*.
 a. ferrugineus Rey.....1895.
 abietis Schrank.....1798, p. 480.....Germany.
 piniphilus Herbst.....1797, vii, p. 21.....Northern and middle Europe.....*Pinus*.
 rotundicollis Desbrochers.....1810, p. 191.....Russia.
 scabricollis Miller.....1859, p. 304.....Austria, Hungary, Bohemia.....*Picea*.
 validirostris Gyllenhal, in Schoenherr.....1836, p. 259.....Northern Europe, Germany, Austria.....*Pinus sylvestris* (cones).
 notatus Redtenbacher.....1874, p. 418.....Germany.
- ASIA (SIBERIA).
- cembra* Motschulsky.....1860, p. 158.....Dauria (eastern Siberia) as far as the banks
 of the Amur River.....*Pinus cembra*.
insignatus Boheman.....Schoenherr.....Gen. Curc., vii, p. 133.
 laricus Motschulsky.....1860, p. 159.....Dauria (eastern Siberia).....*Pinus* and *Larix*.
irroratus Reitter.....1899, p. 208.....Kamtschatka (eastern Siberia).
- JAPAN.
- nitidus* Roelofs.....1874, p. 121.....Japan.
obscurus Roelofs.....1874, p. 122.....Japan.

TAXONOMY.

CHARACTERS USED BY DIFFERENT AUTHORS.

Beginning with the second division of the Coleoptera or suborder Rhynchophora of most of the authors, the principal characters compiled from Lacordaire (1863), Le Conte and Horn (1876), Ganglbauer (1903), Kolbe (1903), and Bedel (1886-1888), which led up to the family Curculionidæ may be summarized as follows:

SUBORDINAL AND FAMILY CHARACTERS.

Head prolonged into a beak; maxillary palpi rigid, *4-jointed*, without *palparium* (see "Revisional notes," page 9); labial palpi 3-jointed; labrum absent; gular sutures wanting; prosternum with epimera extending across the base (see "Revisional notes," page 9); testicles globular; abdomen always with 5 (visible) ventral segments (see "Revisional notes," page 9); tibiæ without movable spines; *pygidium divided* (see "Revisional notes," page 9); elytra with strong fold toward inner edge; tarsi dilated, brushlike beneath, third joint bilobed, fourth obscure; mandibles without accessory pieces; antennæ geniculate, clubbed; beak more or less curved.

Continuing through the family Curculionidæ, the principal characters, adopted by one or more of the authors mentioned, which lead up to the subfamilies, tribes, or groups to which the genus *Pissodes* was referred, are as follows:

TRIBAL AND SUBFAMILY CHARACTERS.

Lacordaire (1863, pp. 442-464): Mentum leaving maxilla exposed; submentum forming a peduncle; anterior coxæ usually contiguous; pygidium covered by the elytra; metasternum more or less elongate; metepisternum at least moderately broad; antennal funiculus 7-jointed; beak variable, with antennal grooves; mesepimerum not ascending toward base of elytra; prothorax with anterior ventral margin usually emarginate. Tribe Hylobiides.

Tarsal claws free; elytra with elevations at base; mesepimerum usually large; body oblong, oval. Group Hylobiides.

Le Conte and Horn (1876, pp. 122, 137): Tibiæ with tooth of outer apical angle small; eyes not contiguous beneath; mandibles with 3 teeth; side pieces of metathorax distinct; lateral angles of first ventral segment not visible; mentum transverse; labial palpi large. Tribe Hylobiini.

Stierlin (1883, p. 403): Tibiæ compressed; inner edge bisinuate with apical hook. Subfamily Hylobiini.

Bedel (1888, p. 65): Tibiæ without distinct groove on the inner edge, but with an incurved apical tooth; ventral segments 2 and 4

with straight sutures; anterior coxæ separated, but without groove for beak; tarsal claws small. Tribe *Pissodini*.

Nüsslin (1905, p. 110): Beak with antennal insertion near the middle. Subfamily *Pissodini*.

REVISIONAL NOTES.

GENERIC CHARACTERS.

The anterior ventral margin of the prothorax is not slightly emarginate in any of the species examined by the writer. The reference to a dentate femur was based on the species of *Hylobius* and *Hilipus*. With these exceptions, the original description applies very well to all of the known species.

SUBORDINAL AND FAMILY CHARACTERS.

There has been considerable difference of opinion among systematists as to whether the palpus should be referred to as 4-jointed or 3-jointed.

It is evident to the writer that the lateral segment of the maxilla, which has been mistaken for the basal joint of the palpus, is homologous with the palpifer in other Coleoptera and orders of insects, and it would seem, therefore, that the rigid, 3-jointed palpi should be recognized as one of the important characters to distinguish the true Rhynchophora from the other Coleoptera. It would remove the Anthribidæ and some other groups which, on account of the absence of gular sutures, have been placed with the Rhynchophora, but the writer is inclined to agree with some recent authors that these really do not belong in the Rhynchophora. In representatives of the Curculionidæ, Scolytidæ, and several other families examined by the writer, the maxillary palpus is distinctly 3-jointed. In some, as in *Pissodes*, the palpifer closely resembles a basal joint of the palpus, but it joins the stipes and the apex does not extend beyond the base of the galea. Therefore it can not belong to the palpus, but is the part of the body of the maxilla to which the palpus is attached, designated as the palpifer.

ABDOMINAL SEGMENTS.

The abdominal tergites 7 and 8 have been referred to by various authors as the pygidium, propygidium, divided pygidium, etc. Indeed, the terms "pygidium" and "propygidium" have been extensively used in systematic entomology, and there is a very general lack of uniformity in their application to the apical or sub-apical tergite without regard to their numerical relation. There seems to be serious objection to this general application of these terms in classification, from the fact that in comparative anatomy

they have no meaning. Therefore in the use of the terms "pygidium" or "propygidium" it is important that the numerical position of the tergite should be mentioned.

In the Curculionidæ, for instance, tergite 7 of the female occupies the pygal position, while tergite 7 of the male occupies the propygal position, and tergite 8 the pygal. In the Curculionidæ, Scolytidæ, and many other Coleoptera abdominal tergite 7 is by far the most important of the series, owing to the fact that it presents important characters of structure, sculpture, stridulating accessories, sex, etc. (see Plate VI).

There is also some confusion with reference to the abdominal sternites, or ventral segments. The 5 segments often referred to as the first to fifth are the sternites of the third to seventh abdominal segments, the first and second being obscured by the coxal cavity (Hopkins, 1909, fig. 38). Therefore they should be referred to either in their proper numerical order or as the 5 visible abdominal sternites.

REVISED CLASSIFICATION.

It appears to the writer that it would contribute to a more convenient and natural arrangement if we would give the Curculionidæ of most authors the rank of superfamily, and thus promote the old subfamilies and tribes to families and subfamilies. Thus the genus *Pissodes* would fall in the superfamily Curculionoidea, family Curculionidæ, and subfamily Pissodinae.

The subfamily Pissodinae would come next to the group of genera comprising the subfamily Hylobiinae. The two subfamilies are characterized as follows:

SUBFAMILY HYLOBIINÆ.

Anterior coxæ contiguous; prothorax with anterior ventral margin emarginate and produced toward the sides; beak stout, with antennal insertion in front of middle or toward the tip; eyes oval; tibiæ without tooth on inner apical angle. The North American genera of this subfamily are distinguished as follows:

- | | |
|---|-----------------------|
| I. Metasternum very short..... | <i>Paraplinthus</i> . |
| II. Metasternum long. | |
| A. Tibiæ with outer apical angle dilated..... | <i>Pachylobius</i> . |
| B. Tibiæ with outer apical angle not dilated. | |
| a1. Tibiæ commonly narrowed toward tip..... | <i>Hilipus</i> . |
| a2. Tibiæ not narrowed toward tip. | |
| b1. Femora not toothed..... | <i>Hypomolyx</i> . |
| | <i>Eudocimus</i> . |
| b2. Femora toothed..... | <i>Hylobius</i> . |

SUBFAMILY PISSODINÆ.

Anterior coxæ slightly separated; prothorax with anterior ventral margin not emarginate or produced toward sides; beak usually slender, with antennal insertion at or toward middle; eyes rounded; tibiæ with tooth on inner apical angle.

Metasternum long, femora not toothed..... *Pissodes*.

SUBORDINAL TO SUBFAMILY CHARACTERS.

Head behind the eyes without gular space; maxillary and labial palpi rigid, 3-jointed; labrum wanting or obscure.

Suborder Rhynchophora.

Beak or rostrum prominent; elytra with lateral fold or groove; abdomen of sexes with different number of tergites (8 in the males, 7 in the females); tarsi with fourth joint obscure, third bilobed, ventral surface of first to third densely clothed with fine velvety hairs, fifth joint with simple claws Superfamily Curculionoidea.

Gular peduncle (submentum) usually long; antennæ 11-jointed, geniculate..... Family Curculionidæ.

Prothorax with anterior ventral margin not distinctly emarginate; tibiæ with incurved apical tooth; femora unarmed; anterior coxæ not widely separated; abdominal tergites covered by the elytra; sternites 3 and 4 (1st and 2nd visible) very long, 5 and 6 short, 7 as long as 5 and 6 together; eyes rounded, widely separated.

Subfamily Pissodinæ.

GENERIC CHARACTERS.

Length, ranging from 3.7 to 10 mm.; body oblong, reddish brown to black, sparsely to thickly clothed with slender to broad scales, the latter often forming spots on the pronotum, elytra, and femora.

Pronotum variable; broader than long, rarely as long as broad, narrowed in front of middle and usually constricted toward head; posterior angles rounded, rectangular or acute; punctures of dorsal surface with intervening flat or elevated contiguous spaces which sometimes obscure the punctures.

Elytra variable, more than as long again, with the base as broad or slightly broader than the pronotum, the sides parallel or slightly narrowed posteriorly, and slightly constricted on each side of the declivity; interspaces convex to flat, the alternating ones often broader and more elevated; punctures of striæ regular or irregular in size. Declivity oblique, the third and ninth interspaces joined around a distinct impression at the apex of the fourth, seventh, and eighth interspaces; fifth strongly elevated at the vertex. Apex of each elytron rounded or subacute; striæ distinctly punctured.

Head (figs. 1, 2) behind the eyes globular, about one-half maximum width of prothorax, smooth, punctured, slightly impressed between the eyes and with a few scales on the front toward the margins of the eyes.

Beak slender, cylindrical, punctured, as long as prothorax or longer, with sides parallel or slightly narrowed toward middle, or slightly broader toward base of mandibles. Antennal insertion at or toward middle and the antennal groove beginning just in front of insertion and extending almost parallel with ventral margin to near eyes.

Antennæ (fig. 1).—Scape shorter than funicle, which is 7-jointed; first joint about as long as second and third together; second to seventh of about equal length, but slightly increasing in width toward club; first joint of club large, much longer on one side, and sparsely clothed with short hairs and long bristles; other joints of club slightly more flattened on one side, more densely clothed with fine hairs, and the sutures as shown in figures 1 and 2.

ANATOMICAL DETAILS OF THE ADULT.^a

THE HEAD.

The generic characters and anatomical details of the external skeleton and appendages of the head are shown in figures 1 and 2. When compared with the head of a scolytid beetle (figs. 3, 4), it is plain that the subordinal characters are common to both, but further than this there are certain features which at once refer them not only to different families but, in the writer's opinion, to different divisions of at least superfamily rank.

Mouth parts.—The *labrum* and *clypeus* are not represented, and the *epistoma* is only represented externally by a smoother area faintly defined by an obscure line and lateral bristles. As usual, the lateral angles, or area, support the dorsal articulation of the mandibles. The *hypostoma* also is obscurely defined externally, but is represented by the thickened declivous anterior margin of the ventral wall of the beak, by the sides of the submentum, and by a somewhat irregular apodeme, the anterior angles of which support the ventral articulation of the mandibles, the middle supporting the maxillary cardo, the inner anterior angle produced along the lateral area of the submentum, and the posterior angle ending just beneath the large hypostomal puncture. Thus the hypostomal area is that part of the ventral wall of the rostrum which lies anterior to the indistinct limit of the *pregula*. The *pleurostoma* is represented by the convex area surrounding the large mandibular scrobe. The solid *submentum*, or "gular peduncle" of authors, is evidently homologous with the bifid

^a For anatomical nomenclature, see Technical Series 17, Part I, Bureau of Entomology, U. S. Dept. of Agriculture, 1909.

submentum in *Dendroctonus*. Its apex is truncate or rounded, and supports the *labium*, the *mentum* of which is about as long as the

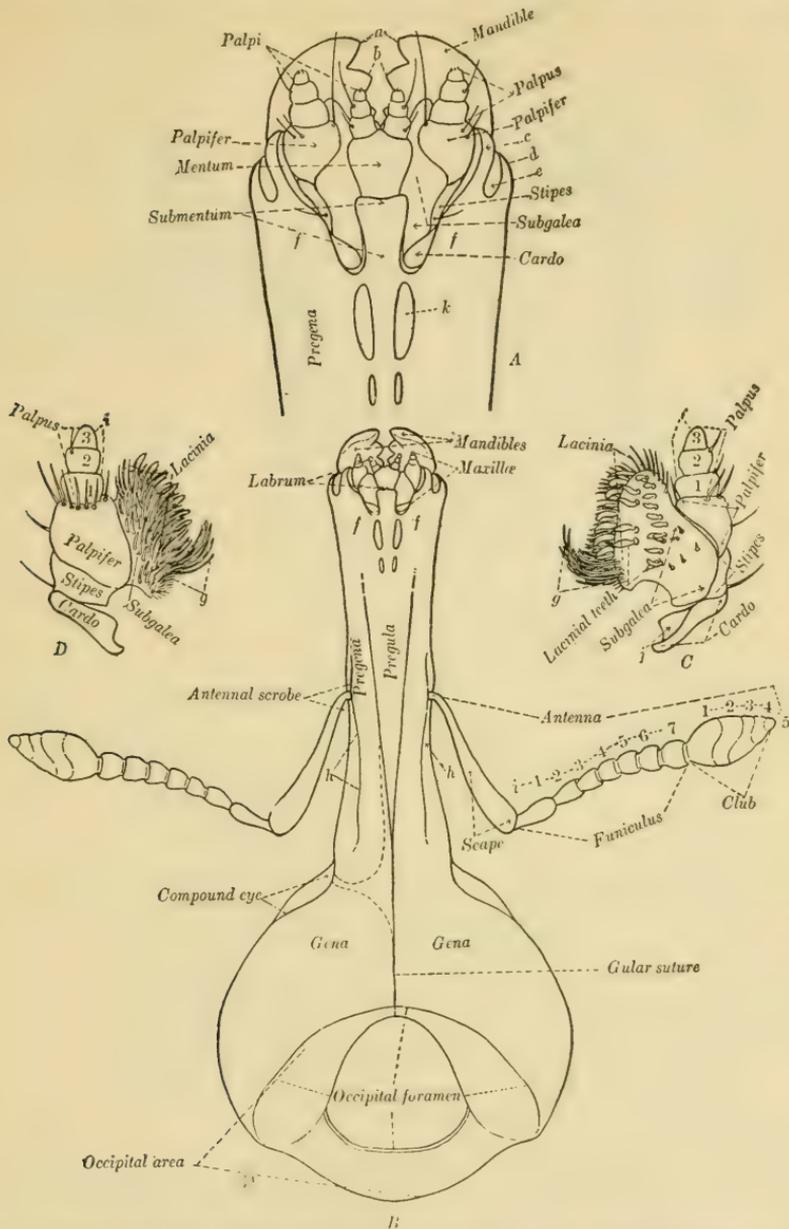


FIG. 1.—*Pissodes strobi*: Head, ventral aspect, and mouth parts. *A*, Ventral aspect of apical region of beak; *B*, ventral aspect of head; *C*, interno-lateral aspect of maxilla; *D*, externo-lateral aspect of maxilla; *a*, apical tooth; *b*, subapical tooth; *c*, lateral arm of hypostoma; *d*, pleurostoma; *e*, mandibular scrobe; *f*, hypostomal area; *g*, lacinial bristles; *h*, antennal groove; *i*, joints; *j*, fossa of cardo; *k*, hypostomal puncture. (Author's illustration.)

submentum and a little broader. The *labial palpifer* is not defined, but is represented by the anterior third of the *mentum*. The *labial*

palpi are stout, conical, and 3-jointed, and not so long as the mentum, the first and second joints of about equal length and the third short.

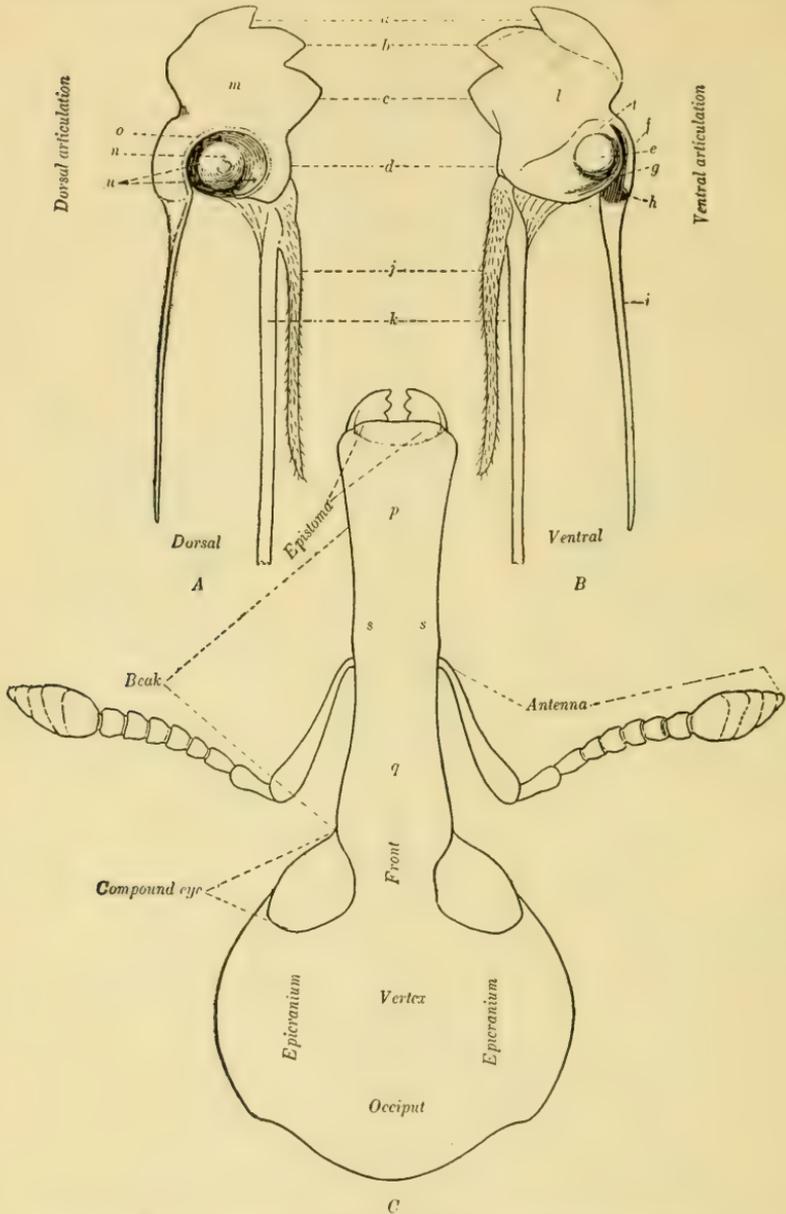


FIG. 2.—*Pissodes strobi*: Head, dorsal aspect, and mandibles. *A*, Dorsal aspect of left mandible; *B*, ventral aspect of left mandible; *C*, dorsal aspect of head; *a*, apical tooth; *b*, subapical tooth; *c*, median tooth; *d*, molar; *e*, median condyle; *f*, lateral muscle process; *g*, lateral condyle; *h*, lateral fossa; *i*, extensor tendon; *j*, pharyngeal bracon; *k*, retractor tendon; *l*, ventral area; *m*, dorsal area; *n*, median condyle; *o*, anterior fossa; *p*, anterior section of beak; *q*, posterior section of beak; *s*, dorsal area; *t*, anterior condyle; *u*, lateral fossa. (Author's illustration.)

The *ligula* is narrow and clothed with long bristles rising from the inner anterior margin of the mentum.

The form and relative proportions of the *maxillæ* are shown in figure 1, *C, D*, and in place in *A*. The *cardo* is short and stout, and articulates with the hypostomal apodeme. The *extensor*, *flexor*, and other *muscles* of the *cardo*, *maxilla*, and *labium* are attached to the

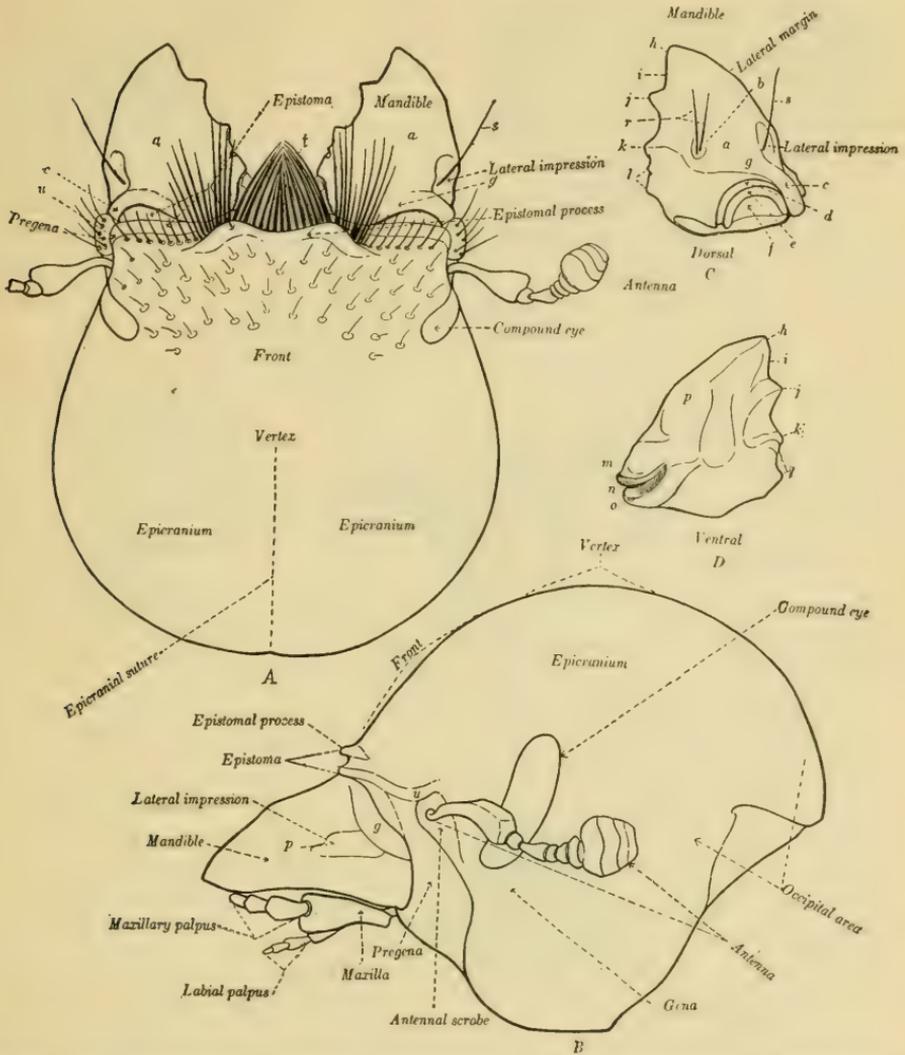


FIG. 3.—*Dendroctonus valens*: Head, dorsal and lateral aspects. *A*, Dorsal aspect of head; *B*, lateral aspect of head; *C*, dorsal aspect of right mandible; *D*, ventral aspect of right mandible; *a*, dorsal area; *b*, dorsal impression; *c*, anterior condyle; *d*, median fossa; *e*, median condyle; *f*, posterior fossa; *g*, basal ridge; *h*, apical tooth; *i*, acute margin; *j*, subapical tooth; *k*, median tooth; *l*, molar; *m*, anterior condyle; *n*, median fossa; *o*, posterior condyle; *p*, lateral area; *r*, dorsal bristles of mandible; *s*, lateral bristles of mandible; *t*, epistomal bristles; *u*, lateral angle of epistoma. (Author's illustration.)

inner ventral wall of the beak in a median triangular space between the hypostomal punctures and converging to a point near the anterior limit of the pregula. The *stipes* is clearly defined as a subbasal piece articulating with the *cardo* and joined to the palpifer and subgalea

by distinct sutures, and in this respect is very different from that in *Dendroctonus*, in which it is fused with the palpifer and subgalea. The *maxillary palpifer* is large and stout and from an interno-lateral

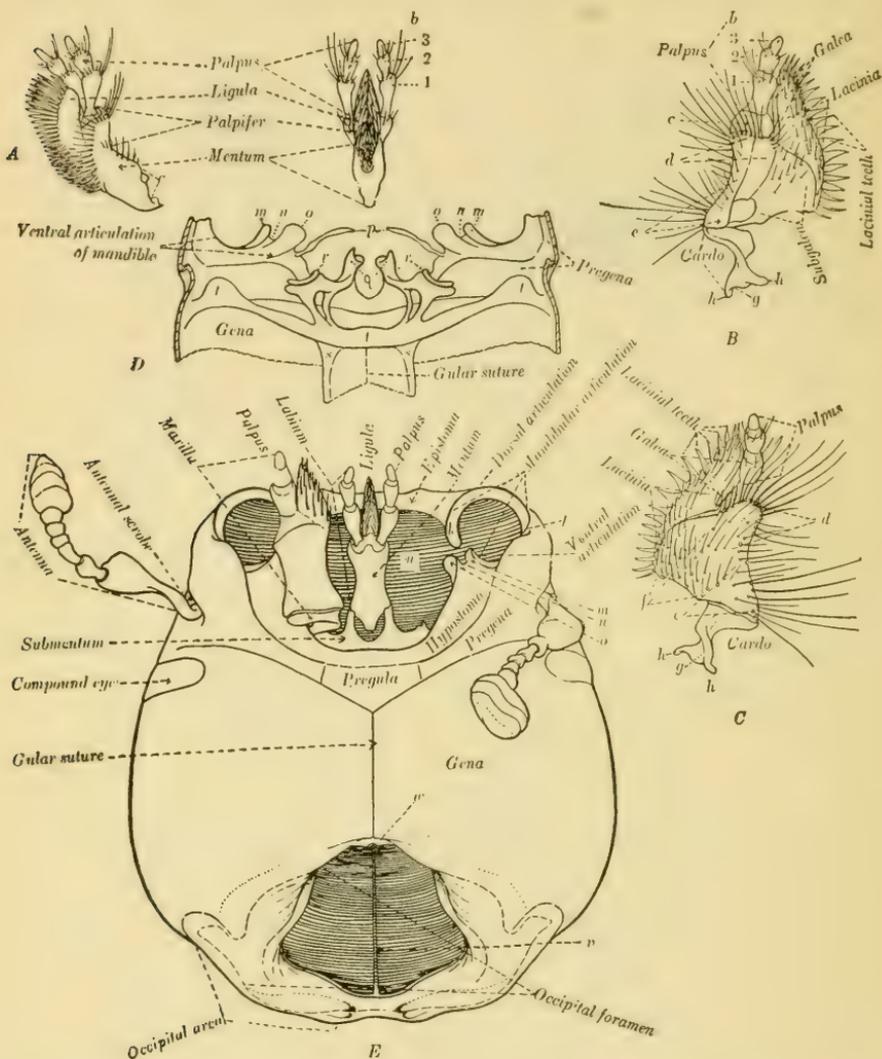


FIG. 4.—*Dendroctonus valens*: Head, ventral aspect, and mouth parts. *A*, Labium; *B*, maxilla, interno-lateral aspect; *C*, same, extero-lateral aspect; *D*, hypostomal region, dorsal aspect; *E*, head, ventral aspect; *a*, basal fossa of mentum; *b*, joints; *c*, basal membrane; *d*, palpiferal area; *e*, stipal area; *f*, subgaleal area; *g*, fossa; *h*, muscle processes; *k*, median condyle; *l*, lateral fossa; *m*, anterior condyle; *n*, median fossa; *o*, posterior condyle; *p*, hypopharyngeal bracon; *q*, submental process; *r*, maxillary condyle; *s*, gular apodeme; *u*, oral foramen; *v*, occipital apodeme; *w*, postgular piece. (Author's illustration.)

aspect is longer than the stipes and cardo together and much longer than the palpus. It is separated from the subgalea and stipes by distinct sutures, and resembles a very large first joint of the palpus.

The *subgalea*, *galea*, and *lacinia* are represented by one broad lobe without even the indication of sutures separating the lacinia from the subgalea as in *Dendroctonus*. The interno-lateral face and internal margin of the lobe are armed with stout lacinial teeth, while the externo-lateral face is clothed with bristles and hairs, those of the posterior angle being very long and curved. The palpus is stout, conical, 3-jointed, shorter than the palpifer, joints 1 and 2 of about equal length and 3 shorter.

The character of the *mandibles* is shown in figure 2, *A* and *B*. They are stout, subrectangular, and without a scar on the "outer surface." The inner edge has 3 prominent teeth; the apical, subapical, and median teeth are stout, triangular, and about equal in size, the molar not represented. The outer lateral area is deeply impressed at the base of the lateral muscle process, which is long and broad. The ventral articulation has a simple median "ball" condyle, while the dorsal articulation has a median "ball" condyle surrounded by a deep fossa. The *extensor* and *retractor muscles* are attached to the inner wall of the cranium, and are connected to the mandibles by long, very slender, subchitinous tendons (fig. 2, *i,k*). The *pharyngeal bracon* is also long and slender, and apparently subchitinous, thus serving as a rigid support or brace to the lateral wall of the *pharynx*.

The characters of the *antennæ* are shown in figures 1 and 2. The *scape* is slightly shorter than the *funiculus*, and the *club* is about half as long as either one. The funiculus is 7-jointed; joint 1 is about as long as joints 2 and 3 together; joints 2 to 7 are of about equal length and increase slightly in width toward the club. The club is subcylindrical, ovate, acuminate, with apex subacute and with 5 obscurely defined joints. Joint 1 is much longer on one side than on the other and sparsely clothed with short hairs and long bristles; the remaining 4 are about equal in length, slightly more impressed on the anterior face, and densely clothed with fine hairs which obscure the sutures; the sutures, according to the point of view, may be oblique, transverse, recurved, or procurved.

The *pregula* is clearly defined in the ventral area of the rostrum. The sutures diverge anteriorly from their junction with the median gular suture near the base of the rostrum. The *pregena* is represented by the longitudinal area between the pregular suture and the antennal groove.

THE THORAX.

The thorax, as is usual, consists of 3 distinct segments (fig. 9, p. 28). The prothorax articulates freely with the mesothorax, but the mesothorax and metathorax are firmly connected. The combined length of the sternal areas of the three thoracic segments is slightly greater than that of the sternal area of the abdomen, while the com-

bined length of the dorsal or tergal areas of the thoracic segments is also slightly greater than the tergal area of the abdomen. The pronotum is slightly longer than the mesotergum and metatergum together. The prosternal area is much longer than the mesosternal and about equal to that of the metasternal area. The metapleura show the same relative proportions as the sterna, and together are much longer than the abdominal pleura. The anterior dorsal margin of the pronotum is not greatly extended beyond that of the sternum, as it is in *Dendroctonus*; the posterior margin of the metatergum is but slightly extended anteriorly beyond the posterior ventral margin of the same segment, but it is much in advance of the posterior margin of the metapleura. (For a discussion of the divisions of the thoracic segments of insects and of the nomenclature, see Hopkins, 1909, pp. 23-35.)

THE PROTHORAX.

As is usual in the rhynchophorous beetles, the tergal, pleural, and sternal areas are fused into a continuous band. In addition to the preceding description of the *pronotum* there is usually a median elevated line extending from the anterior impression to the posterior margin, and each side of this line toward the middle there are two distinct impressions filled with whitish or yellowish scales, thus forming distinct subdorsal spots. There is also a broad, posterior, dorsal impression near the posterior margin. The lateral areas are usually marked with spots of scales, which are more or less distinct and variable in size and form. The anterior margin is usually evenly curved, but is sometimes slightly emarginate. The anterior ventral margin is never emarginate or distinctly produced toward the sides. The posterior dorsal margin is slightly bisinuate, and the posterior and lateral declivities of the notum are vertical. The posterior ventral margin is elevated and uniformly curved. The *episternal* and *epimeral* areas are not indicated by surface sculpture, but the *pre-episternal* area is plainly indicated by a transverse elevation anterior to a distinct transverse pleural groove. This groove also extends across the *sternal* area and thus defines the *presternal* area, which is strongly convex. The *sternum* is flat to subconvex, subdeclivous, the posterior section terminating in an acute point between the coxæ. The *sternellum* is represented by a small but distinct intercoxal piece and the *poststernellum* ("epimerum" of authors) by the narrow posterior area which incloses the coxæ. The coxal cavities are large, with the inner margins but slightly separated.

THE MESOTHORAX.

The mesothorax is short and partially hidden from view by the prothorax, which covers the anterior third of the sternites, pleurites, and tergites, while the base of the elytra normally covers the posterior

areas of the tergites, leaving only the scutellar process or scutellum exposed between the basal angles. This process is densely clothed with white or yellow scales.

When the prothorax and elytra are removed the *mesotergum* is found to be rectangular in form; the *prescutum* is clearly defined as a convex strongly chitinized notal plate, occupying about two-thirds of the tergal area. The anterior margin is acutely emarginate and the anterior angles strongly produced. The *prephragma* is strongly flexed beneath the posterior dorsal area. The *scutum* appears to be represented by a narrow dorsal area between the median process of the scutellum and the posterior limit of the prescutum, and by the lateral submembranous areas between the oblique lateral margin of the prescutum and the scutellum. The *scutellum* is represented by the prominent median process and laterally by the chitinous piece just posterior to the scutal area. The *postscutellum* is represented by the subventral and flexed margin of the scutellum and by a slender lateral arm.

Mesopleura.—The episternum, preepisternum, epimerum, and postepimerum are all clearly defined. The *preepisternum* is similar to that of *Dendroctonus*. It is nearly as large as the episternum, narrowed toward the sternum, and very broad toward the opposite extremity, where it projects over the anterior dorsal angles of the episternum and epimerum. The surface is testaceous and opaque. Its posterior margin is clearly defined by a distinct but narrow lateral impression, which is densely clothed with fine whitish scales. The anterior is strongly declivous, concave, shining, and the *preepisternal process* is prominent and broad, but not stout as it is in *Dendroctonus*. The oblique ventral margin is thickened, but the posterior dorsal section is very thin and without a distinct arm connecting it with the articulating condyles. In this respect and in the strongly dilated dorsal section the preepisternum is very different from that in *Dendroctonus*. The *episternum* forms an isosceles triangle with the anterior dorsal margin narrowly produced and disappearing beneath the dilated end of the preepisternum. The ventral and posterior angles are equal and acute. The surface is coarsely punctured and, as is common over the entire ventral area of the body, each puncture bears a broad scale. The *epimerum* is narrow, oblique, and broad at its junction with the anterior dorsal angle of the metepisternal plate. The ventral end is truncate, while the dorsal end is strongly narrowed and produced forward beneath the preepisternum, where it joins with the angle of the episternum to form the articulating processes. The *postepimerum* is narrow, declivous, and shining.

The *mesosternal area* is short, with the anterior margin bisinuate, the intercoxal piece elevated and truncate at apex, and the excoxal pieces distinct. The *preepisternum* is represented by a narrow shining

area, but the *sternellum* and *poststernellum* are not represented by external areas. The coxal cavities are not widely separated. The mesothoracic spiracle is large and situated near the ventral edge of the preepisternal process where it is covered by the prothorax.

THE METATHORAX.

The *metatergum* is quite similar in general character to that in *Dendroctonus* (Hopkins, 1909, fig. 20); it is shorter and broad, and the *postscutellum* is very short and declivous. The membranous area of the *prescutum* is broad. The dorsal band is narrower. The scutellar groove is broad but less produced anteriorly. The metatergal costæ are not elevated above the scutum. The prescutal lobes are less prominent and the pleural hooks of the postscutellum are long and slender. Internally the median apodeme is more oblique and more acutely joined to the anterior apodeme. The longitudinal ridges formed by the deep lateral impressions of the scutellar groove are much more prominent and continuous from the anterior apodeme to near the posterior margin. The basal area of the wing and the articulating accessories are similar to those in *Dendroctonus*, differing only in minor details.

The *metapleura* are also similar to those in *Dendroctonus*, except that the *episternum* is narrower, the anterior ventral angle more produced and acute, the posterior end narrowed, and the exposed triangular plate of the *postepimerum* longer. The chitinous area of the *epimerum* is narrow, while the submembranous area or postepimeral area is correspondingly broad. The pleural clavicle is very long and the clavicle and coracoid processes are distinctly separated.

The *metasternal area* is a third longer than the mesosternal and twice as broad as long, without a median longitudinal groove, but with a median impression toward the posterior margin of the *sternum* proper. The *sternellum* is represented by an intercoxal piece covered by the median process of the abdominal sternite, and flexed beneath this is a plate which evidently represents the *poststernellum*. The coxal cavities are very large, widely separated, and suppress the first and second abdominal sternites. The metathoracic spiracle is situated in an open space between the metapleural clavicle and the mesepimerum.

THE ABDOMEN.

Tergites.—The abdominal tergites increase slightly in length from tergite 1 to tergite 4, inclusive, and also become more uniformly subchitinous; 5 and 6 are shorter than 4, and 6 is more membranous and has a pair of membranous lobes which are absent in the five preceding tergites; 7 and 8 are chitinous and clothed with short hairs. The epipleurites are membranous and quite clearly defined in living examples. The spiracle of segment 1 is very large, as usual, and the

others diminish slightly in size to and including the seventh. Spiracle 8 is evidently not represented. The character of abdominal tergites 7 and 8 in the males and females of different species is clearly shown in Plate VI. It will be noted that they are quite different from the corresponding tergites in *Dendroctonus*, both in form and vestiture. In those of *Pissodes* two or three hairs rise from each puncture instead of one, as in *Dendroctonus*, and in tergite 7 of the male the middle section of the posterior margin is broadly retuse, with the principal stridulating scrapers on the subacute lateral angles. In the female the posterior margin of tergite 7 is broadly rounded. The sensory tubercles in tergite 7 of both sexes appear to be of considerable taxonomic importance, especially in their number and arrangement.

Sternites.—The characteristic form and relative proportions of the abdominal sternites are shown in fig. 9 (p. 28). The intercoxal process of sternite 3 (first visible sternite) is broad, with a slightly produced acute apex. In addition to the description of the abdominal sternites on page 10, suture 3 (or the first visible suture) is bisinuate, with the middle section strongly curved forward. Sutures 4, 5, and 6 continue straight to the lateral margin. The apex of sternite 7 in the males is variously sculptured, as described in the synopsis of secondary sexual characters. Sternite 8 in the males (Plate IX, *f*) is small, separated in two sections, and forms the so-called genital plate, while in the females (Plate VII, *c*) it is solid and evidently fused with tergite 9, which is evidently represented by the chitinous rod on apodeme *d*, and the fork *j*.

The *hypopleurites* are completely covered by the elytra; 1 and 2 are fused with the anterior end of 3. The sides of 3 and 4 are nearly vertical and have the dorsal edges acute, to fit into the posterior lateral groove of the elytra; 5, 6, and 7 are oblique and increase in width to and including 7, the posterior margin of which is obliquely curved to fit around the lateral section of tergite 8 in the male or 7 in the female.

THE WINGS.

Mesothoracic wings (elytra).—In addition to the description on page 11, the mesothoracic wings, or elytra, have each 10 striæ and 11 interspaces, the latter including the costal and anal margins. The costal edge is deeply grooved for the reception of the produced dorsal edge of the metepisternum in the anterior section and of hypopleurites 3 and 4 in the posterior section. Beginning near the posterior end of this groove and extending obliquely to the apex there is a triangular area on the inner face of both elytra, which in the male is finely sulcate and serves as the stridulating rasp, while in the female the surface is roughened, with irregular elevations, apparently not available for producing sound. The subacute lateral angles of abdominal tergite 7 of the male evidently serve as the stridulatory scrapers.

Metathoracic wings.—The metathoracic wings are similar to those of *Dendroctonus*, but are at once distinguished by the two branches faintly connected with an evident cross-vein between the media and cubitus. The writer has not made a sufficient study of the modification of the veins in coleopterous wings to warrant anything more than the provisional interpretations indicated in the recently published figure (Hopkins, 1909, fig. 1).

INTERNAL ANATOMY.

The only parts of the internal anatomy that have been studied in detail by the writer are the reproductive organs of both sexes, which are of special interest, both from a systematic and from an economic point of view. These present taxonomic characters of last resort in the determination of the species. Those of the female are of interest from the fact that it is claimed that individuals must attain an age of several months before the ovaries are sufficiently matured for the development of eggs; also, that a single copulation may suffice for a long period; therefore it is important in our economic studies to be able to readily recognize the sexes and the approximate age of specimens collected at different times. The details of the male reproductive organs are shown in Plates VIII to XI, and require little explanation in addition to that given in the legends and synopsis. It will be seen that there are specific differences in the main body or stem (Plate XI), as well as in the fork (Plate X). The organs of reproduction in a very young female are shown in Plates VII and VIII, the parts of which are fully explained in the legends.

The profile of the abdomen (Plates VII and IX, *A*), with the parts *in situ*, shows the relation of the ventral and dorsal segments and genital plates to the different parts of the reproductive organs, certain parts of which are evidently direct modifications of the ninth and tenth dorsal and ventral segments. The figures are intended to illustrate the main features and are in some respects subdiagrammatical.

SECONDARY SEXUAL CHARACTERS.

Females.—In the females there are but 7 visible abdominal tergites, the eighth being completely covered by the seventh, which forms the pygidium. The beak is longer, smoother, and more slender than in the males. The apical or seventh abdominal sternite is usually shorter than the two preceding sternites together, which are usually less convex and more evenly punctured. The inner apical tooth of the tibiae is also smaller.

Males.—In the males there are 8 visible abdominal tergites; the seventh is distinguished by the broadly retuse posterior margin, while the eighth is prominent, with the apex broadly rounded, and forms the pygidium. The abdominal sternites 3 and 4 are more con-

vex than in the female, less evenly punctured and more shining toward the middle. The beak is stout, shorter, less shining, and more distinctly punctured. The inner apical tooth of the tibiæ is usually more prominent.

THE EGGS.

The eggs are pearly white, slightly oblong, and equally rounded at both ends.

THE LARVA.^a

The larva (Plate V, A) is yellowish-white, cylindrical, footless, with 3 thoracic and 9 distinct abdominal segments, the anal lobes representing the tenth; the thoracic segments not distinctly larger than the first abdominal. The hairs of the second prothoracic segment to the seventh abdominal segment are small and obscure; those of the head, first prothoracic, and eighth and ninth abdominal are longer and more conspicuous. The first thoracic segment has a shining dorsal plate and sometimes a distinct sternal plate. The ventral lobes of the three thoracic segments have inconspicuous foot calli, each with fine, erect hairs. The first thoracic segment has a distinct spiracle; the second and third segments are without spiracles, but the spiracles are distinct in the first to the eighth abdominal, and are round and not oblong or oval, as in *Hylobiinae*.

The head (figs. 5-8 and Plate V, A).—The head is light brown, the anterior margin and mandibles much darker. When removed, it is as broad as long (not including the mandibles), narrower in front than at middle, the sides broadly rounded from middle to apex, which is somewhat angular. The sides are nearly straight from the middle to the anterior angles, and the lateral area has an oblique, longitudinal, lighter area or stripe; the epicranial and frontal sutures are distinct and much lighter in color in fresh specimens. There are also 2 short, narrow, longitudinal stripes rising from the

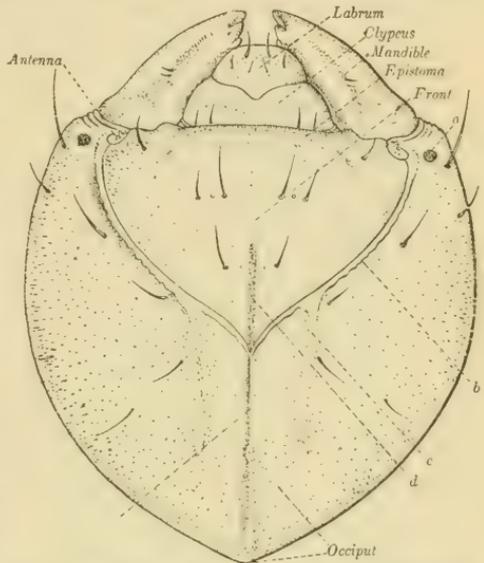


FIG. 5.—*Pissodes sitchensis*: Head of larva, dorsal aspect. a, Eye spot; b, frontal suture; c, subdorsal stripe; d, median line; e, epicranial suture. (Original.)

^a For anatomical nomenclature, see Hopkins, 1909, pp. 57-64,

frontal suture. The anatomical details are very similar to those of *Dendroctonus*. The *frontal area* is triangular, with a distinct median line from the apex to or beyond the middle. The sutural margins are irregular or sinuate. The normal arrangement of the hairs is shown in figure 8. The *antennæ* are very small, conical, 1-jointed, and situated at the anterior extremity of the frontal suture. The *epistoma* is represented by the thickened anterior margin of the front, with which it is fused. It is usually darker in color, with the anterior margin declivous and nearly straight, and the lateral angles slightly produced and elevated where they support the dorsal articulation of the mandibles. The pleurostoma is represented by the thickened declivous area surrounding the mandibular foramen.

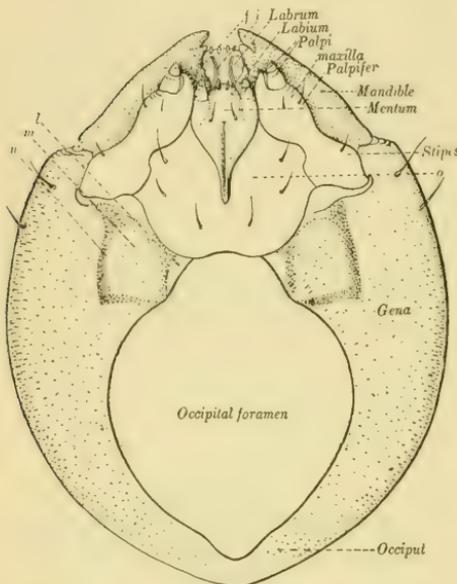


FIG. 6. — *Pissodes sitchensis*: Head of larva, ventral aspect. *f*, Apical papilla of labrum; *i*, labial hooks; *l*, gular plate; *m*, gular area; *n*, location of gular apodeme; *o*, submental lobe. (Original.)

The *mandibles* are rather stout, triangular, with 3 teeth on the anterior half of the inner edge. The apical tooth is usually acute, the subapical acute and near the apex, and the third or median tooth obtuse, emarginate, or triangular; usually the basal or molar tooth is not represented. The articulation is quite similar to that in larvæ of *Dendroctonus*. The dorso-lateral area of the mandible has a small impression and short bristle. The *eyes* are represented in some species by minute black spots beneath the exoskeleton, but apparently without lenses. The *maxillæ* (fig. 6) are much longer than broad, with a distinct cardo, and the stipes, palpiger, and

inner lobe are fused into one piece; the lateral area is elevated toward the base, as seen in balsam and when removed from the head. The palpi are 2-jointed, and the inner face of the lobes is armed with stout lacinal teeth. The *labium* (fig. 6), ventral aspect, has a large, membranous submental lobe (*o*) attached to and contiguous with the integument of the prothoracic sterna and laterally to that of the maxilla; it is also attached by ligaments to the intergular plate. The mentum is represented by a median triangular chitinous plate near the middle of the submentum. The mentum, palpifer, and ligula are fused, and the palpi are short, conical, and 2-jointed; the inner part of the ligula is membranous and contiguous with the pharynx. The arrangement of

the hairs on both the maxillæ and labium, as shown in figure 6, is characteristic and quite constant. The clypeus (fig. 5) is broad at base, the sides narrowed to the apical angles, and slightly to distinctly longer than the labrum. The *labrum* (fig. 5) is more chitinous, about three times as broad as long from apex of clypeus, the ventral posterior margin angular, and extending beyond the margin of the clypeus. The labral hooks are distinct (in balsam mounts), only slightly longer than the labrum, and, as usual, support the anterior portion of the epipharynx. An examination of the larvæ of 14 species showed that there is considerable specific variation in the form and proportion of the frontal area, clypeus, labrum, and mandibles. The last have characters of some divisional and subdivisional value, but the characters have not been sufficiently studied to present them in tabular form for the identification of the species. Certain characters common to one or more species of a division are given in a provisional synopsis on page 39.

THE PUPA.

(Plate V, B.)

An examination of the pupæ of 6 species of the first division and 3 species of the second division shows that the following characters are common to all: The apex of the posterior tarsus is even with the apex of the wing pad; the apex of the antenna extends toward the middle and in front of the anterior femur, but does not rest against it or touch the wing pad; the anterior, middle, and posterior femora have each 2 minute subapical spines; the head has $\frac{2}{3}$ prominent spines toward the vertex, 2 smaller ones on the sides toward the eyes, and 2 small ones each side of the front between the eyes, and usually 3 pairs of smaller ones on the beak between the frontal ones and the base of the antennæ; the prothorax has 3 pairs of dorsal spines, one pair moderately closely placed on or toward the anterior margin, one widely separated pair on the median area, and the other pair situated toward the base and still more widely separated; the lateral area has 2 closely placed spines near the middle, and the basal angle has an oblique row of 3 spines; the mesoscutum and metascutum have each 2 rather closely placed spines on each side of the median space; the abdomen has 8 distinct dorsal tergites, and the dorsal area of each is armed with 2 spines, which slightly increase in prominence from the first segment to the sixth or seventh. In

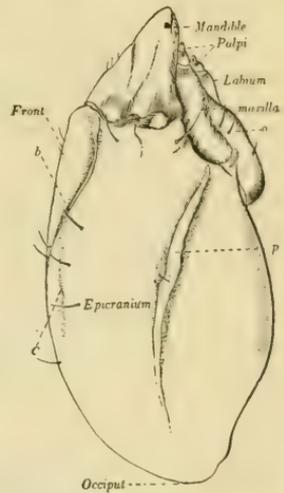


FIG. 7. — *Pissodes sitchensis*: Head of larva, lateral aspect. *b*, Frontal suture; *c*, subdorsal stripe; *o*, submental lobe; *p*, lateral stripe. (Original.)

some species there are alternating smaller, less regular spines between the dorsal and lateral ones. The lateral area of each tergite is armed with two spines and the epipleural lobes are each also distinctly or obscurely armed with one or two spines, and the ninth segment, as usual, is armed with two prominent pleural spines. (See Hopkins, 1909, figs. 37, 38, for anatomical nomenclature.)

HOST TREES.

The host trees of *Pissodes* are, so far as known, restricted to the

conifers, and include *Pinus*, *Picea*, *Abies*, *Larix*, *Pseudotsuga*, and *Cedrus*. Some of the species infest both living and dying or newly felled trees, while others appear to confine their attack to those which are sickly, dying, or felled. Some of them infest the living terminals and upper branches, others the upper or middle, stem, or base; some prefer to infest the thick bark of large trees, while others show a preference for the thinner bark of saplings and poles. (See table, pp. 41-42.)

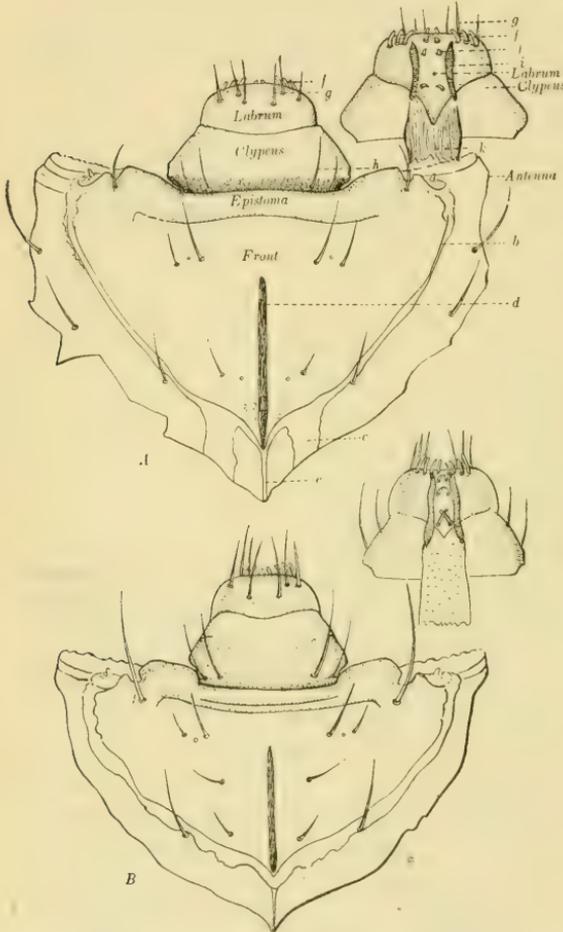


FIG. 8.—A: *Pissodes piperi*, front of head of larva. *b*, Frontal suture; *c*, subdorsal stripe; *d*, median line; *e*, epicranial suture; *f*, apical papilla; *g*, labial bristles; *h*, clypeal bristles; *i*, labral hooks or epipharyngeal bracons; *j*, epipharyngeal papilla; *k*, oesophagus. B: *Pissodes nemorensis*, front of head of larva. Nomenclature same as in A. (Original.)

GENERAL HABITS.

The eggs are deposited in cavities excavated by means of the beak in the outer or inner portion of the inner bark. Some species deposit one or two eggs in a single cavity, while others deposit many. The larvae obtain their food from the inner bark through which they extend their irregular mines (Plates XII to XVIII), and when they have completed their development

they excavate transformation cells, or pupal cases, in the outer portion of the wood, or, rarely, in the inner bark. These cells are inclosed by a thick covering of excelsior-like wood fiber, forming the so-called "chip cocoons," which are perhaps a more characteristic feature of the species of this genus than of any other.

GENERAL LIFE HISTORY.

The characteristic features in the life history of the species are the long life of the adult, the slow sexual maturity, the long period in which eggs may be deposited by a single female, and a single generation annually. In some species the broods develop within two or three months after the eggs are deposited, while in others it requires a longer period. The adults of some of the species emerge from the bark and hibernate in the ground, while others pass the winter in the bark.

GENERAL DISTRIBUTION.

The genus is represented in all sections of the United States characterized by natural growth of their host trees, and in other sections where such trees have been introduced to a sufficient extent to support them. (See table, pp. 40-41.)

THE NORTH AMERICAN SPECIES OF *PISSODES*.

NATURAL CLASSIFICATION OF THE SPECIES.

In the following key and synopses (pp. 30-38) an attempt is made toward a natural classification of the species of *Pissodes* into primary and secondary divisions, sections, series, etc., according to characters which indicate lines of specialization and natural affinities. It will be noted that the general modification, as in most *Cureulionidæ*, is from a short or stout beak to a longer or more slender one, and in general from small to larger forms.

The characters of the pronotum, as commonly used to indicate species and groups of species, are found to be of little value in separating primary, or even secondary, divisions, but are of more importance in separating the subsections, series, and species. The specialization is plainly from a rounded, obtuse, to a rectangular and acute basal angle, but this specialization is confined to the smaller groups, and is therefore represented in the several sections as parallel developments. The pronotum is, in fact, quite variable in the individuals of the same species. In some reared specimens of the same species there is a wide range from a rounded to an acute basal angle, while in one specimen of *Pissodes nemorensis* the angle of one side is rectangular, while that of the other is acute. These radical departures from the normal may, however, be considered as deformities.

The length of the beak also varies; thus, in some of the females it is shorter than in some males of the same species. The elytra are more or less variable in form, but appear to be more constant than the other parts, and show little or no sexual difference.

The character and position of the spots of densely placed scales appear to be of special value in the classification of the genus, but these are sometimes rendered obscure in old, rubbed, and dirty specimens. The scales are so firmly attached, however, that they are often sufficiently retained in old specimens to be of value. Dirty specimens can be easily cleaned with chloroform or xylol, the latter being especially valuable for the removal of resin.

STATISTICAL TAXONOMY.

In a comparative study of the characters which distinguish the major and minor divisions and species of a genus or a larger group of

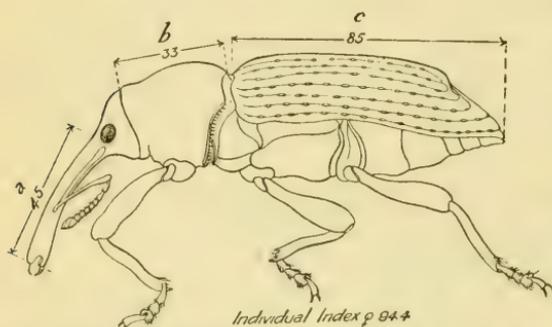


FIG. 9.—*Pissodes fraseri*: Lateral aspect, showing method of determining individual index. *a*, Length of beak; *b*, length of prothorax; *c*, length of elytra. (Original.)

organisms, a progressive modification of certain parts of the body structure is usually found to serve (together with other characters) as an index to a natural classification. Therefore the importance of having some clear and definite method of indicating the range and limit of such lines of modification or specialization is apparent.

The writer's experience with the statistical method in comparative studies of such modifications has convinced him that when it is accurately applied a mathematical formula may be determined to express the limit and relative taxonomic importance of a given modification in one or more structural characters, to indicate specific differences, and to show the relative position and rank the species occupy in a natural classification. Thus we may adopt for certain groups of insects a statistical taxonomy as a guide toward the classification of the species into natural divisions.

In the bark-weevils of the genus *Pissodes* we have a good example for the application of this method. One of the principal lines of modification available for statistical study is the progressive elongation of the beak. Therefore when we compare the average ratio or mode of the length of the beak to both the length of the prothorax and length of the elytra (fig. 9) in a number of individuals of one species with that of an equal number of individuals of another species,

no matter what differences there may be in the length of the body of the individuals, we get a mathematical expression, or index, of the difference in their relative proportions.

The following examples will serve to illustrate the application of the method:^a

Example 1.

Female individual of *Pissodes strobi*.

a, Length of beak, 29 micrometer divisions.

b, Length of prothorax, 31 micrometer divisions.

c, Length of elytra, 73 micrometer divisions.

$a \div b = .935$.

$a \div c = .397$, $+ .935 = 1.332$, $\div 2 = .666$ = Index of relative proportions of an individual.

Now, if 50 male individuals of this species show a range in the individual index of 61 to 64, with an average or mode of 63, and 50 females show a range of 65 to 69, with a mode of 68, the relative proportions for each sex and for the species are expressed by the formula, ♂ 63-♀ 68.

Example 2.

Female individual of *Pissodes fraseri* (fig. 9).

a, Length of beak, 45 micrometer divisions.

b, Length of prothorax, 33 micrometer divisions.

c, Length of elytra, 85 micrometer divisions.

$a \div b = 1.366$.

$a \div c = .529$, $+ 1.366 = 1.895$, $\div 2 = .947$ +. If 50 male individuals show an index range of 72 to 73 and a mode of 72, and 50 females show a range of 91 to 111, with a mode of 100, the formula would be ♂ 72-♀ 100.

P. strobi, formula ♂ 63-♀ 68.

P. fraseri, formula ♂ 72-♀ 100.

According to other characters, these two species fall in the same division of the genus, but in different subdivisions. The formulas for the species of the first division range from ♂ 57-♀ 62 to ♂ 72-♀ 100. Those of the first subdivision range from ♂ 57-♀ 62 to ♂ 74-♀ 79, while those of the second subdivision range from ♂ 64-♀ 70 to ♂ 72-♀ 100.

Thus the formulas for *P. strobi* and *P. fraseri*, together with the characters which refer them to their respective primary and minor divisions, indicate the natural position and rank they should occupy in the classification. (See Plate II.)

It is interesting to note that the Hylobiinæ, which are plainly less modified in respect to the length of the beak than the Pissodinæ, show their relative lower position in the determined formulas for representatives of the 4 principal genera (*Paraplinthus*, ♂ 47, ♀ 58; *Hilipus*, ♂ 35, ♀ 68; *Eudocimus*, ♂ 38, ♀ 49; *Hylobius*, ♂ 48, ♀ 56). It will be noted that the females of only two of the genera fall within the range of the Pissodinæ, while *Hylobius*, which has some affinities

^aMeasurements up to 10 mm. may be made by means of a microscope with a micrometer eyepiece and a 2-inch objective, the tube adjusted so that each division in the micrometer scale equals five one-hundredths of a millimeter.

with *P. affinis* of the second division of the genus *Pissodes*, does not come within the range, but occupies the position probably held by the more primitive forms of the *affinis* division. (See Plate II.)

MORPHOLOGICAL AND PHYSIOLOGICAL CHARACTERS AND CHARACTERISTICS.

The plan of combining morphological characters and physiological characteristics as a basis for specific distinction, as discussed by the writer in the technical contribution on *Dendroctonus* (Hopkins, 1909, p. 64), has been followed in the study and classification of the species of *Pissodes*. The close resemblance of the adults of allied species and the wide range of specific variation render it very difficult and often practically impossible to refer some of the individuals to the species by external characters of the adults alone, but with information on the distribution, host, habit, seasonal history, etc., they can often be referred to their species without a moment's hesitation. Specimens without locality labels and some additional information are therefore of no value to the economic investigator, and will evidently become of less and less value to the systematists. The importance of utilizing bionomic data as guides to the identification of species will doubtless become more popular in the future and contribute to a more rapid advancement of the essential knowledge required by the systematic and economic entomologist in research work.

KEY TO THE SPECIES.

- I. Elytral interspaces 3 and 5 broader or more elevated than 2 and 4.
- A. Elytra always with anterior and posterior spots.
- a1. Elytra with distinct spots near vertex of declivity.
- b1. Beak moderately stout, always shorter than prothorax.
- c1. Elytra with distinct anterior spots and very large posterior ones.
 Posterior spot with distinct dark border 1. *similis*
 Posterior spot without distinct dark border..... 2. *utahensis*.
- c2. Elytra with indistinct anterior spots and small posterior ones.
 3. *barberi*.
- b2. Beak slender, shorter or longer than prothorax.
- c3. Elytra with anterior and posterior spots large.
 Posterior spots of elytra without dark border. Pacific Coast.
 4. *sitchensis*.
 Posterior spots of elytra usually with dark border. Rocky
 Mountains..... 5. *engelmanni*.
 Posterior spots of elytra with or without dark border. Eastern
 U. S..... 6. *strobi*.
- c4. Elytra with small to moderately large anterior and posterior spots.
- d1. Posterior brown spots moderately large.
 Posterior brown and white spots usually separated. East-
 ern and northern U. S..... 7. *approximatus*.
 Posterior brown and white spots fused. Central and north-
 ern Rocky Mountains..... 8. *schwarzi*.

- d2.* Posterior brown spots small.
- e1.* Elytral interspaces 3 and 5 elevated and broad.
 Posterior spots fused, the yellow one larger. Manitoba..... 9. *canadensis*.
 Posterior spots usually separated, yellow one small.
 Elytra noticeably narrowed posteriorly from base.
 10. *nemorensis*.
 Elytra not noticeably narrowed posteriorly from base. South Atlantic States..... 11. *deodarae*.
 Elytra noticeably narrowed posteriorly; white and brown spots separated, the latter very small.
 12. *californicus*.
- e2.* Elytral interspaces 3 and 5 narrow, strongly elevated.
 Pronotal punctures coarse but not dense.. 13. *yosemite*.
 Pronotal punctures coarse and dense..... 14. *webbi*.
- a2.* Elytra with transverse band of white and yellow scales near vertex.
- b3.* Pronotum with posterior angles acute..... 15. *radiatae*.
b4. Pronotum with posterior angles subrectangular..... 16. *fasciatus*.
- B. Elytra usually without distinct anterior spots, and with posterior spot anterior to vertex of declivity.
- a3.* Pronotum with basal angles subrectangular..... 17. *costatus*.
a4. Pronotum with basal angles rounded.
- b5.* Pronotal punctures distinctly separated.
- c5.* Pronotum not distinctly narrower than elytra.
- d3.* Pronotum stout, deeply constricted anteriorly.. 18. *fiskei*.
d4. Pronotum subelongate, not deeply constricted anteriorly.
 Pronotum moderately stout; elytral interspaces 3 and 5 scarcely elevated; with anterior spot..... 19. *nigrae*.
 Pronotum elongate.
 Elytral interspaces 3 and 5 slightly elevated, flattened; with anterior spot..... 20. *puncticollis*.
 Elytral interspaces 3 broader and more elevated; without anterior spot..... 21. *murrayanae*.
- c6.* Pronotum distinctly narrower than elytra.
 Pronotal punctures irregular, not dense; punctures of striæ irregular..... 22. *coloradensis*.
 Pronotal punctures regular, moderately dense; punctures of striæ coarse, irregular..... 23. *alascensis*.
 Pronotal punctures dense, regular; punctures of striæ irregular.
 24. *rotundatus*.
- b6.* Pronotal punctures irregular, not distinctly separated.
- c7.* Elytral striæ with punctures very irregular.
 Gray, densely clothed with scales; spots prominent. 25. *burkei*.
 Black, not densely clothed with scales; spots obscure. 26. *piperi*.
- c8.* Elytral striæ with punctures moderately irregular; spots obscure.
 Pronotum convex, without dorsal impressions and elevations.
 27. *dubius*.
 Pronotum moderately convex and usually with dorsal impressions and elevations..... 28. *fraseri*.
- II. Elytral interspaces 3 and 5 not broader or more elevated than 2 and 4.
 Elytra with distinct posterior spots..... 29. *affinis*.
 Elytra with small posterior spots..... 30. *curriei*.

SYNOPSIS OF ADULT CHARACTERS, WITH DESCRIPTIONS OF NEW SPECIES.^a

Elytral interspaces 3 and 5 broader or more elevated than 2 and 4.

Division I, pages 32, 43.

Elytral interspaces 3 and 5 not broader or more elevated than 2 and 4.

Division II, pages 36, 64.

DIVISION I.

Elytra always with distinct spots of densely placed scales on the anterior lateral area and always with spots or bands of scales situated near the vertex of the declivity.

Subdivision A, pages 32, 44.

Elytra usually without distinct spots on the anterior lateral area and with small spots situated between the vertex of the declivity and middle of elytra.

Subdivision B, pages 35, 56.

SUBDIVISION A.

Elytra with distinct spots near vertex of declivity.....Section a1, pages 32, 44.

Elytra with transverse band of white and yellow scales near vertex of declivity.

Section a2, pages 34, 55.

Section a1.

Beak moderately stout, shorter than prothorax; pronotum with basal angles sub-
obtuse; elytra with interspaces 3 and 5 strongly elevated and rugose.

Subsection b1, pages 32, 44.

Beak slender, shorter or longer than prothorax; pronotum with basal angles rectan-
gular; elytral interspaces 3 and 5 moderately to strongly elevated.

Subsection b2, pages 33, 46.

Subsection b1.

Elytra with distinct anterior spots and very large posterior ones; pronotum distinctly
narrower than elytra, punctures indistinct, irregular.....Series c1, page 32.

Elytra with indistinct anterior spots and small transverse posterior ones; pronotum
not distinctly narrower than elytra, punctures distinct and regular.

Series c2, page 32.

Series c1.

Length 3.7 to 4 mm.; brown; pronotal and elytral punctures moderately coarse; pos-
terior spot of elytra with distinct dark border. Maine and high mountains of
North Carolina, probably in *Abies fraseri*, and New Hampshire in *Abies balsamea*.
Species index, ♂ 57-♀ 62.....1. *similis* n. sp., page 44.

Length 3.9 mm.; dark brown; pronotal and elytral punctures coarse; posterior spot
of elytra without distinct dark border, third and fifth interspaces with acute
rugosities, spots prominent. Park City, Utah, and Bear Lake, British Columbia.
Species index, ♂ 63-♀ 64.....2. *utahensis* n. sp., page 45.

Series c2.

Length 5 to 5.5 mm.; black; pronotal and elytral punctures very coarse; elytra with
interspaces 3 and 5 broad and prominent. Humboldt, Cal., Astoria, Oregon,
and Tenino, Wash. Species index, ♂ 62 ♀ 65.....3. *barberi* n. sp., page 45.

^a The divisional, subdivisional, sectional, subsectional, serial, and species characters constitute a complete description of each species; *c. g.*, I, A, a1, b1, c1, and *species* 1.

Subsection b2.

Elytra with large anterior and posterior spots; sides parallel; beak never longer than prothorax.....Series c3, page 33.

Elytra with small to moderately large anterior and posterior spots; sides usually slightly narrowed posteriorly; beak sometimes longer than prothorax.

Series c4, page 33.

Series c3.

Length 4.2 to 5 mm.; brown; pronotum distinctly narrower than elytra, not distinctly shining, and the punctures moderately coarse and dense; posterior spots of elytra without dark border; punctures of striae coarse, distinct. Hoquiam and Pialschie, Wash., in tops of *Picea sitchensis*. Species index, ♂ 61-♀ 64.

4. *sitchensis* n. sp., page 47.

Length 5 to 5.3 mm.; brown; pronotum not distinctly narrower than elytra, shining, and the punctures coarse; posterior spots of elytra usually with faint dark border; punctures of striae indistinct, especially on lateral area. Smith's Ferry, Idaho, and Pikes Peak, Colo., in tops of *Picea engelmanni*. Species index, ♂ 62-♀ 68.....5. *engelmanni* n. sp., page 47.

Length 4.5 to 6 mm.; brown; pronotum slightly narrower than elytra, moderately shining, and the punctures dense; posterior spot of elytra with or without faint dark border. Eastern United States, in terminals of *Pinus strobus*, rarely in terminals of *Pinus resinosa* and terminals of *Picea*. Species index, ♂ 63-♀ 68.

6. *strobi* Peck, page 48.

Series c4.

Posterior brown spots of elytra moderately large; fork of male genitalia very stout.

Subseries d1, page 33.

Posterior brown spots of elytra small; fork of male genitalia long and slender.

Subseries d2, page 33.

Subseries d1.

Length 4.3 to 6.7 mm.; brown; pronotum not distinctly narrower than elytra, punctures moderately coarse; elytral interspace 3 broad, flattened, moderately rugose, and posterior white and yellow spots usually separated, the brown one smaller but not very small as in species 10, and the white one extending over the second interspace. Mountains of North Carolina northward to New Hampshire, and west to Lake Superior region, in *Pinus* under bark on stumps and logs and trunks of dying trees, and base of saplings. Species index, ♂ 65-♀ 71.

7. *approximatus* n. sp., page 49.

Length 5.2 to 6.7 mm.; brown; pronotum slightly narrower than elytra, punctures coarse; elytral interspaces 3 and 5 distinctly elevated and rugose, the punctures of striae coarse, and the posterior white and yellow spots fused, not extending over the second interspace. Colorado, in *Pinus scopulorum*, thick bark on base, stems, tops, and terminals of saplings. Species index, ♂ 71-♀ 75.

8. *schwarzi* n. sp.; page 50.

Subseries d2.

Elytral interspaces 3 and 5 distinctly elevated and broader than 2 and 4; pronotal punctures moderately coarse and densely placed.....Minor series e1, page 34.

Elytral interspaces 3 and 5 but slightly broader than 2 and 4, strongly elevated and acutely rugose; pronotum narrower than elytra, punctures very coarse.

Minor series e2, page 34.

Minor series e1.

- Length 6.2 to 7 mm.; brown; pronotum as broad as elytra, with sides rounded; elytra with sides scarcely narrowed posteriorly, interspaces 3 and 5 broad, elevated, rugose, the posterior spots fused, and the yellow one large; beak not longer than the prothorax in the males. Winnipeg, Manitoba, in *Pinus?* Species index, ♂ 66-♀ 79.....9. *canadensis* n. sp., page 51.
- Length 4.9 to 7.7 mm.; brown; pronotum with sides not strongly rounded; elytra with sides narrowed posteriorly from base, posterior spots usually separated, the yellow one very small and the white one extending to first interspace; beak usually longer than prothorax in both sexes. Boardman, N. C., and mountains of North Carolina, to Florida and Texas, in bark of *Pinus* logs, stumps, trunks of dying trees, and rarely in base of saplings. Species index, ♂ 67-♀ 78.
10. *nemorensis* Germar, page 51.
- Length 4.2 to 5.8 mm.; light brown; body slender; pronotum slightly narrower than elytra; elytra with sides nearly parallel, interspaces 3 and 5 but slightly elevated, posterior brown spot very small; beak longer than prothorax in both sexes. Experiment, Ga., in stems, branches, and tops of *Cedrus deodara*. Species index, ♂ 74-♀ 79.....11. *deodaræ* n. sp., page 52.
- Length 8.6 mm.; brown; pronotum broad, with sides broadly rounded; elytra with sides distinctly narrowed posteriorly, interspace 3 very broad, not coarsely rugose as in *yosemite*; posterior spots separated, the brown one very small; beak distinctly longer than prothorax. Yosemite Valley, Cal., in bark of living pine with *P. yosemite*. Species index, ♀ 83.....12. *californicus* n. sp., page 53.

Minor series e2.

- Length 5.1 to 7.7 mm.; brown; pronotal punctures very coarse, not dense; elytra with sides nearly parallel, interspaces 3 and 5 strongly elevated, acutely rugose, punctures of striae rather coarse, and posterior spots fused on lateral area. Yosemite Valley, Siskiyou County, and Lake Tahoe, Cal., in *Pinus ponderosa* and *Pinus lambertiana*. Species index, ♂ 65-♀ 77.....13. *yosemite* n. sp., page 53.
- Length 4.8 to 6.8 mm.; brown; pronotal punctures very coarse and dense; elytra with sides nearly parallel, interspaces 3 and 5 elevated and rugose, punctures of striae rather coarse, and posterior spots prominent and fused on the sides. Mountains of southern New Mexico and Arizona, in *Pinus strobiformis* and *Pinus ponderosa*. Species index, ♂ 73-♀ 78.....14. *webbi* n. sp., page 54.

Section a2.

- Pronotum with posterior angles acute.....Subsection b3, pages 34, 55.
Pronotum with posterior angles subrectangular.....Subsection b4, pages 34, 55.

Subsection b3.

- Length 5.1 to 7.4 mm.; brown; pronotum broader toward base, angles acute, sides converging anteriorly, slightly constricted toward head, punctures coarse, distinct; elytra with anterior spots small, yellow, and the posterior band principally of white scales. Monterey, Cal., in bark of logs and trunks of *Pinus radiata*; also one specimen from Easton, Wash. Species index, ♂ 63-♀ 65.
15. *radiatæ* n. sp., page 55.

Subsection b4.

- Length 5.1 to 8.3 mm.; brown; pronotum narrower than elytra, sides rounded and slightly narrowed anteriorly but not distinctly constricted toward head; elytra with anterior spots prominent, oblique, yellow, the posterior indistinct band composed of scattering white and yellow scales. Oregon, Washington, Idaho, and British Columbia, in *Pseudotsuga mucronata*. Species index, ♂ 62-♀ 67.
16. *fasciatus* Le Conte, page 56.

SUBDIVISION B.

Pronotum with basal angles subrectangular; beak rather stout, moderately long.

Section a3, pages 35, 57.

Pronotum with basal angles rounded; beak slender, moderately to very long.

Section a4, pages 35, 58.

Section a3.

Length 5.5 to 7.1 mm.; dark brown; pronotal punctures not distinctly separated; elytra with faint anterior spot toward the middle and indistinct spots of reddish brown and white scales behind the middle, interspaces with many minute white spots toward sides and on declivity. Hoquiam, Wash., in thick bark on trunks of dying trees and stumps of *Picea sitchensis*. Species index, ♂ 64-♀ 70.

17. *costatus* Mannerheim, page 57.

Section a4.

Pronotal punctures distinctly separated; punctures of elytral striae small to coarse.

Subsection b5, pages 35, 59.

Pronotal punctures irregular, not distinctly separated; punctures of elytral striae very coarse and irregular.....Subsection b6, pages 36, 62.

Subsection b5.

Pronotum not distinctly narrower than elytra.....Series c5, page 35.

Pronotum distinctly narrower than elytra.....Series c6, page 36.

Series c5.

Pronotum short, stout, sides strongly rounded and constricted toward the anterior margin; elytral interspaces strongly elevated with rather coarse rugosities.

Subseries d3, page 35.

Pronotum elongate, sides rounded, but not deeply constricted toward head; elytral interspaces with fine rugosities.....Subseries d4, page 35.

Subseries d3.

Length 4.2 to 5.2 mm.; dark brown; elytra without anterior spot but with broad posterior one, interspaces 3 and 5 strongly elevated, convex, rugose; punctures of striae small. New Hampshire, in thin bark on dying *Picea mariana* and *Picea rubens*. Species index, ♂ 77-♀ 81.....18. *fiskei* n. sp., page 59.

Subseries d4.

Length 4.4 to 5.6 mm.; dark brown; pronotum short, broad; elytra with small obscure anterior spots and distinct posterior ones situated toward the middle, interspaces 3 and 5 flattened, scarcely elevated, rugosities fine; punctures of striae coarse.

Webster, N. H., in *Picea mariana*, bark of small tree. Species index, ♂ 68-♀ 84.

19. *nigræ* n. sp., page 59.

Length 4.2 to 6.1 mm.; light brown; pronotum elongate, punctures coarse, irregular; elytra with small anterior spots and more distinct posterior ones just behind the middle, interspaces 3 and 5 slightly elevated and flattened; punctures of striae moderately coarse. Mountains of West Virginia, in *Picea rubens*, thick bark on logs. Species index, ♂ 74-♀ 87.....20. *puncticollis* n. sp., page 60.

Length 4.1 mm.; dark brown; pronotum elongate, punctures moderately coarse, regular; elytra without anterior spots and with very small posterior ones each side behind the middle, interspace 3 distinctly broader, elevated; striae coarser toward the base.

Wallowa, Oregon, in *Pinus murrayana*; reared from bark. Species index, ♀ 78.

21. *murrayanae* u. sp., page 60.

Series c6.

Length 6.9 to 7 mm.; dark brown; pronotal punctures irregular, elytra without distinct anterior spots, but with distinct spots of yellow scales behind the middle, interspaces 3 and 5 strongly elevated, and punctures of striae irregular. Leadville, Colo., National Park, Wyo., and Black Hills, S. Dak., in *Picea canadensis* thick bark on base of trees. Species index, ♀ 87.

22. *coloradensis* n. sp., page 60.

Length 6.5 mm.; black; pronotal punctures coarse, regular, closely placed and rather deep; elytra without anterior spots, but with small, rather distinct, posterior ones, punctures of striae coarse, irregular, and smaller on the lateral area, interspaces 3 and 5 reddish, strongly elevated, and broad. Arctic Circle, Alaska, and Montana in *Picea engelmanni*. Species index, ♀ 89.

23. *alascensis* n. sp., page 61.

Length 6 to 7.3 mm.; black; pronotal punctures dense, regular; elytra rarely with small anterior white spots, but with small white spots behind the middle, interspace 3 very broad, interspatial rugosities not coarse, punctures of striae irregular and not smaller on the lateral area. Marquette, Mich., Lake Superior region, probably in *Picea*. Species index, ♀ 90.....24. *rotundatus* Le Conte, page 61.

Subsection b6.

Punctures of elytral striae very irregular, spots of scales moderately distinct; pronotum not distinctly narrower than elytra.....Series c7, page 36.

Punctures of elytral striae moderately irregular, spots of scales evident but small and obscured by scattering white or yellow scales; pronotum distinctly narrower than elytra.....Series c8, page 36.

Series c7.

Length 6 to 7.7 mm.; gray; elytra and pronotum rather densely clothed with whitish scales; elytra with rather distinct anterior and posterior spots, and punctures of striae not very closely placed. Ouray, Colo., Alta and Park City, Utah, probably in *Abies*? Species index, ♂ 74-♀ 82.....25. *burkei* n. sp., page 62.

Length 7.4 to 10 mm.; black; elytra and pronotum sparsely clothed with whitish scales; elytra with anterior and posterior spots evident but small, and punctures of striae very deep and closely placed. Mount Rainier, Wash., and Centerville, Idaho, in *Abies lasiocarpa* and *Abies concolor*; also at Glacier, B. C. Species index, ♂ 81-♀ 83.....26. *piperi* n. sp., page 62.

Series c8.

Length 4.8 to 5.7 mm.; black; beak moderately long; pronotum convex, without dorsal irregularities. Maine to Lake Superior, in *Abies balsamea*. Species index, ♂ 72-♀ 88.....27. *dubius* Le Conte, page 63.

Length 4.6 to 9.1 mm.; black; beak very long, even in the male; pronotum somewhat flattened, and usually with dorsal irregularities, sometimes distinctly impressed towards base. High mountains of North Carolina in *Abies fraseri*. Species index, ♂ 72-♀ 100.....28. *fraseri* n. sp., page 63.

DIVISION II.

Elytral interspaces 3 and 5 not more elevated or broader than 2 and 4; beak short, slender; pronotum broad, with sides behind the middle nearly parallel, and the basal angles rectangular; punctures of elytral striae moderately coarse, regular; posterior tibia of male fringed with long bristles.

- Length 5.5 to 8 mm.; black, elytra with or without faint anterior spots but with distinct transverse spots of white or yellow scales near vertex, and the punctures of striae moderately coarse. Wisconsin to New Hampshire, in *Pinus strobus*. Species index, ♂ 61-♀ 67.....29. *affinis* Randall, page 64.
- Length 5.6 to 7.7 mm.; black, elytra with obscure anterior spots and small posterior ones, the punctures of striae coarse and deep. Kaslo, B. C. Species index, ♂ 62, 30. *currici* n. sp., page 65.

SYNOPSIS OF PRIMARY SEXUAL CHARACTERS.

MALE GENITALIA.

- Stem with apex *uniformly rounded* Division I
 Stem with apex *not uniformly rounded* Division II

DIVISION I.

Section a1.

- Fork slender.....Species 4, 5, 6
 Fork short.....Species 4
 Fork long.....Species 5
 Fork moderately stout.....Species 6
 Fork long and stout.....Species 7, 8
 Fork long and slender.....Species 9, 10, 11, 13

Section a2.

- Stem narrowed toward apex, but not constricted.....Species 15
 Stem broad toward apex, slightly constricted anteriorly.....Species 16

Section a4.

- Fork long and slender.....Species 27, 28

DIVISION II.

- Fork very stout.....Species 29, 30

SYNOPSIS OF SECONDARY SEXUAL CHARACTERS.

- Beak longer and more slender in females than in males.....The Genus
 Hind tibia of male *without* long fringe of hairs.....Division I
 Hind tibia of male *with* long fringe of hairs.....Division II

DIVISION I.

- Beak in both sexes usually shorter than prothorax, rarely longer.....Subdivision A
 Beak in both sexes rarely shorter than prothorax, commonly much longer.....Subdivision B

SUBDIVISION A.

- Apical margin of abdominal sternite 7 sinuate or not in males.....Section a1
 Apical margin of abdominal sternite 7 not sinuate in males.....Section a2

Section a1.

- Apical margin of abdominal sternite 7 not sinuate in males.....Subsection b1, Species 1, 2, 3
 Apical margin of abdominal sternite 7 faintly sinuate in males.....Subsection b2

Subsection b2.

Beak shorter than prothorax in males, rarely longer in females.

Series c3, Species 4, 5, 6

Beak as long as prothorax or longer in males, usually longer and often distinctly so, in females.....Series c4, Species 7, 8, 9, 10, 11, 12, 13, 14

Section a2.

Beak in both sexes shorter than prothorax.....Species 15, 16

SUBDIVISION B.

Apical margin of abdominal sternite 7 faintly sinuate, but without apical process in females.....Section a3, Species 17

Apical margin of abdominal sternite 7 without or with process in males....Section a4

Section a4, Subsection b5.

Apical margin of abdominal sternite 7 sinuate, but without median process in males.....Species 18

Apical margin with median process in males.....Species 20

Subsection b6.

Apical margin of abdominal sternite 7 with apex uniformly rounded in males.

Species 25, 26, 27, 28

DIVISION II.

Beak shorter than prothorax in both sexes, apical margin of abdominal sternite 7 with truncate process rising from deep emargination in males.....Species 29, 30

SYNOPSIS OF PUPAL CHARACTERS.

DIVISION I.

Head *with* one or more minute spines on posterior margin of eyes....Subdivision A

Head *without* minute spines on posterior margin of eyes.....Subdivision B

SUBDIVISION A.

Abdominal tergites with small spines alternating with larger ones, especially on tergites 3 to 6.....Section a1

Abdominal tergites without small spines alternating with larger ones....Section a2

Section a1, Series c3.

Abdominal tergites 5 and 6 *with* small spines between the more prominent dorsal ones.....Species 4, 6

Abdominal tergites 5 and 6 *without* small spines between the more prominent dorsal ones.....Species 5

Series c4.

Abdominal tergites 5 to 6 without small spines between the more prominent dorsal ones.....Species 7-14

Section a2.

Abdomen with prominent epipleural spines.....Series c5, Species 15

Abdomen with small epipleural spines.....Series c6, Species 16

SUBDIVISION B.

- Abdominal tergites with small spines alternating with the larger ones and with small spines between the more prominent dorsal ones.
- Epipleurite 9 with bristles.....Section a3
Epipleurite 9 without bristles.....Section a4

Section a3.

- Abdominal tergites 4 to 5 with two small spines between the more prominent dorsal ones.....Species 17

Section a4.

- Abdominal tergites 4 to 5 with four small spines between the more prominent dorsal ones.
- Beak without pair of spines between middle and apex.....Species 25, 26
Beak with pair of small spines between middle and apex.....Species 27

DIVISION II.

- Abdominal tergites 4 and 5 with two small spines between the more prominent dorsal ones; beak with pair of small spines between apex and middle.....Species 29

SYNOPSIS OF LARVAL CHARACTERS.

DIVISION I, SUBDIVISION A.

- Mandibles with middle tooth emarginate.....Section a1
Mandibles with middle tooth triangular.....Sections a2, a3
Mandibles with middle tooth emarginate or triangular.....Section a4

Section a1.

- Apical tooth acute.....Subsection b2
Abdominal spiracles distinct.
- Head without distinct eye-spots.....Species 4, 5
Head with distinct eye-spots.....Species 6

Series c1.

- Abdominal spiracles distinct.
- Head without distinct eye-spots.....Species 7, 10
Head with distinct eye-spots.....Species 14

Section a2.

- Apical tooth obtuse; head with distinct eye-spots.....Species 15
Apical tooth acute; head with distinct eye-spots.....Species 16

SUBDIVISION B.

Section a3.

- Abdominal spiracles obscure; apical tooth acute; median tooth triangular; head with distinct eye-spots.....Species 17

*Section a4.**Series c5.*

- Abdominal spiracles moderately distinct.
- Apical tooth obtuse; middle tooth triangular; head without eye-spots..Species 18
Apical tooth acute; middle tooth emarginate; head without distinct eye-spots.
Species 20

Series c7.

Abdominal spiracles moderately distinct; apical, subapical, and median teeth obtuse; head with distinct eye-spots.....	Species 25
Abdominal spiracles obscure; apical tooth acute; middle tooth triangular; head without distinct eye-spots.....	Species 26

Series c8.

Abdominal spiracles obscure; apical tooth acute; median tooth emarginate.....	Species 27
Apical tooth obtuse; median tooth emarginate.....	Species 28

TABLE OF DISTRIBUTION.

THE WORLD.

In *Europe and Asia*, from Spain and England into eastern Siberia and Japan and northward into Sweden and Russia, probably to the Arctic Circle; in *North America*, from Mexico and Florida to the Arctic Circle in Alaska and eastward to the Atlantic.....The genus

NORTH AMERICA—DIVISION I.

SUBDIVISION A.

Section a1.

Maine to higher mountains of North Carolina.....	Species 1
Mountains of Utah to Bear Lake, British Columbia.....	Species 2
Coast of northwestern California to western Washington.....	Species 3
Coast of northwestern Oregon and western Washington.....	Species 4
Smiths Ferry, Idaho, to Pikes Peak, Colorado.....	Species 5
New Brunswick, southwest through mountains to Biltmore, N. C. (distribution of white pine).....	Species 6
Eastern United States, south through mountains to North Carolina and eastward to Maine.....	Species 7
Eastern Washington to Leadville, Colo., and Black Hills of South Dakota.....	Species 8
Winnipeg, Manitoba, to Michigan.....	Species 9
Atlantic coast region and Lower Austral life zone, northward probably to Long Island, New York, and westward through the Gulf States into Texas.....	Species 10
Georgia.....	Species 11
Yosemite Valley, California.....	Species 12
Mountains of northern California.....	Species 13
Southern New Mexico and Arizona, and probably mountains of western Texas, into Mexico.....	Species 14

Section a2.

Monterey and Palo Alto, Cal., Easton, Wash.....	Species 15
Northwestern California, into British Columbia.....	Species 16

SUBDIVISION B.

Section a3.

Coast of western Washington to Sitka.....	Species 17
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Section *a*.

New Hampshire	Species 18
New Hampshire	Species 19
High mountains of West Virginia	Species 20
Northeastern Oregon	Species 21
Black Hills, South Dakota, and central Colorado	Species 22
Koyukuk River, Alaska, lat. 67° 69', long. 151°	Species 23
Northern Michigan	Species 24
Colorado and Utah	Species 25
Mount Rainier, Washington	Species 26
Maine to Northern Michigan	Species 27
Higher mountains of North Carolina	Species 28

DIVISION II.

New Hampshire to northern Pennsylvania, westward into Minnesota	Species 29
Kaslo, British Columbia	Species 30

TABLE SHOWING RELATIONS OF SPECIES TO HOST TREES.

<i>Pissodes</i> species numbers.	Hosts, etc.
1.	<i>Abies balsamea</i> and <i>A. fraseri</i> . Dying bark on branches and witch's broom.
2.	<i>Abies?</i> (Not observed.)
3.	<i>Picea sitchensis?</i> (Not observed.)
4.	<i>Picea sitchensis</i> . Living bark of terminals and tops of young trees, causing serious injury.
5.	<i>Picea engelmanni</i> . Living bark of terminals and tops of young trees, causing serious injury.
6.	<i>Pinus strobus</i> , common; <i>Pinus rigida</i> , rare; <i>Pinus divaricata</i> , rare; <i>Picea rubens</i> , frequent; <i>Picea excelsa</i> , frequent. Living terminals of saplings and small trees, causing serious damage to white pine.
7.	<i>Pinus strobus</i> , <i>Pinus rigida</i> , <i>Pinus echinata</i> , <i>Pinus resinosa</i> , <i>Pinus virginiana</i> , and <i>Pinus pungens</i> . Living and dying thick and thin bark on base and trunks of standing and felled trees, stumps, and base and stems of saplings. Injurious to the last.
8.	<i>Pinus ponderosa</i> and <i>Pinus scopulorum</i> . Living and dying bark on base, stems, tops (?), and terminals of saplings.
9.	<i>Pinus?</i> (Not observed.)
10.	<i>Pinus palustris</i> , <i>Pinus taeda</i> , <i>Pinus virginiana</i> , and <i>Pinus echinata</i> . Living and dying thick bark on standing and felled trees, stumps, and base and stems of saplings.
11.	<i>Cedrus deodara</i> . Living branches, tops, and terminals, causing serious injury.
12.	<i>Pinus ponderosa</i> . Living thick bark on trunks of small trees, evidently causing scars.
13.	<i>Pinus ponderosa</i> and <i>Pinus lambertiana</i> . Living and dying thick bark on standing and felled trees and stumps and on base and stems of saplings.
14.	<i>Pinus strobiformis</i> , <i>Pinus scopulorum</i> , and <i>Pinus contorta (murrayana)</i> . Living (?) and dying bark on base and stems of saplings and of standing and felled trees.
15.	<i>Pinus radiata</i> and <i>Pinus sylvestris</i> . Thick and dying bark on standing and felled trees and stumps and on base, stems, tops, and tops of saplings.
16.	<i>Pseudotsuga taxifolia</i> . Living and dying thick bark on standing and felled trees and stumps and on base and stems of saplings, causing serious injury to saplings.
17.	<i>Picea sitchensis</i> . Living and dying thick bark on standing girdled trees and stumps of felled ones.

Pissodes
species
numbers.

Hosts, etc.

18. *Picea rubens* and *Picea mariana*. Dying (?) thick bark on logs, stumps, and trunks of small standing trees.
19. *Picea mariana*. Dying bark on trunk of small tree.
20. *Picea rubens*. Dying bark on felled and standing trees.
21. *Pinus contorta* (*murrayana*). Thin bark on standing tree.
22. *Picea canadensis* and *Picea engelmanni*? Dying thick bark on base of standing trees.
23. *Picea*. Thick bark on living trees. (Brunner's notes.)
24. Probably in *Picea rubens*? and *Picea canadensis*? (Not observed.)
25. *Abies lasiocarpa* and *Abies concolor*? Living thick bark on trunks and base of living and dying trees. Injurious.
26. *Abies lasiocarpa* and *Abies concolor*. Living and dying thick bark on living and dying trees.
27. *Abies balsamea*. Living and dying bark on trunks of living and dying trees and snags of storm-broken trees; also in trunks of felled trees.
28. *Abies fraseri*. Living and dying bark on trunks of living and dying trees.
29. *Pinus strobus*. Thick bark on stump.
30. Host not observed; probably pine.

TABLE OF HOST TREES.

Tree species. (Britton classification, 1908.)	Common name.	<i>Pissodes</i> species number
<i>Pinus strobus</i>	White pine.....	6, 7, 29.
<i>lambertiana</i>	Sugar pine.....	13.
<i>strobiformis</i>	Mexican white pine.....	14.
<i>resinosa</i>	Red pine.....	7.
<i>ponderosa</i>	Western yellow pine.....	8, 12, 13.
<i>scopulorum</i>	Rock pine.....	8, 14.
<i>murrayana</i>	Lodgepole pine.....	14, 21.
<i>palustris</i>	Longleaf pine.....	10.
<i>rigida</i>	Pitch pine.....	6, 7.
<i>echinata</i>	Shortleaf pine.....	7, 10.
<i>tæda</i>	Loblolly pine.....	10.
<i>radiata</i>	Monterey pine.....	15.
<i>banksiana</i> (<i>divaricata</i>).....	Gray pine.....	6.
<i>virginiana</i>	Virginia or scrub pine.....	7, 10.
<i>pungens</i>	Table mountain pine.....	7.
<i>sylvestris</i> (introduced).....	Silver pine.....	15.
<i>Picea canadensis</i>	White spruce.....	22, 24?.
<i>rubens</i>	Red spruce.....	6, 18, 20.
<i>mariana</i>	Black spruce.....	19.
<i>excelsa</i> (introduced).....	Norway spruce.....	6.
<i>engelmanni</i>	Engelmann spruce.....	5, 22?, 23.
<i>sitchensis</i>	Sitka spruce.....	3?, 4, 17.
<i>Pseudotsuga mucronata</i> (<i>taxifolia</i>).....	Douglas spruce.....	16.
<i>Abies balsamea</i>	Balsam fir.....	1, 27.
<i>fraseri</i>	Fraser's balsam fir.....	1, 28.
<i>lasiocarpa</i>	White fir.....	25, 26.
<i>concolor</i>	Silver fir.....	25?, 26?.
<i>Cedrus deodara</i> (introduced).....	Deodar cedar.....	11.

CHARACTERS COMMON TO THE SPECIES OF THE GENUS.

Adults.—Prothorax with anterior ventral margin not distinctly emarginate; tibiæ with incurved apical tooth; femora unarmed; anterior coxæ not widely separated; abdominal tergites covered by elytra; sternites 3 and 4 (first and second visible) very long; 5 and 6 short; 7 as long as 5 and 6 together; eyes rounded, widely separated; body oblong, reddish brown to black, sparsely to thickly clothed with slender to broad scales, the latter often forming spots on the pronotum, elytra, and femora.

Sexes.—Females with but 7 visible abdominal tergites; beak longer, smoother, and more slender than in the males. Males with 8 visible abdominal tergites; beak shorter, stouter, less shining, and more distinctly punctured.

Eggs.—Pearly white, slightly oblong, and equally rounded at both ends.

Larvæ.—Elongate, cylindrical, yellowish white, footless; body with 12 closely wrinkled segments, those of the thorax not larger or more permanent than the first abdominal.

Pupæ.—Of the general size and form of the adults, with the beak folded on the mesosterna and metasterna; tips of the posterior tarsi even with tips of wing-pads; head, beak, and abdominal segments armed with spines, the ninth abdominal having 2 rather prominent epipleural spines.

Larval galleries.—Excavated in the inner bark and sometimes marking or grooving the surface of the wood; elongate, winding, and either in the bark or outer wood, ending in pupal cells which are lined with excelsior-like borings.

Host trees.—*Pinus*, *Picea*, *Abies*, *Cedrus*, and *Pseudotsuga*.

Distribution.—Spain and England into eastern Siberia and Japan; America north of Mexico.

CHARACTERS COMMON TO THE SPECIES OF THE MAJOR AND MINOR DIVISIONS.

DIVISION I.

(Species Nos. 1 to 28.)

Adults.—Elytral interspaces 3 and 5 broader and more elevated than 2 and 4.

Sexes.—Hind tibiæ of the males without long fringe of hairs.

Pupæ and larvæ.—Apparently without distinctive divisional characters, so far as observed.

SUBDIVISION A.

(Species Nos. 1 to 16.)

Adults.—Elytra always with a distinct spot of densely placed scales on the anterior lateral area, and always with a spot or band of scales near the vertex of the declivity.

Sexes.—Beak of both sexes usually shorter than the prothorax, rarely longer.

Pupæ.—Eyes with one or more minute spines on the posterior margin.

Larvæ.—The subdivisional characters of the larva have not been recognized.

SECTION a1.

(Species Nos. 1 to 14.)

Adults.—Elytra with distinct spots (instead of a continuous band) near the vertex of the declivity.

Sexes.—Apical margin of the seventh abdominal sternite of the male not sinuate, or rarely so.

Pupæ.—Abdominal tergites with small scutellar spines, alternating with larger ones.

Larvæ.—Median tooth of mandible emarginate.

Host trees.—*Abies*, *Picea*, *Pinus*, and *Cedrus*.

Distribution.—Eastern and western United States, from the Gulf States and Mexico into Canada and British Columbia.

SUBSECTION b1.

(Species Nos. 1 to 3.)

Adults.—Beak moderately stout, shorter than the prothorax; basal angles of pronotum subobtusely; third and fifth elytral interspaces strongly elevated and rugose. In species 1 and 2 the anterior spots on the elytra are distinct, the posterior ones are very large, and the pronotum is distinctly narrower than the elytra, while in species 3 the anterior and posterior spots are indistinct and the pronotum is not distinctly narrower than the elytra.

Sexes.—Apical margin of seventh abdominal sternite of male *not* emarginate.

Host trees.—*Abies*, so far as observed.

Distribution.—Species 1, North Carolina; species 2, British Columbia; species 3, California into Washington.

1. *Pissodes similis* n. sp.

(Plate III, fig. 1.)

The type specimen is labeled "Type No. 7424, U.S.N.M.;" name; "type of drawing; Black Mts., N. C., VI. 27-30; ♀." It was collected by Dr. William Beutenmuller in the spruce forest on

Black Mountain, North Carolina, in 1905. The type and one male are in the type collection of the U. S. National Museum. Three females and one male from the same locality, labeled, respectively, "VI-17," "VI-17," "VI-19," and "VI-30," were returned to the American Museum of Natural History, New York City. A dead specimen was collected by the writer at Camp Caribou, Maine, June 7, 1900, on dead branch of "witch's broom," on balsam fir. Larval mines and pupal cells were observed in adjoining twigs, and another dead specimen was taken at Waterville, N. H., May 4, 1906, from a pupal cell in dead branch of "witch's broom," on balsam fir. Several specimens had emerged from the same branch.

Distinctive characters.—This species is closely allied to *P. utahensis*, from which it is distinguished by the moderately coarse pronotal punctures and the very large posterior spot which extends anteriorly to the middle of the elytra, and is surrounded by a distinct dark border.

Variations.—The specimens vary in length from 3.7 to 4 mm., and in color from light brown to dark brown, with but slight variation in the spots. Eight adult specimens were examined.

Host trees.—*Abies balsamea*; *Abies fraseri*.

Distribution (Plate XIX, fig. 1).—(Hopk.U.S.) *Maine*: Camp Caribou, Parmachene Lake. *New Hampshire*: Waterville. (A.M.N.H.) *North Carolina*: Black Mountains.

2. *Pissodes utahensis* n. sp.

The type specimen is labeled "Type No. 7425, U.S.N.M.;" name; "type of drawing; Park City, Ut., 6.17; Coll. Hubbard & Schwarz; 952; ♂ 1."

Distinctive characters.—This species is closely allied to the preceding, from which it is distinguished by the coarser pronotal punctures and the smaller posterior spots, which do not extend forward to the middle of the elytra and do not have a distinct darker border.

Variation.—There is very little variation in size, but the scales vary from white to a yellowish brown. Five adult specimens, 4 males and 1 female, have been examined.

Host tree.—Unknown, probably *Abies*.

Distribution (Plate XIX, fig. 2).—(U.S.N.M.) *British Columbia*: Bear Lake (London Hill Mine). *Utah*: Alta, Park City.

3. *Pissodes barberi* n. sp.

The type specimen is labeled "Type No. 7426, U.S.N.M.;" name; "Bair's R[an]ch, Redw[oo]d Cr[ee]k; Humboldt Co., Cal., 13.6 [June 13, 1903]; H. S. Barber, collector; 327; ♀ 1."

Distinctive characters.—This species is at once distinguished from all of the other species of the first subdivision by its darker color, the very coarse punctures of the pronotum and elytral striae, the

strongly elevated and acutely rugose third and fifth interspaces of the elytra, and the small posterior spot. The pronotal punctures are also more distinctly separated than in the other species.

Variations.—There is some variation in size—the length ranging from 5 mm. to 5.5 mm.—and in the elytral spots, color of scales, etc. Three adult specimens, 1 female and 2 males, have been examined.

Host tree.—Unknown, probably *Picea*.

Distribution (Plate XIX, fig. 3).—(U.S.N.M.) *California*: Humboldt County. *Oregon*: Astoria. *Washington*: Tenino.

SUBSECTION b2.

(Species Nos. 4 to 14.)

Adults.—The beak is slender and shorter than the prothorax in some species and longer in others. The basal angles of the pronotum are rectangular but not acute. The third and fifth elytral interspaces are moderately to strongly elevated and rugose. Species 4 to 6 have large anterior and posterior spots on the elytra. The sides of the elytra are parallel and the beak is never longer than the prothorax. Species 7 to 14 have small anterior and posterior spots on the elytra; the elytra are slightly narrowed anteriorly and the beak in some of the species is longer than the prothorax. Species 9 to 12 have the third and fifth interspaces of the elytra distinctly elevated and broader than the second and fourth, and the punctures of the pronotum are moderately coarse and densely placed. Species 13 and 14 have the third and fifth interspaces of the elytra only slightly broader than the second and fourth, but strongly elevated and acutely rugose. The pronotum is distinctly narrower than the elytra and the pronotal punctures are very coarse.

Sexes.—In species 4 to 6 the beak of the males is shorter than the thorax and that of the females is rarely longer, while in species 7 to 14 the beak of the males is as long as the prothorax, and in a few cases longer; that of the females is usually longer and often distinctly so.

Pupæ.—The fifth and sixth abdominal tergites of species 4 and 6 have small spines between the prominent dorsal ones, while in species 5 and 7 to 14 they are obscure or absent.

Larvæ.—The apical tooth of the mandibles is acute and the abdominal spiracles are distinct. In species 4, 5, and 7 to 10 the eye spots are distinct, while in species 6 and 14 they are not.

Hosts.—Species 4 and 5, *Picea*; species 6, *Pinus* and *Picea*; species 7, 8, 10, and 12 to 14, *Pinus*; species 11, *Cedrus*.

Distribution.—Species 4, Rocky Mountains; species 5, Pacific coast; species 6 and 7, eastern United States; species 8, northern Rocky Mountains; species 9, Canada; species 10, 11, Southern States; species 12, 13, California; species 14, southern Rocky Mountains.

4. *Pissodes sitchensis* n. sp.

(Plate V, fig. B; Plate XIII; text figs. 5-7.)

The type specimen is labeled "Type No. 7428, U.S.N.M.;" name; "Hoquiam, Wash.; H. E. Burke, collector; ♀; Hopk. U. S. 2289c." The species was described from a large series, including all stages, work, and parasites, collected and reared from terminals.

Distinctive characters. This species is closely allied to *P. engelmanni* and *P. strobi*, from the first of which it is distinguished by the subopaque pronotum, the absence of dark band on the posterior spot of the elytra, and the rather coarse punctures of the elytral striæ; from the latter it is distinguished by its average smaller size and narrower prothorax, as well as by its distribution and habits.

Variations.—There is not very much variation in size—length 5 to 5.3 mm. The color ranges from light to dark brown. The spots of scales vary in size, color, and density, and there is some variation in the relative width of the prothorax and in the size of the punctures of the elytral striæ. More than 200 specimens have been examined, including both sexes, larvæ, pupæ, and work.

Host tree.—*Picea sitchensis*, infesting tops and terminals of saplings and small trees; quite injurious.

Extensive observations have been made by Mr. Burke on the habits and seasonal history of this species.

Distribution (Plate XIX, fig. 4).—(Hopk. U. S.) *Oregon*: Astoria. *Washington*: Hoquiam, North Bend, Pialschie, Satsop.

5. *Pissodes engelmanni* n. sp.

(Plate VI, fig. 5.)

The type specimen is labeled "Type No. 7427, U.S.N.M.;" name; "type of drawing; *Picea engelmanni*; Smith's Ferry, Idaho, Aug. 10, '05; J. L. Webb, collector; ♀ 3; Hopk. U. S. 5314." From a series of 50 adults reared August 23 to November 14 from section of top of spruce containing larvæ and pupæ collected August 10, 1905.

Distinctive characters.—This species is distinguished from the preceding in that the pronotum is shining, the posterior spot of the elytra has a dark border, and the punctures of the elytral striæ are indistinct, especially on the lateral area. From *P. strobi* it is distinguished by its generally smaller size, coarse punctures of the pronotum, and more obscure punctures of the elytral striæ, as also by its distribution, habits, and host.

Variations.—There is very little variation in size. The color ranges from light to dark brown, the spots of scales vary in size, color, and density, and the dark border of the posterior spot from distinct to obscure. The punctures of the pronotum and elytra vary considerably in size and distinctness. More than 150 specimens were examined, including both sexes, larvæ, pupæ, and work.

Host tree.—*Picea engelmanni*, infesting tops and terminals of saplings and small trees; quite injurious.

Extensive observations on the habits and seasonal history of this species have been made by Messrs. Burke and Webb.

Distribution (Plate XIX, fig. 5).—(Hopk. U. S.) *Colorado*: Manitou Park. *Idaho*: Smiths Ferry. *Montana*: Little Belt National Forest.

6. *Pissodes strobi* Peck.

(Plate III, fig. 6; Plate VI, fig. 6; Plate XIV; text figs. 1, 2.)

This species is represented in the collection by a typical specimen labeled with name, "type of drawing; *Pinus strobus*; Webster, N. H.; W. F. Fiske, collector; ♀ 6; Hopk. U. S. 3215b;" by 2 specimens labeled "*Pinus strobus*; Milford, Pa.; A. D. Hopkins, Nov. 14–25, bred; Hopk. U. S. 6077," and by one small specimen labeled "Edsallville, Pa."

Distinctive characters.—This species is most closely allied to *P. engelmanni*, from which it is distinguished by its average larger size, dense punctures of the pronotum and distinct punctures of the elytral striæ, as well as by its distribution and habits.

Variations.—There is considerable variation in size—4.5 to 6 mm. in length—but the average is nearer the latter extreme. The color ranges from dark to light brown. The spots of scales vary considerably in size, density, and color and in the presence or absence of a dark border to posterior lateral spot of the elytra. There is also considerable variation in the form of the pronotum and in the punctures of the pronotum and elytral striæ. More than 500 specimens were examined, including all stages and work.

Host trees.—*Pinus strobus*, *Pinus rigida*, *Pinus divaricata*, *Picea rubens*, and *Picea excelsa*; infesting terminals. Very injurious to white pine, much less so to the other species.

Distribution (Plate XIX, fig. 6).—(Hopk. U. S.) *Connecticut*: Hartford, Pomfret Center. *Maine*: Alfred, Bangor, Portland. *Massachusetts*: Framingham. *Michigan*: Grand Rapids. *New Hampshire*: Colebrook, Dover, Franconia, Keene, Monadnock, Newport, Penacook, Pike, Rochester, Tamworth, Webster, Wiers. *New York*: Kiamesha, Kidders. *North Carolina*: Biltmore (Davidsons River). *Pennsylvania*: Cisuarun, Milford, Mount Airy (Franklin County), Trucksville, Wilkesbarre. *West Virginia*: Kanawha Station, Cairo. *Wisconsin*: Ashland. *Canada*: Ontario—Guelph, Ottawa; New Brunswick—Chatham, Frederickton. (Hopk. W. Va.) *Massachusetts*: Middlesex Falls. *West Virginia*: St. George, Tucker County. (U.S.N.M.) *Massachusetts*: Boston. *Pennsylvania*: Edsallville. *Michigan*: Grand Ledge. *New Hampshire*: Contoocook. *New York*: New Baltimore.

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- Rhynchænus strobi* Peck, 1817, p. 2, pl. 2. Harris, 1841, pp. 63-64.
Pissodes strobi (Peck) Say, 1831, p. 14 (in part). Fitch, 1858, pp. 732-736, pl. 3, fig. 1. Say, 1859, p. 277 (in part). Walsh and Riley, 1869, p. 26, fig. 22. Gemminger and Harold, 1871, p. 2432. Le Baron, 1874, p. 139, fig. 63. Thomas, 1876, pp. 133-134 (in part). Le Conte, 1876, pp. 142-143 (in part). Fuller, 1880, pp. 5-6, fig. 2. Saunders, 1883, p. 55, fig. 23 (in part). Packard, 1886, pp. 322-325, pl. 9 (in part). Lintner, 1888, p. 24, figs. 6, 7. Packard, 1890, pp. 734-741 (in part). Riley and Howard, 1890, p. 348 (parasite); 1891, p. 468 (in part). Lintner, 1893, pp. 344-345, fig. 22 (in part). Hopkins, 1893, p. 205, No. 219 (in part); 1899, pp. 259-260, 345, 441 (in part). Chittenden, 1899, pp. 58-59, figs. 11, 12 (in part). Felt, 1906, pp. 397-401 (in part). Hopkins, 1906, pp. 252-253, figs. 61, 62; 1907, pp. 1-7, figs. 1-6; 1909, pp. 11, 16, 17, figs. 8, 9.

7. *Pissodes approximatus* n. sp.

(Plate VI, fig. 7; Plate XV, figs. A, B.)

The type specimen is labeled "Type No. 7430, U.S.N.M.;" name; "*Pinus strobus*; Lynn Woods, Mass.; A. D. Hopkins, June 11, '06, bred; ♀; Hopk. U. S. 6332." This specimen was reared from larvæ in bark from base of white pine sapling defoliated by the gipsy moth. The type series is represented by a male labeled the same as the type, one labeled "Camb.; Coll. Hubbard & Schwarz; ♂," and 2 males labeled "Marquette, Mich., 27.6; Coll. Hubbard & Schwarz."

Distinctive characters.—This species has been commonly confused with *P. strobi* in collections and literature, but is distinguished from it by the average large size, elongate body, the sides of the elytra more distinctly narrowed posteriorly. The beak is longer, and the spots of the elytra are uniformly smaller, the posterior ones rarely connected. It is also definitely separated by its marked difference in habits. It is distinguished from *P. nemorensis*, to which it is more closely allied, by its average smaller size, shorter beak, and larger posterior brown spot of the elytra, and, except in regions where the two species may overlap, it may be at once distinguished by its distribution. It is distinguished from its closest ally, *P. schwarzi*, by the moderately coarse pronotal punctures.

Variations.—There is much variation in size, the length ranging from 4.3 to 6.7 mm., but extremes are rare. The color ranges from dark brown, nearly black, to brown, but the prevailing color is dark. There is considerable variation in the structure of the pronotum and elytra and in the punctures, spots, etc., but the spots of scales, while variable in size and color, are commonly small, and never as large as in the average *P. strobi*. More than 140 specimens were examined, including all stages and work.

Host trees.—*Pinus strobus*, *Pinus rigida*, *Pinus echinata*, *Pinus resinosa*, *Pinus virginiana*, and *Pinus pungens*, occurring in thick bark on trunks of trees and base of saplings; sometimes injurious to the saplings.

Distribution (Plate XIX, fig. 7).—(Hopk. U. S.). *Maine*: Lake Moxie. *Massachusetts*: Lynn Woods, Springfield. *Michigan*: Grand Island, Munising. *New Hampshire*: Penacook, Waterville, Webster. *North Carolina*: Biltmore, Hendersonville, Pink Beds. *Pennsylvania*: Milford. *Virginia*: Rock Springs. *Wisconsin*: Lac du Flambeau. *Canada*: Guelph.

(Hopk. W. Va.) *West Virginia*: Deckers Creek, Greenbrier County, Greene Spring, Hampshire County, Harpers Ferry, Morgantown, Pendleton County, Romney, Tibbs Run, Tucker County. (U.S. N.M.) *Massachusetts*: Cambridge, Marion, Springfield. *Michigan*: Eagle Harbor, Marquette, Whitefish Point. *New Hampshire*: Durham, Hanover. *New York*: New York City and vicinity. *Wisconsin*: Bayfield.

8. *Pissodes schwarzi* n. sp.

(Plate III, fig. 8; Plate XVI, fig. B.)

The type specimen is labeled "Type No. 7455, U.S.N.M.;" name; "Veta Pass, Col., 24.6; Coll. Hubbard & Schwarz; ♀." This, together with another specimen, a male from the same locality, was evidently collected by Mr. E. A. Schwarz, for whom the species is named. The specimens were found in the United States National Museum under *P. costatus*.

Distinctive characters.—This species is evidently confused in collections under the name *P. costatus*. Specimens of *P. schwarzi* and *P. yosemite* had been referred to *P. costatus* by the writer until the specimens from Sitka spruce were recognized as representing the latter. With possibly a single exception, the specimens referred to by Le Conte under *P. costatus* evidently belonged to *P. yosemite*. *P. schwarzi* is not allied to the specimens I have referred to *P. costatus*. In general appearance it comes nearer *P. yosemite* and *P. webbi*, but according to the character of the fork of the male genitalia it falls in the series with *P. approximatus*, from which it is distinguished by the narrow pronotum with coarse punctures and by the larger posterior spots of the elytra. It is distinguished from *P. webbi* by its relatively broader pronotum, the punctures of which are less coarse and more densely placed, and from *P. yosemite* by the same character; also it is distinguished from both by its distribution.

Variations.—There is quite a wide range of variation in size, the length ranging from 5.2 to 6.7 mm., and in the density of the pronotal punctures, size and density of spots of scales, and relative elevation of elytral interspaces 3 and 5, so that some specimens may be found which appear to connect it with the other species, but it is the writer's opinion that when we know more of the habits and seasonal history of the northern Rocky Mountain *Pissodes* some of the species here included will be found to represent one or more undescribed species, and especially Hopk. U. S. 2386a, which was found ovipos-

iting in the terminal of a pine sapling. Forty-nine specimens have been examined, including all stages and work.

Host tree.—*Pinus ponderosa scopulorum*, in thick bark on trunks of trees, in base of saplings, and possibly in tops and terminals.

Distribution (Plate XIX, fig. 8).—(Hopk. U. S.). *Colorado*: Estes Park. *Idaho*: Centerville. *South Dakota*: Black Hills, Custer, Lead. *Washington*: Buckeye (U.S.N.M.) *Colorado*: Breckenridge, Estes Park, La Veta Pass, Leadville. *Montana*: Helena. *South Dakota*: Custer. *Washington*: Buckeye. *Canada*: Alberta, Banff Springs.

BIBLIOGRAPHY AND SYNONYMY.

Pissodes costatus (not of Mann.) Hopkins, 1906, p. 254, fig. 63.

9. *Pissodes canadensis* n. sp.

The type specimen is labeled "Type No. 7431, U.S.N.M.;" name; "Winnipeg, Man[itoba], Hanham; ♀ 1." This, with two other specimens, a male and a female, were found in the Wickham collection in the United States National Museum under *P. strobi*.

Distinctive characters.—This species may be easily confused with *P. approximatus* by its general external appearance, but the difference in the fork of the male genitalia indicates that it is distinct and more nearly related to *P. nemorensis*. It is distinguished from *P. approximatus* by the somewhat stouter body and prothorax. The alternate interspaces of the elytra are acutely rugose, the posterior spots are more completely fused on the lateral area, and the beak is longer. It is easily separated from *P. nemorensis* by the relatively shorter beak and stouter body and fused posterior spots of the elytra, as also by its distribution.

Variations.—There is not much variation in the three specimens except that the alternating elevated interspaces are less acutely rugose in one specimen than in the other two specimens. Three adult specimens were examined.

Host tree.—Not known, but it is evidently pine.

Distribution (Plate XX, fig. 9).—(U.S.N.M.). (Wickham Collection) *Canada*: Manitoba (Winnipeg).

10. *Pissodes nemorensis* Germar.

(Plate XV, fig. C; text fig. 8, B.)

The species is represented in the collection by a typical specimen labeled with rectangular red label; name; "*Pinus*; Calhoun, Ala.; A. D. Hopkins, Apr. 25, '05, bred; ♀ 1; Hopk. U. S. 1174d."

Distinctive characters.—There seems to be little doubt that this is the long unrecognized species described by Germar in connection with the description of the genus and commonly referred to as synonymous with *P. strobi*, with which it has been confused in col-

lections and literature. The reference in the description to the beak being longer than the prothorax is sufficient to distinguish it from *P. strobi*, and the type locality, "Kentucky," is sufficient to place it within the range of this common southern form. This species is very readily distinguished from *P. strobi* by its average larger size, much longer beak, smaller spots of scales on elytra, and by its habits and general distribution, although the ranges of the two species may overlap in some places. It is distinguished from *P. approximatus* (with which it may occur in the Transition zone around the Appalachian Mountain ranges) by its average larger size, longer beak, the elytra more distinctly narrowed posteriorly, and much smaller posterior brown spot. It is also distinguished from its closest ally (*P. deodaræ*), the only other species known to occupy the Gulf States region, by its average larger size and shorter beak, and by the posteriorly narrowed elytra and more distinctly elevated third and fifth elytral interspaces.

Variations.—There is much variation in size, the length ranging from 4.9 to 7.7 mm., and in color from nearly black to light brown, the darker areas predominating. There is also much variation in all of the structural and sculptural characters and in the size, density, and color of the spots. More than 250 specimens have been examined, including all stages and work.

Host trees.—*Pinus palustris* *Pinus tæda*, *Pinus virginiana*, and *Pinus echinata*, in thick bark on trunks of dying and felled trees, stumps, stems, and base of saplings, etc. Apparently it is not especially injurious.

Distribution (Plate XX, fig. 10).—(Hopk. U.S.) *Alabama*: Calhoun. *District of Columbia*: Langdon, Rock Creek Park. *Georgia*: Demorest, Macon, Thomasville. *Maryland*: Silver Spring. *North Carolina*: Boardman, Tryon. *South Carolina*: Lumber. *Texas*: Deweyville, Houston. *Virginia*: Hawlin, Princess Anne County, Virginia Beach. *West Virginia*: Kanawha Station. (Hopk. W. Va.) *West Virginia*: Lockheart's Run, Roosevelt. (U. S. N. M., under *P. strobi*.) *Alabama*: Prattville. *Florida*: Tallahassee. *Maryland*: Piney Point. *North Carolina*: Retreat, Graybeard Mountains.

BIBLIOGRAPHY AND SYNONYMY.

- Pissodes nemorensis* Germar, 1824, p. 318. Gemminger and Harold, 1871, p. 2431.
Pissodes strobi (not of Peck) Say, 1831, p. 14 (in part). Harris, 1841, p. 63 (in part).
 Say, 1859, p. 277 (in part). Le Conte, 1876, p. 142 (in part). Thomas, 1877, p. 134 (in part). Hopkins, 1893, p. 205, No. 219 (in part); 1899, p. 429 (parasite); 1899, p. 441 (in part).

11. *Pissodes deodaræ* n. sp.

The type specimen is labeled "Type No. 7433, U.S.N.M.;" name; "deodar; Experiment, Ga., Apr. 25, '03; Fiske, Col[lecto]r; ♀; Hopk. U. S. 1641c."

Distinctive characters.—This species is distinguished from *P. nemorenensis* by its average smaller size, longer beak, less distinctly elevated elytral interspaces, and the sides of the elytra more distinctly parallel, but it is more distinctly separated by its habit and host. It is not improbable that this is an example of the origin of species through mutation and change of habit and host.

Variations.—There is considerable variation in size, the length ranging from 4.2 to 5.8 mm., but there is not very much variation in the grayish-brown color or in form, sculpture, and vestiture. In fact, it appears to be more constant in general character than almost any of the other species.

Host tree.—*Cedrus deodara*, in living branches, tops, and terminals, causing serious injury.

Distribution (Plate XX, fig. 11).—(Hopk. U. S.) *Georgia*: Experiment.

12. *Pissodes californicus* n. sp.

The type specimen is labeled "Type No. 7456, U. S. N. M.;" name; "*Pinus ponderosa*: Yosemite Val., Cal., June 13, '04; Hopkins, Col[lecto]r; ♀ 4; Hopk. U. S. 2808a." This specimen was collected by the writer at the same time and place as those referred to *P. yosemite*, and was not recognized at the time as distinct.

Distinctive characters. This species is closely related to *P. nemorenensis*, from which it is at once distinguished by the deeply emarginate anterior margin of the pronotum and by its very different habit and distribution. It is also readily distinguished from *P. yosemite* by the broad, closely punctured pronotum with its emarginate anterior margin and by the broad, flattened, third and fifth elytral interspaces. Indeed, it is so markedly different from any of the other western forms that we feel justified in basing our conclusion as to its distinctness on the single specimen.

Host tree.—*Pinus ponderosa*, in thick bark on living trees, causing serious scars.

Distribution (Plate XX, fig. 12).—(Hopk. U. S.) *California*: Yosemite Valley.

13. *Pissodes yosemite* n. sp.

(Plate XVI, fig. A.)

The type specimen is labeled "Type No. 7434, U. S. N. M.;" name; "*Pinus ponderosa*: Yosemite Val., Cal., June 13, '04; Hopkins, Col[lecto]r; ♂ 1; Hopk. U. S. 2808b." The specimen was collected near Mirror Lake in the thick bark of a tree which was apparently dying from injuries by this and possibly the preceding species.

Distinctive characters.—This species is more closely allied to *P. abbi*, from which it is distinguished by the narrower pronotum with the punctures less densely placed, and by its distribution.

Variations.—There is considerable variation in size, the length ranging from 5.1 to 7 mm., but not much in its reddish-brown color. The spots of whitish scales are usually conspicuous on the sides of the pronotum and near the declivity of the elytra, but there is considerable variation in their size, density, and color. The very coarse punctures of the pronotum and the strongly elevated third and fifth elytral interspaces are quite constant and characteristic. Fifty-one specimens were examined, including adults, larvæ, and work.

Host trees.—*Pinus ponderosa* and *Pinus lambertiana*, in living and dying thick bark on standing and felled trees, stumps, and base and stems of saplings. It is evidently quite injurious.

Distribution (Plate XX, fig. 13).—(Hopk. U. S.) *California*: Sumnerdale and Yosemite. (U. S. N. M.) *California*: Lake Tahoe, Placer County, Siskiyou County, under *P. costatus*. *Washington*: Easton, under *P. fasciatus*.

BIBLIOGRAPHY AND SYNONYMY.

Pissodes costatus (not of Mannerheim) Hopkins, 1906, p. 254, fig. 64.

14. *Pissodes webbi* n. sp.

The type specimen is labeled "Type No. 7459, U. S. N. M.;" name; "*Pinus strobiformis*; bred Nov. 12-7; Sta. Catalina Mts., Ariz.; J. L. Webb, collector; ♀; Hopk. U. S. 5722." The specimen was reared with others from larvæ in thick bark on small felled tree, August 20, 1908. It is named for the collector.

Distinctive characters.—This species is more closely allied to *P. yosemite*, from which it is distinguished by the broader pronotum, with the punctures more closely placed.

Variations.—There is considerable variation in size, the length ranging from 4.8 to 6.8 mm., and in color from nearly black to dark reddish-brown. There is less variation in the spots than usual, which have less white and more of the yellow scales. Over 70 specimens were examined, including all stages and work.

Host trees.—*Pinus strobiformis*, *Pinus scopulorum*, and *Pinus murrayana (contorta)* in living (?) and dying bark on base and stems of saplings and standing and felled trees. It is probably injurious.

Distribution (Plate XX, fig. 14).—(Hopk. U. S.) *Arizona*: Santa Catalina Mountains. *New Mexico*: Capitan Mountains and Cloudcroft.

BIBLIOGRAPHY AND SYNONYMY.

Pissodes strobi (not of Peck) Champion, 1902, p. 119. (May be above species; can not be *P. strobi* Peck.—A. D. H.)

SECTION a2.

SUBSECTIONS b3 AND b4.

(Species Nos. 15 and 16.)

Adults.—Elytra with a transverse band of white and yellow scales instead of a distinct spot near the vertex of the declivity; beak shorter than the prothorax. Species 15 has a broad pronotum with the posterior angles acute, while in species 16 the pronotum is narrow and the angles subrectangular.

Sexes.—Apical margin of seventh abdominal sternite of males not sinuate; beak slightly longer and more slender in the females than in the males.

Pupæ.—Abdominal tergites without distinct small spines alternating with the longer ones. Species 15 has distinct epipleural spines, while species 16 does not.

Larvæ.—Eye spots distinct; apical tooth of mandible obtuse in species 15 and acute in species 16.

Hosts.—Species 15, *Pinus*; species 16, *Pseudotsuga*.

Distribution.—Species 15, coast of California and Washington; species 16, northern California into British Columbia.

15. *Pissodes radiatæ* n. sp.

(Plate III, fig. 15.)

The type specimen is labeled "Type No. 7435, U. S. N. M.; name; *Pinus*; Del Monte, Cal., Sept. 4, '02; A. D. Hopkins, collector; ♀ 4; Hopk. U. S. 1089b." It was reared from a small branch of a transplanted small sapling of *Pinus sylvestris*, collected September 4, 1902, in the grounds of the Del Monte Hotel at Del Monte, Cal.; it was also found in *Pinus radiata*, for which the species is named.

Distinctive characters.—This is a very distinct species, separated from all other North American species by the acute posterior angles of the pronotum. It comes nearer to *P. notatus* of Europe than to any other foreign species, but from this species it is at once distinguished by the strongly elevated third and fifth elytral interspaces.

Variations.—There is considerable variation in size, the length being from 5.1 to 7.4 mm., but not much in color, markings, etc., of the specimens from Monterey and Palo Alto, but the single specimen from Easton, Wash., is small, dark brown, the punctures of the elytra coarser, and the posterior angles of the pronotum very acute. Further specimens from this northern locality and more information relating to their habit and host may show that the northern individuals represent a distinct species. More than 90 specimens have been examined, including all stages and work.

Host trees.—*Pinus radiata* (common) and *Pinus sylvestris* (rare), infesting the thick bark on standing and felled trees and stumps, and the base, stems, and tops of saplings.

Distribution (Plate XX, fig. 15).—(Hopk. U. S.) *California*; Del Monte, Monterey, Palo Alto. (U. S. N. M.) *Washington*: Easton, under *P. fasciatus*.

16. *Pissodes fasciatus* Le Conte.

(Plate III, fig. 16; Plate XVII.)

The species is represented in the collection by a typical specimen labeled with the name "type of drawing; *Pseudotsuga taxifolia*; Hoquiam, Wash.; Burke, collector; ♀; Hopk. U. S. 2064b."

Distinctive characters.—This species is readily distinguished from *P. radiatæ*, to which it is somewhat remotely allied, by the posterior angles being rectangular instead of acute, the third and fifth interspaces less elevated, and also by its habit and host.

Variations.—There is considerable variation in size, from 5.1 to 8.3 mm. in length, and in color from nearly black to reddish and brown; there is also much variation in the size, density, and color of the spots of scales. More than 200 specimens have been examined, including all stages and work.

Host tree.—*Pseudotsuga taxifolia*, living and dying thick bark on standing and felled trees and stumps, and on the base of saplings.

Distribution (Plate XX, fig. 16).—(Hopk. U. S.) *Washington*: Ashford, Keyport, Hoquiam, Meredith, Pialschie. (Webb's collection) *Washington*: Sequim. (U. S. N. M.) *Washington*: Tenino, Easton. *Oregon*: Corvallis, Portland. *British Columbia*: Kaslo, North Bend, Victoria.

BIBLIOGRAPHY.

Pissodes fasciatus Le Conte, 1876, pp. 142-143. Hopkins, 1905, p. 253, figs. 65, 66.

SUBDIVISION B.

(Species Nos. 17 to 28.)

Adults.—Elytra usually without distinct spots on anterior lateral area and with small spots situated between the vertex of the declivity and the median area.

Sexes.—Beak in both sexes rarely shorter than prothorax, commonly much longer, and always distinctly longer in females than in males.

Pupæ.—Eyes without minute spines on posterior margin (so far as observed).

Larvæ.—Without distinctive divisional characters (so far as observed).

Hosts.—*Picea* and *Abies*.

Distribution.—*Section a3*, coast of western Washington to Sitka; *section a4*, Canadian zone, eastern United States from mountains of North Carolina to Canada, and northern Rocky Mountains and Pacific Coast region northward into Alaska.

SECTION a3.

(Species No. 17.)

Adults.—Basal angles of pronotum subrectangular and beak rather stout and moderately long; apical margin of the seventh abdominal sternite of male without apical process, but faintly sinuate.

Pupæ.—Small spines alternating with the longer ones on abdominal tergites and ninth epipleurites with a few bristles.

Larvæ.—Abdominal spiracles obscure; apical tooth of the mandibles acute, the median emarginate, and the eye spots distinct. The host is *Picea sitchensis* from the coast of western Washington to Sitka.

17. *Pissodes costatus* Mannerheim.

This species is represented in the collection by a typical specimen labeled with the name: "*Picea*; Hoquiam, Wash.; A. D. Hopkins, collector; ♀ 2; Hopk. U.S. 2361g." The specimen was reared from among larvæ and pupæ found May 26, 1903, under thick bark in chip cocoons in outer wood of stump of a tree of *Picea sitchensis* felled in 1902. This evidently comes nearer to Mannerheim's species than anything yet recognized, and the fact that it is found in the Sitka spruce is additional evidence.

Distinctive characters.—This is the only representative of the first section (a3) of subdivision B, and therefore is not closely allied to any of the other species of the subdivision. It is distinguished by the closely placed punctures of the pronotum, which become coarser and more distinctly separated toward the posterior lateral section, by the moderately rounded posterior angles of the pronotum, and by the indistinct spots of reddish brown and white scales.

Variations.—The three matured adults examined range in length from 5.5 to 7.1 mm., and in color from dark brown to black. The spots of scales vary in size, color, and density. Three adults and the larva and pupa have been examined.

Host tree.—*Picea sitchensis*, in thick bark on dying and felled trees and stumps.

Distribution (Plate XXI, fig. 17).—(Hopk. U. S.) *Washington*: Hoquiam. *Alaska*: Sitka (the type locality).

BIBLIOGRAPHY.

Pissodes costatus Mannerheim, 1852, p. 354 (reprint p. 71).

SECTION a4.

(Species Nos. 18 to 28.)

Adults.—Basal angles of pronotum rounded; beak slender and moderately to very long.

Species 18 to 24 have the punctures of the pronotum distinctly separated and the punctures of the elytral striae small to coarse. In species 18 to 21 the pronotum is not distinctly narrower than the elytra. Species 18 has a short, stout pronotum with the sides strongly rounded and constricted toward the anterior margin, the elytral interspaces with rather coarse rugosities. Species 19 to 21 have a more elongate pronotum with rounded sides but not distinctly constricted toward the head, and the elytral interspaces have fine rugosities. In species 22 to 24 the pronotum is distinctly narrower than the elytra. Species 25 to 28 have the punctures of the pronotum irregular in size and not distinctly separated and the striae punctures are very coarse and irregular. In species 25 and 26 the striae punctures are very irregular in size, the elytral spots moderately distinct, and the pronotum not distinctly narrower than the elytra. In species 27 and 28 the striae punctures are moderately irregular, the elytral spots are evident but small, and the pronotum is distinctly narrower than the elytra.

Sexes.—In species 18 the apical margin of the seventh abdominal sternite of the males is sinuate but without median process, while in species 20 there is a distinct median process, and in species 25 to 28 the apex is uniformly rounded as in the females.

Pupæ.—The fourth and fifth abdominal tergites have two small spines between the more prominent dorsal ones. In species 26 the rostrum is without a pair of spines between the middle and apex, while in 27 they are present. Head without distinct eye spots (so far as observed).

Larvæ.—In species 18 the abdominal spiracles are moderately distinct, the apical tooth of the mandibles obtuse, and the median tooth triangular. In species 20 the apical tooth is acute, and the median tooth is emarginate. In species 26 to 28 the abdominal spiracles are obscure. In species 26 the apical tooth is acute and the middle tooth triangular. In species 27 the apical tooth is acute and the median one emarginate, while in species 28 the apical tooth is obtuse and the median one emarginate.

Hosts.—Species 18, 19, 20, *Picea*; species 21, *Pinus*; species 22, *Picea*; species 25, 26 and 27, *Abies*.

Distribution.—Species 18, 19, 20, and 28, Canadian zone, West Virginia and New Hampshire; species 21 and 26, Cascade Mountains, Oregon and Washington; species 22 and 25, central Rocky Mountains; species 23, Alaska (Arctic Circle); species 24, northern Michigan; species 27, Maine to northern Michigan.

SUBSECTION b5.

(Species Nos. 18 to 24.)

18. *Pissodes fiskei* n. sp.

(Plate III, fig. 18; Plate XII.)

The type specimen is labeled "Type No. 7438, U.S.N.M.;" name; "type of drawing; *Picea*; Franconia, N. H., Oct. 16, '07; W. F. Fiske, collector; ♀ 1; Hopk. U. S. 3309." It was reared with other specimens from a section of a small spruce tree scorched by fire, collected October 16, 1907.

Distinctive characters.—This is a very distinct species, and may be known from its nearest ally, *P. nigræ*, by the strongly elevated third and fifth elytral interspaces, and the larger yellow posterior spot of densely placed scales, with no trace of an anterior spot. It is at once distinguished from *P. similis*, which may be associated with both species in the bark of the same tree, by its large size, short pronotum, and long beak.

Variations.—There is not much variation in size, the length ranging from 4.2 to 5.2 mm., nor in other characters. Eight specimens of adults and work were examined.

Host trees.—*Picea rubens* and *Picea mariana*, in thick bark on logs and trunks of small standing trees.

Distribution (Plate XXI, fig. 18).—(Hopk. U. S.) *New Hampshire*: Rye.

BIBLIOGRAPHY AND SYNONYMY.

Pissodes strobi (not of Peck) Packard, 1890, pp. 829–830. (Probably *P. fiskei* Hopk.—A. D. H.)

19. *Pissodes nigræ* n. sp.

The type specimen is labeled "Type No. 7458, U.S.N.M.;" name; "*Picea nigra*; Webster, N. H.; W. F. Fiske, collector; Hopk. U. S. 3725a." It was taken from a section of the trunk of a small dead tree, collected May 3, 1906.

Distinctive characters.—This species is distinguished from *P. fiskei* by the much less elevated and less rugose interspaces, longer beak, and small to obscure anterior white spot on the elytra. From *P. puncticollis* it is distinguished by its darker color, stout pronotum, and less distinctly elevated elytral interspaces. It is at once distinguished from *P. similis* by its long beak.

Variations.—The length varies from 4.4 to 6.6 mm. There is very little variation in the color. The anterior spots are obscure in some specimens and the posterior ones vary from yellowish to white.

Host tree.—*Picea mariana*.

Distribution (Plate XXI, fig. 19).—(Hopk. U. S.) *New Hampshire*: Webster.

20. *Pissodes puncticollis* n. sp.

(Plate IV, fig. 20.)

The type is labeled "Type No. 7437, U.S.N.M.;" name; "type of drawing; *Picea*; Randolph Co., W. Va.; A. D. Hopkins, collector; ♀ 1; Hopk. W. Va. 70." It was taken from the dead bark of a spruce log collected August 25, 1890.

Distinctive characters.—Closely allied to *P. murrayanæ*, but distinguished by its light reddish-brown color, irregular and less dense pronotal punctures, and larger size, with the alternating interspaces less distinctly elevated, an anterior spot present, and the posterior spot distinct.

Variations.—The length varies from 4.2 to 6.1 mm.; there is very little variation in the color. The anterior white spot, which is small and situated on the fourth interspace, is obscure in two specimens and situated on the fifth stria in the others. Four adults and 1 larva were examined.

Host tree.—*Picea rubens*, in dying bark on felled and standing trees.

Distribution (Plate XXI, fig. 20).—(Hopk. W. Va.) *West Virginia*: Cheat Bridge, Randolph County, Bayard, Tucker County.

21. *Pissodes murrayanæ* n. sp.

The type specimen is labeled "Type No. 7436, U.S.N.M.;" name; "*Pinus murrayana*; Wallowa, Oreg.; A. D. Hopkins, Apr. 10, '07, bred; Hopk. U. S. 6560a." It was reared from the section of a small tree received from correspondent, H. K. O'Brien, February 14, 1907.

Distinctive characters.—The single imperfect specimen representing this species is closely allied to *P. puncticollis*, from the type of which it is distinguished by its dark brown color, very small posterior spot, absence of an anterior spot, regular pronotal punctures, and broad third elytral interspace. It is probable that more specimens will show a wider range of variation from those of *P. puncticollis*.

Host tree.—*Pinus murrayana*, in thin bark.

Distribution (Plate XXI, fig. 21).—(Hopk. U. S.) *Oregon*: Wallowa.

22. *Pissodes coloradensis* n. sp.

The type specimen is labeled "Type No. 7439, U.S.N.M.;" name; "Leadville, Colo., H. F. Wickham, July 7-14, '96, 10,000-11,000 ft.; ♀; C. L. 39." (Abdomen removed and mounted on separate pin. Labeled "C L 39 ♀.") Specimen from Wickham's collection in the United States National Museum.

Distinctive characters.—Pronotum distinctly narrower than elytra and punctures irregular, not dense. Elytral scales distinct, giving

the surface a grayish appearance. Posterior spot prominent, this readily distinguishing it from its nearest allies, *P. alascensis* and *P. rotundatus*.

Variations.—Length 7.4 to 9.4 mm. The color ranges from dark brown to black. The color and density of the scales vary as usual, as do also the elevation and rugosities of the alternating interspaces, striae punctures, etc. Twenty-seven specimens of adults were examined.

Host trees.—*Picea canadensis* in the Black Hills of South Dakota. It will evidently be found also in *Picea engelmanni*.

Distribution (Plate XXI, fig. 22).—Black Hills of South Dakota; central Colorado.

23. *Pissodes alascensis* n. sp.

The type specimen is labeled "Type No. 7459, U.S.N.M.;" name; "Koyukuk R., Alas., Lt. 67-69, Lg. 151, summer 1901; W. J. Peters, collector."

Distinctive characters.—The darker color and closely placed yet separated pronotal punctures, sparse elytral scales, and small posterior spot on the elytra serve to distinguish the single specimen of this species from *P. coloradensis*, and the distinctly elevated and rugose elytral punctures distinguish it from *P. rotundatus*. One specimen only was examined.

Host tree.—Probably *Picea*.

Distribution (Plate XXI, fig. 23).—(Hopk. U. S.) *Alaska*: Koyukuk River, Arctic Circle.

24. *Pissodes rotundatus* Le Conte.

(Plate IV, fig. 24.)

This species is represented in the collection by a typical specimen labeled with name: "Marquette, Mich., 4, 7 [July 4]; Coll. Hubbard & Schwarz; ♀ 4."

Distinctive characters.—This species is closely allied to *P. alascensis* from which it is distinguished by the densely placed punctures of the pronotum and the broad and not strongly elevated third and fifth elytral interspaces, which also serve to distinguish it from *P. coloradensis*.

Variations.—The length varies from 6 to 7.3 mm.; there is not much variation in color except as it may be modified by the more numerous white scales on some specimens. Seven specimens of adults were examined.

Host trees.—Probably *Picea rubens* (?) and *Picea canadensis* (?).

Distribution (Plate XXI, fig. 24).—(U.S.N.M.) (H. & S.) *Michigan*: White Fish Point, Marquette, June and July.

BIBLIOGRAPHY.

Pissodes rotundatus Le Conte, 1876, pp. 142, 143-144. Hopkins, 1906, pp. 254, 256, fig. 69.

SUBSECTION b6.

Species Nos. 25 to 28.)

25. *Pissodes burkei* n. sp.

(Plate IV, fig. 25.)

The type specimen is labeled "Type No. 7440 U.S.N.M.;" name; "above Ouray, Colo., 9,000-10,000 ft., Mineral Point Trail, VII, 1897, H. F. Wickham; ♀ 4." From Wickham's collection. Additional specimens collected and host tree determined by H. E. Burke.

Distinctive characters.—This species is quite distinct from *P. rotundatus* but is more closely allied to *P. piperi*, from which it is distinguished by its decidedly grayish appearance and the distinct posterior spot of the elytra.

Variations.—The length varies from 6 to 7.7 mm., but there is comparatively little variation in the color, except in rubbed specimens which are darker. Thirty-two specimens were examined, including all stages and work.

Host tree.—*Abies lasiocarpa*, in thick bark on living and dying trees.

Distribution (Plate XXII, fig. 25).—(Hopk. U. S.) *Utah*: Kamas (Burke, collector). (U.S.N.M.) (H. & S.) *Utah*: Alta and Park City, June (under *P. costatus*). *Colorado*: Ouray (Wickham).

26. *Pissodes piperi* n. sp.

(Plate IV, fig. 26; Plate V, fig. A; Plate XVIII; text fig. 8, A.)

The type specimen is labeled "Type No. 7441, U.S.N.M.;" name; "type of drawing; Mt. Rainier, Wash.; collector, C. V. Piper; ♀ 1." Additional specimens were collected and host trees determined by Messrs. H. E. Burke and J. L. Webb.

Distinctive characters.—This species is at once distinguished from *P. burkei* by its large size, dark color, sparsely placed elytral scales, small posterior spot, and very coarse and deep punctures of elytral striæ.

Variations.—The length varies from 7.4 to 10 mm. and the posterior spots of the elytra vary from obscure to distinct. Five adults and 128 specimens examined, including all stages and work.

Host trees.—*Abies lasiocarpa* and *Abies concolor*, in thick bark on trunks of living (?) and dying trees.

Distribution (Plate XXII, fig. 26).—(Hopk. U. S.) *Washington*: Paradise Valley. *Idaho*: Centerville. (U.S.N.M.) (H. & S.) *British Columbia*: Glacier. *Washington*: Mt. Rainier.

27. *Pissodes dubius* Randall.

(Plate IV, fig. 27.)

This species is represented in the collection by a typical specimen labeled with the name; "Marquette, Mich., 27.6 [June 27]; Coll. Hubbard & Schwarz; ♀ 1."

Distinctive characters.—This species is closely allied to *P. fraseri*, from which it is distinguished by its medium size, moderately long beak, and the regular convex pronotum without broad impressions.

Variations.—The length varies from 4.8 to 5.7 mm. and as usual there is considerable variation in color due to rubbed and immature specimens. Forty-one specimens were examined, including all stages and work.

Host tree.—*Abies balsamea*, in thick living and dying bark on trunks of living and dying trees and stumps of storm-broken trees.

Distribution (Plate XXII, fig. 27).—(Hopk. U. S.) *Maine*: Lake Parmachene, Beaver Pond (Boil Mountain). *New Hampshire*: Dartmouth College, Fabyan, Waterville. *Michigan*: Grand Island. (U.S.N.M.) (H. & S.) *Michigan*: Marquette and White Fish Point.

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Pissodes dubius Randall, 1838, pp. 24-25. Le Conte, 1876, pp. 142, 143. Hopkins, 1906, pp. 254, 256, fig. 67. Felt, 1906, p. 401.

28. *Pissodes fraseri* n. sp.

(Plate VI, fig. 28; text fig. 9.)

The type specimen is labeled "Type No. 7442, U.S.N.M.;" name; "Pisgah Mt., N. C., altitude 5,000 ft.; A. D. Hopkins, collector; ♀; Hopk. U. S. 2868." It was collected June 29, 1904. Adults were common, pupæ frequent, and larvæ rare in pupal cells in inner bark on trunk of large Fraser fir tree, which had evidently died from root disease.

Distinctive characters.—Closely allied to *P. dubius*, from which it is distinguished by its large size, very long beak, and the moderately convex pronotum with basal and oblique subdorsal impressions.

Variations.—The length varies from 4.6 to 9.1 mm. and there is considerable variation in color, size of spots and punctures, length of beak, and impressions of pronotum. One hundred and six specimens were examined, including all stages and work.

Host tree.—*Abies fraseri*, thick living and dying bark on trunks of living and dying trees.

Distribution (Plate XXII, fig. 28).—(Hopk. U. S.) *North Carolina*: Pisgah Mountains (Silver Mountain). (A.M.N.H.) *North Carolina*: Black Mountains (Beutenmüller).

DIVISION II.

(Species Nos. 29 and 30.)

Adults.—Third and fifth elytral interspaces not broader or more elevated than second and fourth. Beak shorter than prothorax, slender. Pronotum broad, with sides behind the middle nearly parallel with the basal angles, rectangular. Punctures of elytral striae moderately coarse, regular.

Sexes.—Posterior tibiae of the males fringed with long hairs. Apical margin of the seventh abdominal sternite of the males with a truncate process arising from a deep emargination.

Pupæ.—Fourth and fifth abdominal tergites with two small spines between the more prominent dorsal ones. Rostrum with a pair of small spines between the apex and the middle.

Larvæ.—Not known.

Host.—*Pinus*.

Distribution.—Species 29, New Hampshire to northern Pennsylvania, westward into Minnesota; species 30, British Columbia.

29. *Pissodes affinis* Randall.

(Plate IV, fig. 29; Plate VI, fig. 29.)

This species is represented in the collection by a typical specimen labeled with name; "Marquette, Mich., 26.6 [June 26]; Coll. Hubbard & Schwarz; ♀ 2."

Distinctive characters.—This species is at once distinguished from all of the preceding ones of the genus by the equal width of the elytral interspaces, the third and fifth of which are not elevated; and from its nearest ally (*P. currici*) by the long posterior spot on the elytra and by the moderately coarse stria punctures.

Variations.—The length varies from 5.5 to 8 mm., and while the sculpture and color are quite constant there is considerable variation in the spots of scales, both in color and density. Twenty-nine adult specimens were examined.

Host tree.—*Pinus strobus*, in thick bark on stump. (As determined by W. F. Fiske.)

Distribution (Plate XXII, fig. 29).—(Hopk. U. S.) (Fiske collector) *New Hampshire*: Webster or Penacook. (U.S.N.M.) *Minnesota*. (H. & S.) *Michigan*: Marquette (June and July); Eagle Harbor (Wickham). *Wisconsin*: Bayfield. *New Hampshire*: Hampton. *New York*: Ithaca (Chittenden). *Pennsylvania*: *Massachusetts*.

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Pissodes affinis Randall, 1838, p. 24. Le Conte, 1876, pp. 142, 143. Schwarz, 1889, p. 176 (male character). Hopkins, 1906, pp. 254, 256, fig. 68. Felt, 1906, p. 402.

30. *Pissodes curriei* n. sp.

(Plate VI, fig. 30.)

The type specimen is labeled "Type No. 7443, U.S.N.M.;" name; "Kaslo, B. C., 2.7 [July 2, 1903]; R. P. Currie, collector; ♂ 1."

Distinctive characters.—This species is distinguished from *P. affinis* by the very sparsely placed scales, the obscure anterior spots, the small posterior spot on the elytra, and the coarse and deep striae punctures.

Variations.—The length varies from 5.6 to 7.7 mm. There is very little variation in sculpture, spots of scales, etc. Seven adult specimens were examined.

Host tree.—Unknown, probably *Pinus*.

Distribution (Plate XXII, fig. 30).—(U.S.N.M.) *British Columbia*: Kaslo.

LIST OF DESCRIBED SPECIES OF *PISSODES*.^a

Species No.	Name.	Habitat.	Host.
1.	<i>similis</i> Hopkins.....	North America.....	<i>Abies</i> .
2.	<i>utahensis</i> Hopkins.....	North America.....	<i>Abies</i> .
3.	<i>barberi</i> Hopkins.....	North America.....	<i>Picea</i> .
4.	<i>sitchensis</i> Hopkins.....	North America.....	<i>Picea</i> .
5.	<i>engelmanni</i> Hopkins.....	North America.....	<i>Picea</i> .
6.	<i>strobi</i> Peck.....	North America.....	<i>Pinus</i> and <i>Picea</i> .
	<i>validirostris</i> Gyllenhal.....	Europe.....	<i>Pinus</i> (cones).
7.	<i>approximatus</i> Hopkins.....	North America.....	<i>Pinus</i> .
8.	<i>schwarzi</i> Hopkins.....	North America.....	<i>Pinus</i> .
9.	<i>canadensis</i> Hopkins.....	North America.....	
10.	<i>nemorensis</i> Germar.....	North America.....	Pine.
11.	<i>deodaræ</i> Hopkins.....	North America.....	Pine.
12.	<i>californicus</i> Hopkins.....	North America.....	<i>Pinus</i> .
13.	<i>yosemite</i> Hopkins.....	North America.....	<i>Pinus</i> .
14.	<i>webbi</i> Hopkins.....	North America.....	<i>Pinus</i> .
	<i>notatus</i> Fabricius.....	Europe.....	<i>Pinus</i> , <i>Picea</i> , <i>Larix</i> (trunk).
15.	<i>radiatæ</i> Hopkins.....	North America.....	<i>Pinus</i> .
16.	<i>fasciatus</i> Le Conte.....	North America.....	<i>Pseudotsuga</i> .
	<i>scabricollis</i> Miller.....	{Austria..... Hungary..... Bohemia.....}	<i>Picea</i> (tops).
17.	<i>costatus</i> Mannerheim.....	North America.....	<i>Picea</i> .
18.	<i>fiskei</i> Hopkins.....	North America.....	<i>Picea</i> .
	<i>obscurus</i> Reclus.....	Japan.....	
19.	<i>nigræ</i> Hopkins.....	North America.....	<i>Picea</i> .
20.	<i>puncticollis</i> Hopkins.....	North America.....	<i>Picea</i> .
21.	<i>murrayanæ</i> Hopkins.....	North America.....	<i>Pinus</i> .
22.	<i>coloradensis</i> Hopkins.....	North America.....	<i>Picea</i> ?
23.	<i>alascensis</i> Hopkins.....	North America.....	<i>Picea</i> ?
	<i>hareyniæ</i> Herbst.....	Europe.....	<i>Picea</i> (twigs).

^a North American species are numbered; foreign species are without numbers.

Species No.	Name.	Habitat.	Host.
24.	<i>rotundatus</i> Le Conte.....	North America.....	<i>Picea</i> .
	<i>rotundicollis</i> Desbrochers.....	Russia.....	
25.	<i>burkei</i> Hopkins.....	North America.....	<i>Abies</i> .
26.	<i>piperi</i> Hopkins.....	North America.....	<i>Abies</i> .
	<i>piceæ</i> Illiger.....	Middle Europe.....	<i>Abies</i> (twigs and trunk).
27.	<i>dubius</i> Le Conte.....	North America.....	<i>Abies</i> .
28.	<i>fraseri</i> Hopkins.....	North America.....	<i>Abies</i> .
	<i>insignatus</i> Boheman.....	Siberia.....	<i>Pinus, Larix</i> .
	<i>piniphilus</i> Herbst.....	Europe.....	Pine (terminals and trunk).
	<i>irroratus</i> Reitter.....	Siberia.....	
	<i>cembrae</i> Motschulsky.....	East Siberia.....	<i>Pinus</i> .
	<i>gyllenhalii</i> Gyllenhal.....	{Europe..... Siberia.....	
	<i>pini</i> Linnæus.....	Europe.....	<i>Pinus</i> (thick bark), <i>Picea, Larix</i> .
29.	<i>affinis</i> Randall.....	North America.....	<i>Pinus</i> .
30.	<i>curriei</i> Hopkins.....	North America.....	

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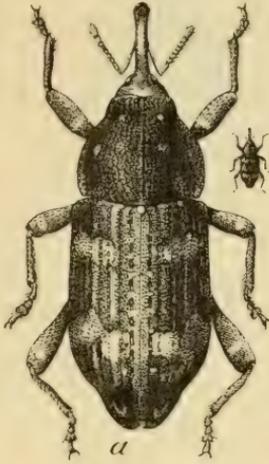
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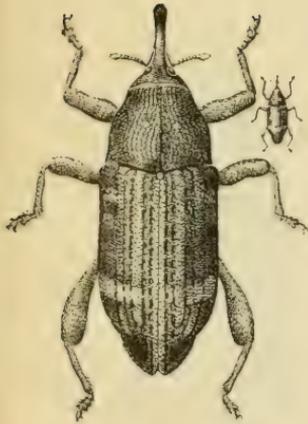
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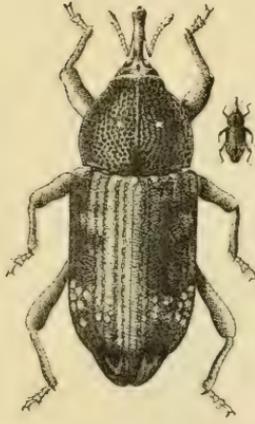
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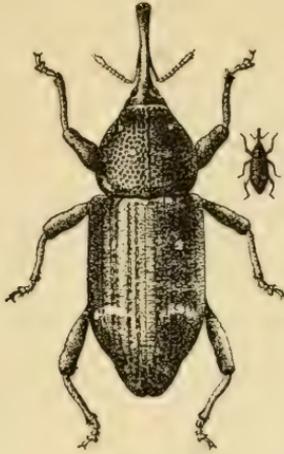
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ADULTS OF PISSODES.

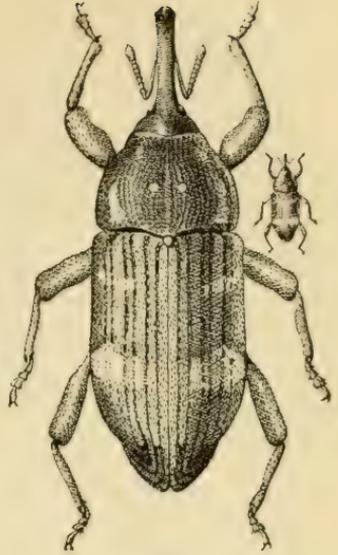
Fig. 1.—*P. similis*. (Original.) Fig. 6.—*P. strobi*. (Author's illustration.) Fig. 8.—*P. schwarzi*. (Author's illustration.) Fig. 15.—*P. radiatze*. (Original.) Fig. 16.—*P. fasciatus*. (Author's illustration.) Fig. 18.—*P. fiskei*. (Original.)



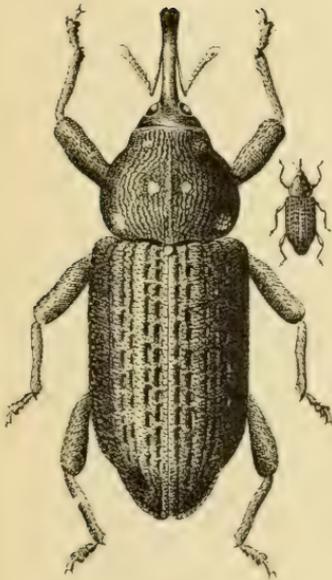
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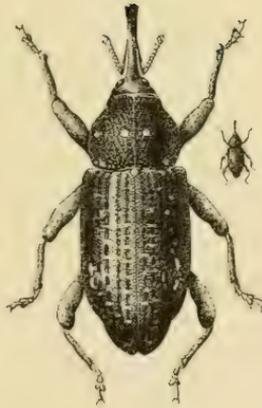
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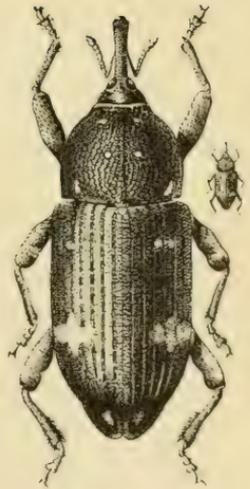
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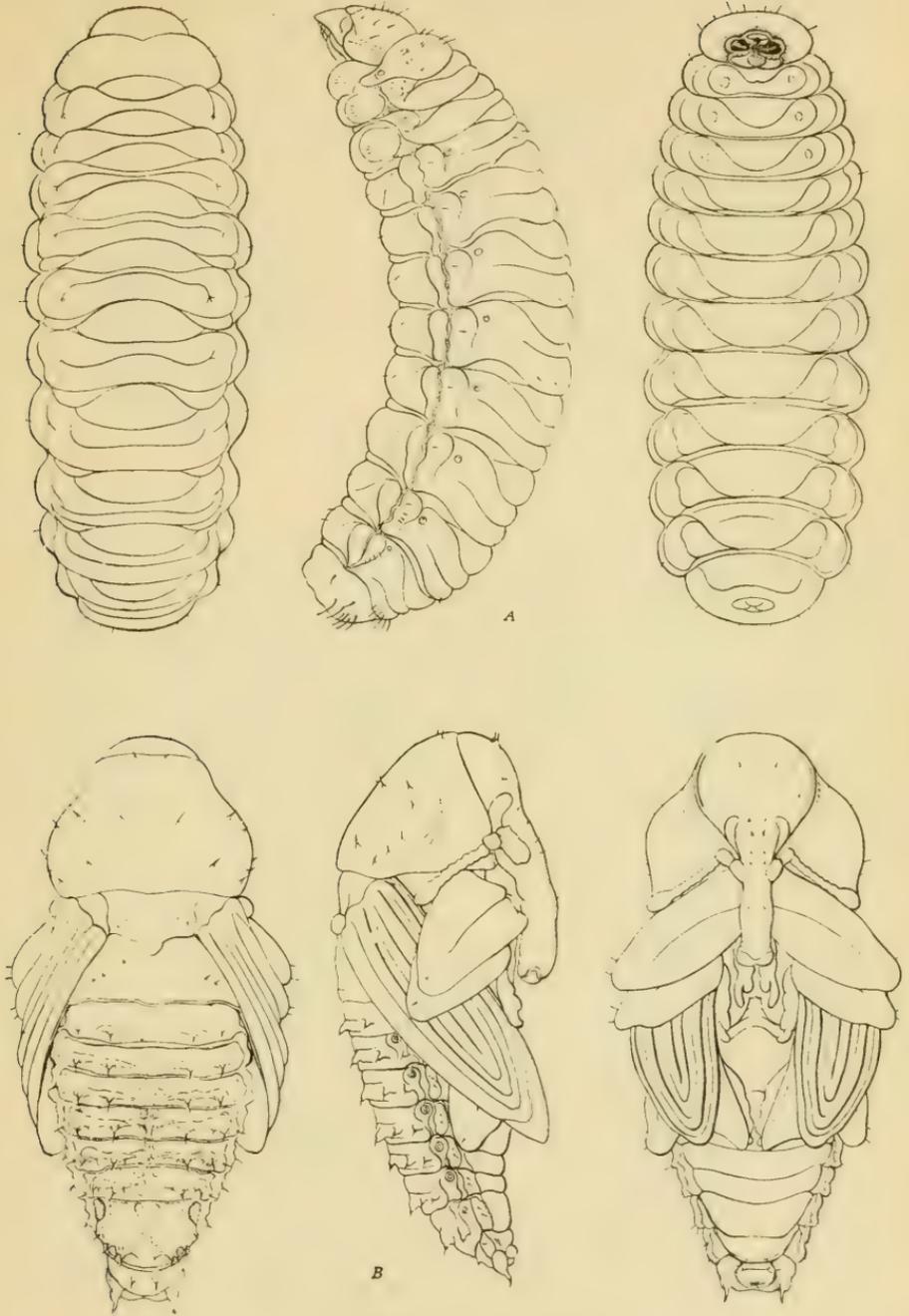
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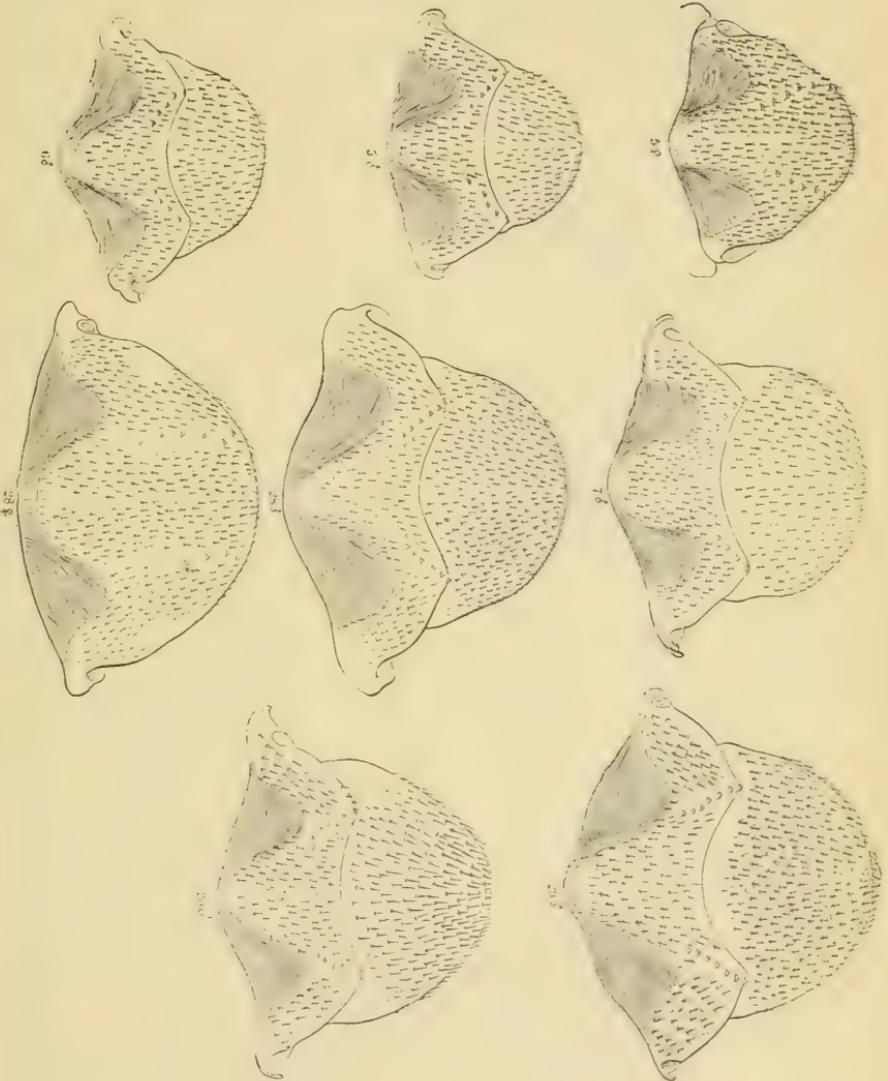
ADULTS OF PISSODES.

Fig. 20.—*P. puncticollis*. (Original.) Fig. 24.—*P. rotundatus*. (Author's illustration.) Fig. 25.—*P. burketi*. (Original.) Fig. 26.—*P. piperi*. (Original.) Fig. 27.—*P. dubius*. (Author's illustration.) Fig. 29.—*P. affinis*. (Author's illustration.)



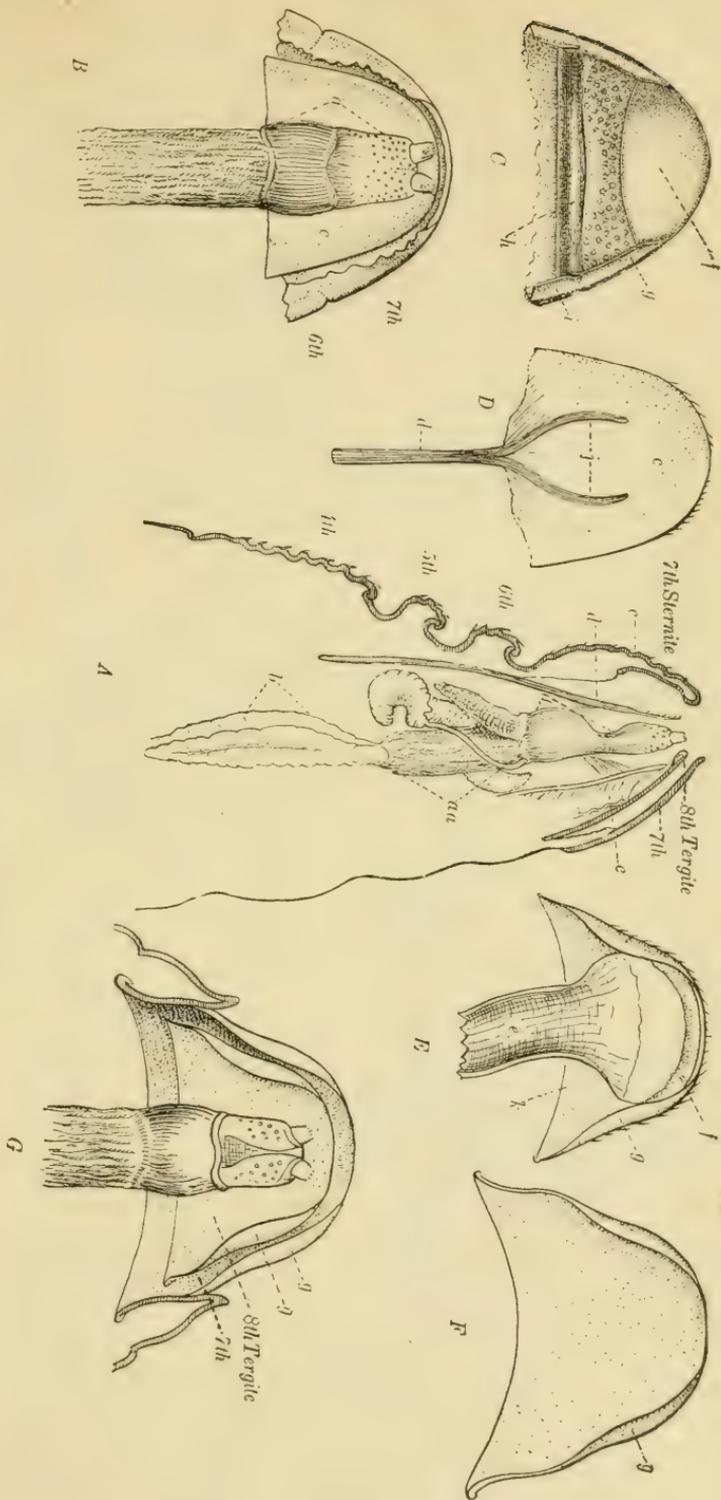
LARVA AND PUPA OF PISSODES.

A.—Larva of *P. piperi*, dorsal, lateral, and ventral aspects. B.—Pupa of *P. sitchensis*, dorsal, lateral, and ventral aspects. (Original.)



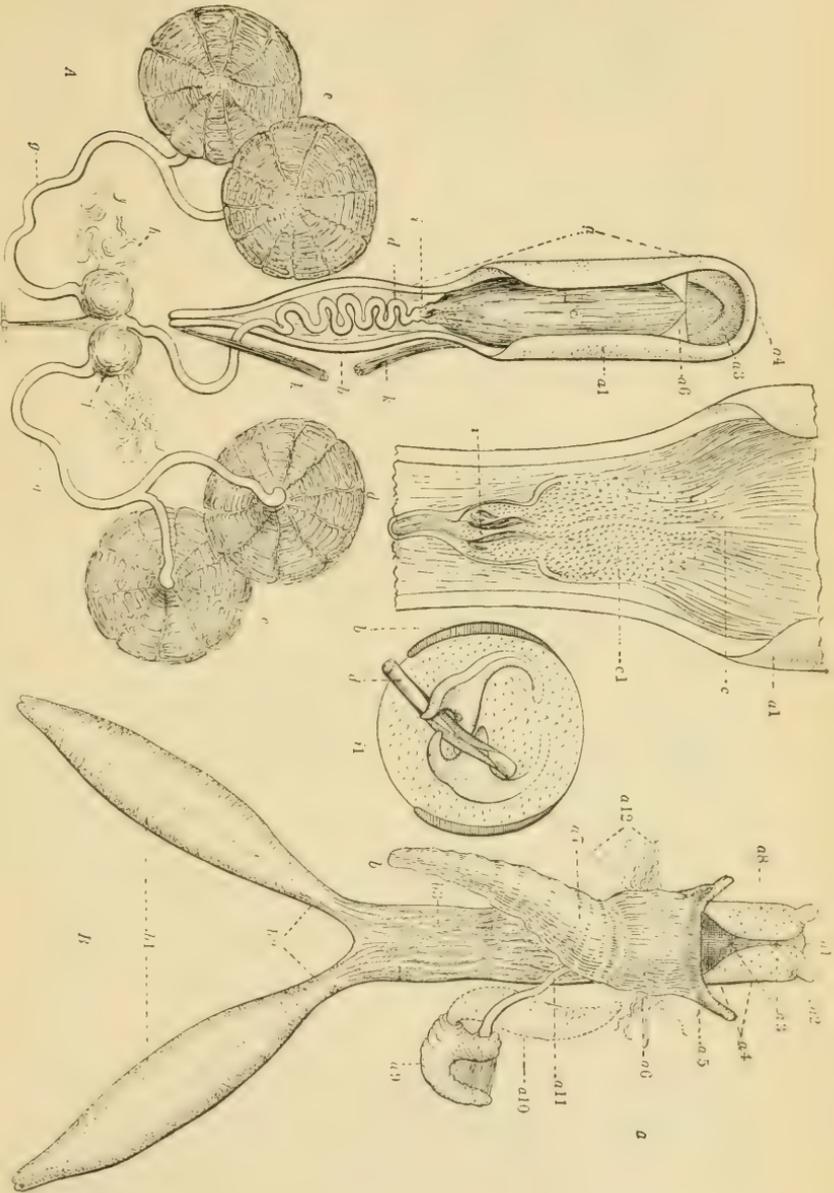
PYGAL TERGITES OF THE ABDOMEN OF PISSODES.

Fig. 29, 30, 31.—Tergites 7 and 8 of *P. engelmanni*. Fig. 29, 30, 31.—Tergites 7 and 8 of *P. engelmanni*. Fig. 32, 33, 34.—Tergites 7 and 8 of *P. strobi*.
Fig. 35, 36.—Tergites 7 and 8 of *P. approximatus*. Fig. 35, 36.—Tergites 7 and 8 of *P. approximatus*. Fig. 37.—Tergite 7 of
P. foveolatus. Fig. 37, 38.—Tergites 7 and 8 of *P. affinis*. Fig. 39, 40.—Tergites 7 and 8 of *P. curvatus*. (Original.)



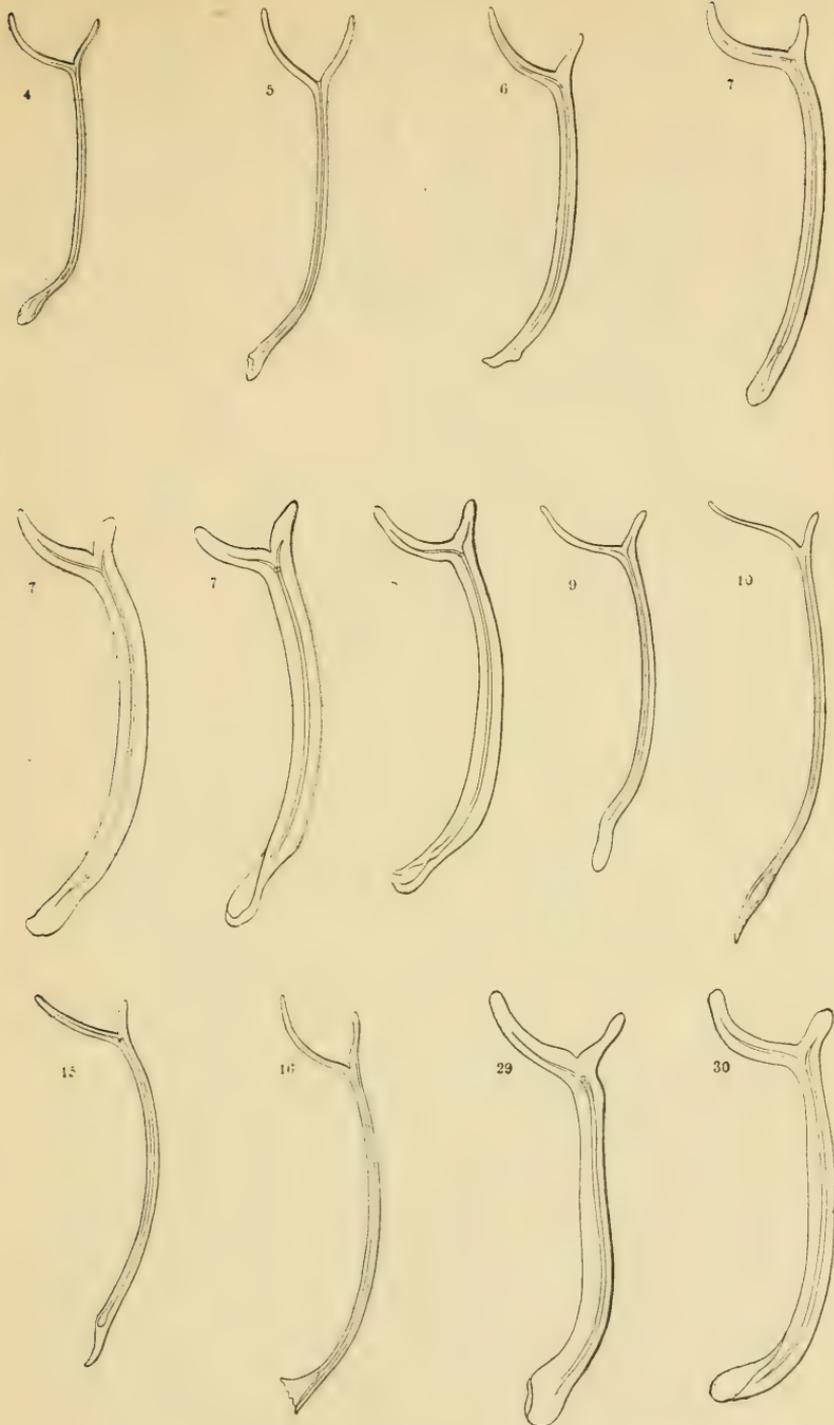
FEMALE REPRODUCTIVE ORGANS OF PISSODES.

4.—Longitudinal section of abdomen showing relative positions of parts, and lateral aspect of the female organs: *a*, posterior section of genitalia; *aa*, median section; *b*, posterior section and ovaries; *c*, genital plate or ninth sternite; *d*, apodeme of the ninth sternite; *e*, rectum. *B*.—Dorsal aspect of posterior part of organs showing relation to abdominal sternites. *C*.—Dorsal aspect of seventh sternite and junction with sixth sternite; *f*, hypopleurite 7; *h*, sutural fold; *i*, hypopleurite 6. *D*.—Dorsal aspect of eighth sternite; *e*, genital plate; *d*, apodeme; *j*, fork. *E*.—Dorsal aspect of eighth tergite; *e*, 4, Rectum; *f*, ventral fold; *g*, epipleurite 8. *F*.—Ventral aspect of seventh tergite; *g*, Epipleurite 7. *G*.—Ventral aspect of anterior section of organs and relations to seventh and eighth tergites. (Original.)



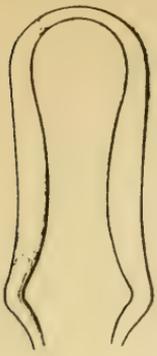
MALE AND FEMALE REPRODUCTIVE ORGANS OF PISSEDES.

A.—Male genitalia: *a*, Body; *a1*, lateral fold; *a3*, apical opening; *a4*, apex; *b*, femora or apodemes; *c*, ejaculatory duct; *c1*, denticulate area; *d*, seminal duct; *e*, testes; *f*, seminal vesicle; *g*, vas deferens; *h*, mucous glands; *l*, seminal valve; *l1*, transverse section, greatly enlarged, showing approximate structure of young adult; *b1*, Ovaries (immature); *b2*, paired oviducts; *b3*, unpaired oviduct; *a1*, anal opening of ovipositor; *a2*, genital papillae; *a3*, ventral canal; *a4*, ovipositor; *a5*, vaginal opening; *a6*, vagina; *a7*, bursa copulatrix; *a8*, latero-ventral fold; *a9*, spermatheca; *a10*, spermathecal gland; *a11*, seminal duct; *a12*, mucous glands. (Original.)

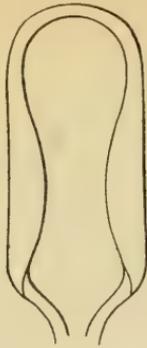


FORKS OF MALE GENITALIA OF PISSODES.

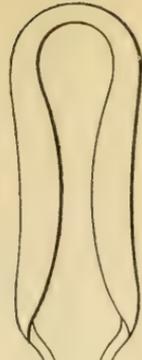
Fig. 4.—*P. sitchensis*. Fig. 5.—*P. engelmanni*. Fig. 6.—*P. strobi*. Fig. 7.—*P. approximatus*.
 Fig. 8.—*P. schwarzi*. Fig. 9.—*P. canadensis*. Fig. 10.—*P. nemorensis*. Fig. 15.—*P. radiata*.
 Fig. 16.—*P. fasciatus*. Fig. 29.—*P. affinis*. Fig. 30.—*P. curriei*. (Original.)



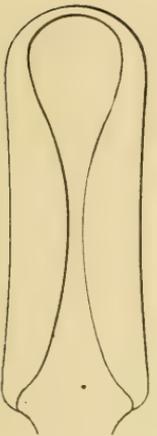
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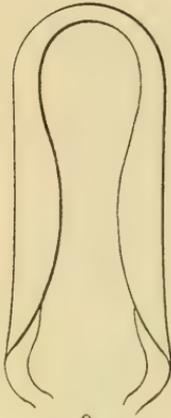
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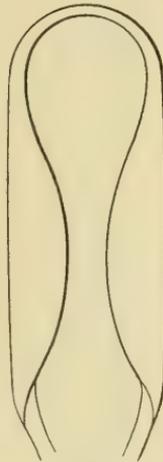
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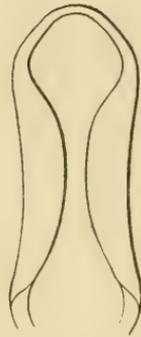
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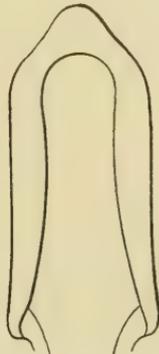
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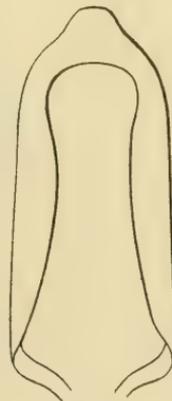
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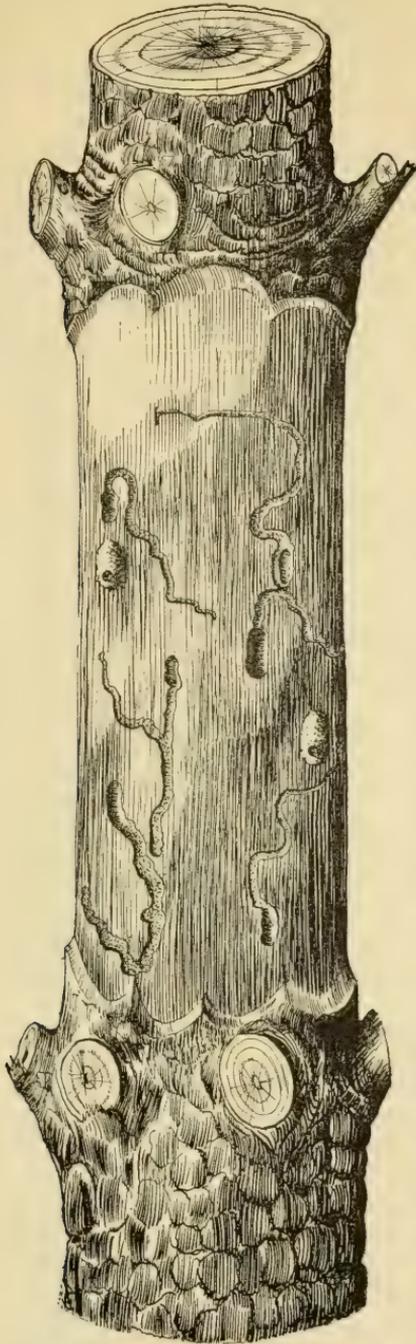
29



30

STEMS OF MALE GENITALIA OF PISSODES.

Fig. 4.—*P. sitchensis*. Fig. 5.—*P. engelmanni*. Fig. 6.—*P. strobi*. Fig. 7.—*P. approxi-*
matus. Fig. 9.—*P. canadensis*. Fig. 10.—*P. nemorensis*. Fig. 15.—*P. radiata*. Fig. 16.—
P. fasciatus. Fig. 29.—*P. affinis*. Fig. 30.—*P. currici*. (Original.)

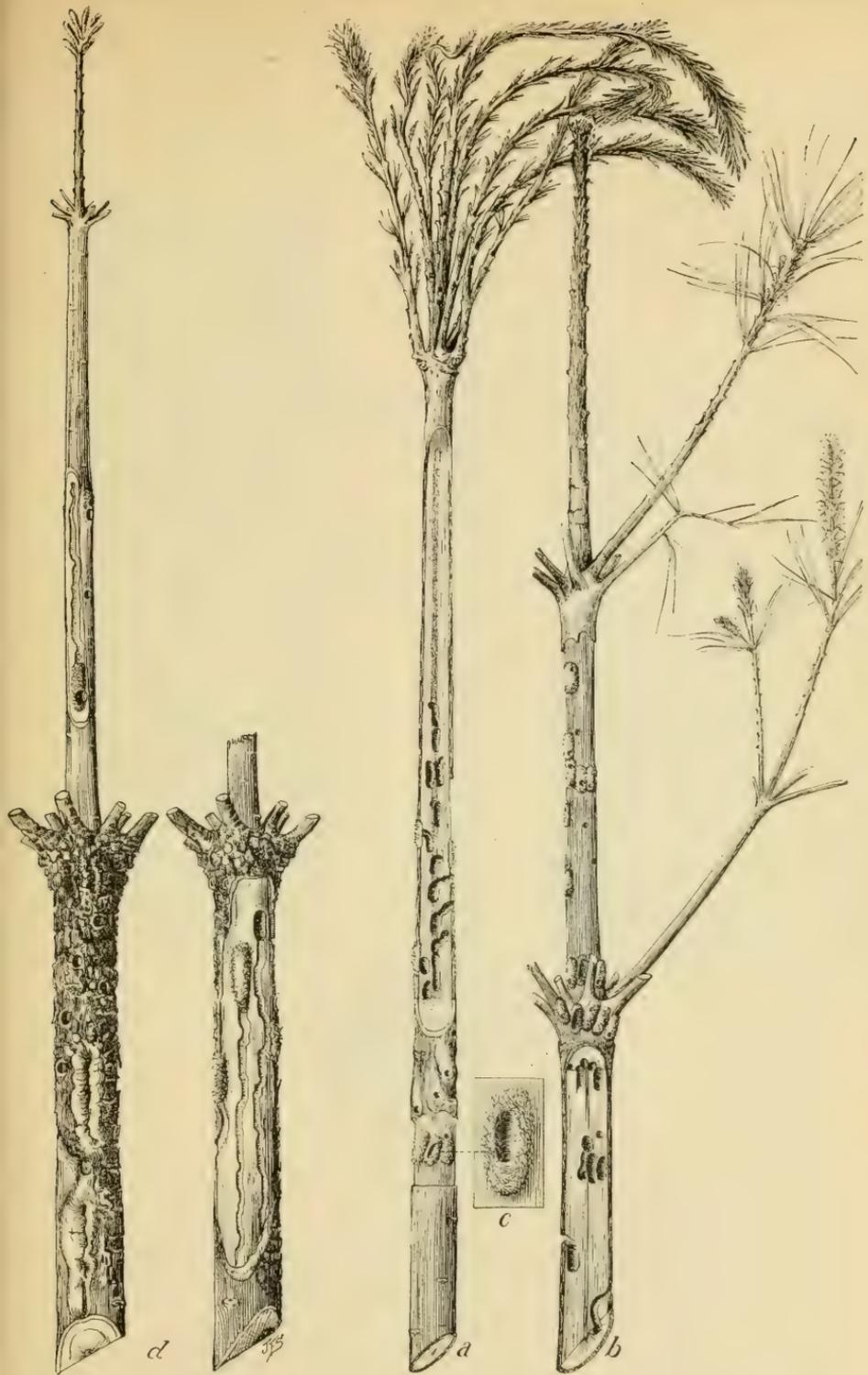


WORK OF PISSODES FISKEI IN INNER BARK AND OUTER WOOD. (ORIGINAL.)



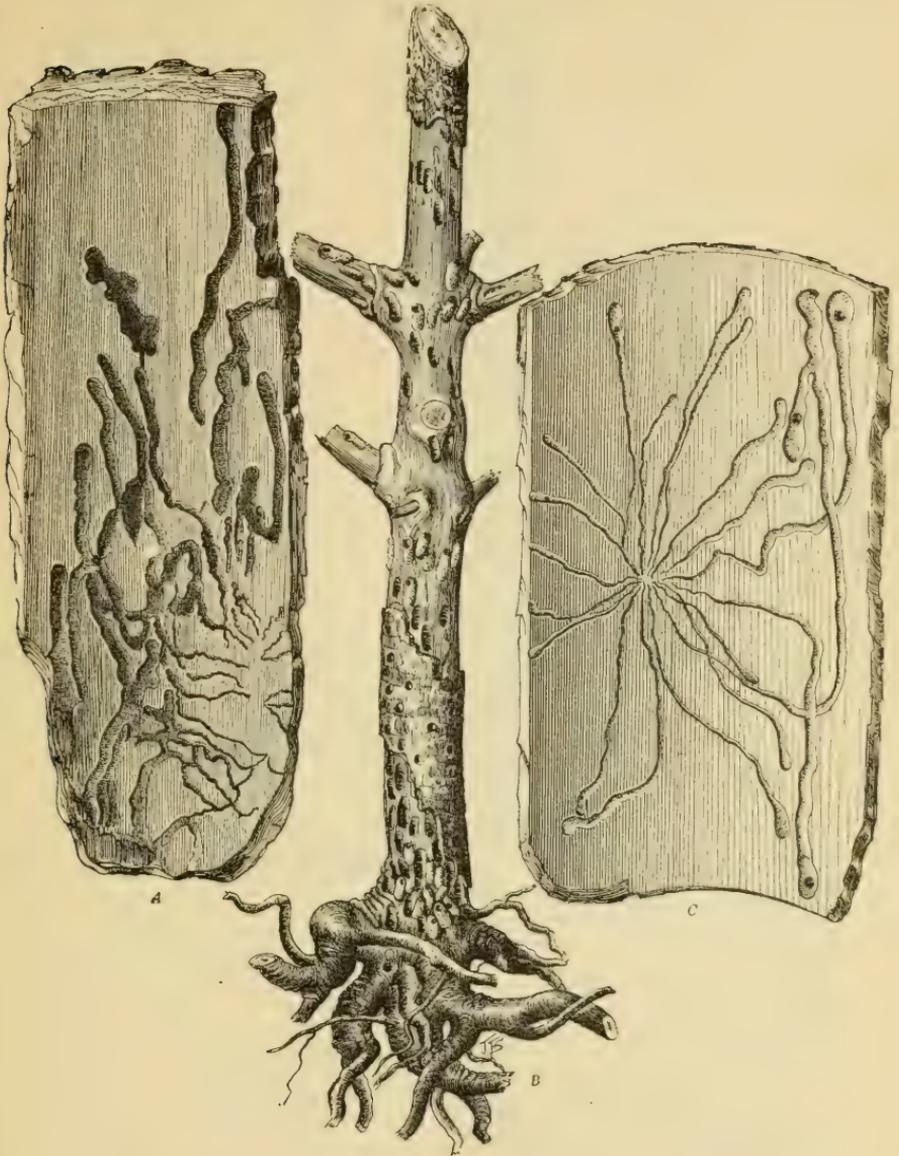
WORK OF *PISSODES SITCHENSIS* IN BARK AND WOOD OF TOPS.

A.—One-year terminal. B.—Four-year-old top; a, One-year internode; b, 2-year internode; c, 3-year internode; d, 4-year internode. (Original.)



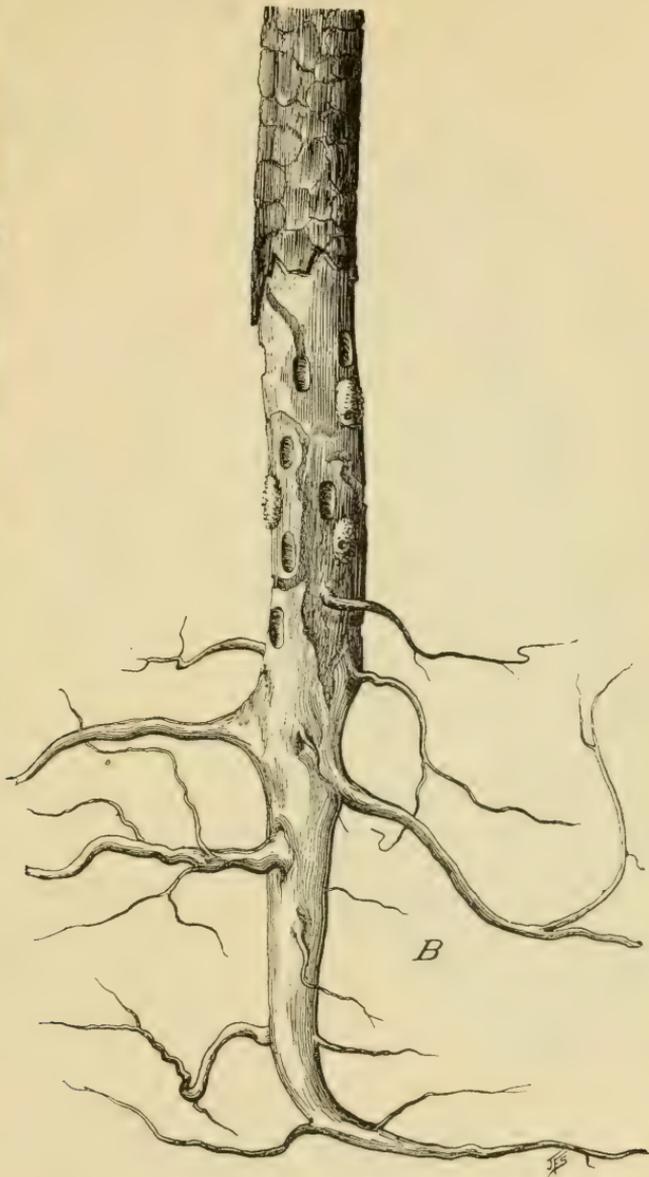
WORK OF PISSODES STROBI, SHOWING CHARACTER OF INJURY, CHIP COCOONS, AND PUPAL CELLS.

a, Vigorous terminal shoot, showing condition of new growth at time pupæ are transforming to adults; b, 3-year-old top, showing how larvæ have migrated from terminal to the 2 and 3 year old internodes; c, chip cocoon and pupal cell, natural size; d, work in 2 and 3 year terminals, showing abnormal habit in the latter. (a-c, Author's illustrations; d, original.)



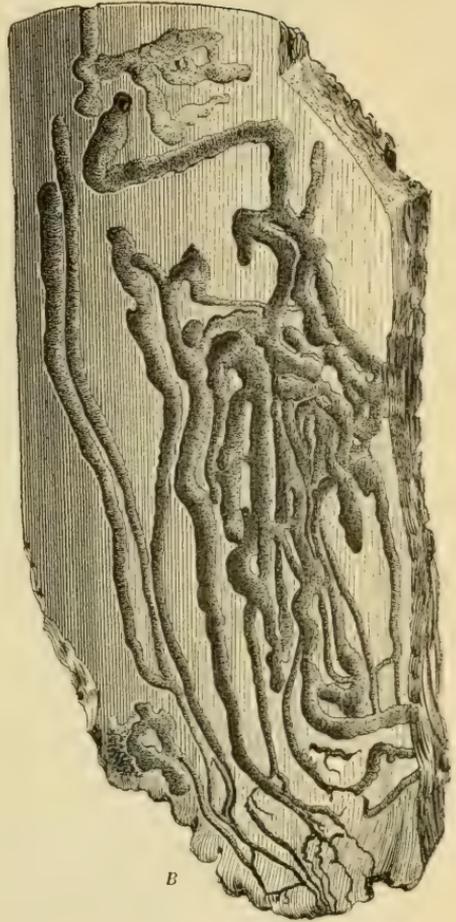
WORK OF PISSODES APPROXIMATUS AND P. NEMORENSIS.

A.—Work of *P. approximatus* in bark. B.—Work of *P. approximatus* in bark and wood of sapling. C.—Work of *P. nemorensis* in bark. (Original.)



WORK OF PISSODES YOSEMITE AND P. SCHWARZI.

A.—*P. yosemitic*: Work in wood and bark. (Author's illustration.) B.—*P. schwarzi*:
Work in wood and bark. (Original.)

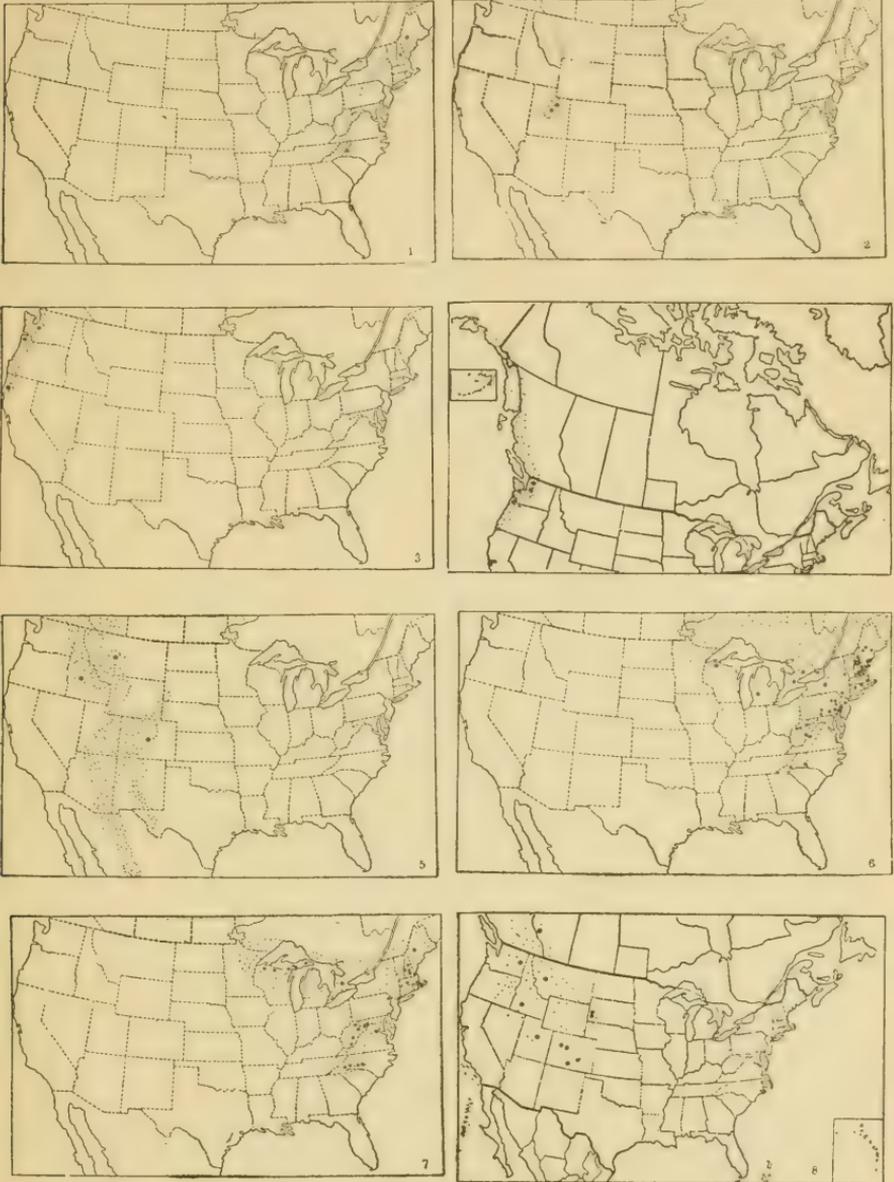


WORK OF PISSEDES FASCIATUS.

A.—Work in bark and wood of stem of sapling. (Author's illustration.) B.—Work in thick bark. (Original.)



WORK OF PISSODES PIPERI IN BARK. (ORIGINAL.)



DISTRIBUTION MAPS OF PISSODES.

Fig. 1.—*P. similis*. Fig. 2.—*P. utahensis*. Fig. 3.—*P. barberi*. Fig. 4.—*P. sitchensis*. Fig. 5.—*P. engelmanni*. Fig. 6.—*P. strobi*. Fig. 7.—*P. approximatus*. Fig. 8.—*P. schwarzi*.



DISTRIBUTION MAPS OF PISSODES.

Fig. 9.—*P. canadensis*. Fig. 10.—*P. nemorensis*. Fig. 11.—*P. decora*. Fig. 12.—*P. californicus*.
Fig. 13.—*P. yosemite*. Fig. 14.—*P. webbi*. Fig. 15.—*P. radiata*. Fig. 16.—*P. fasciatus*.



DISTRIBUTION MAPS OF PISSODES.

Fig. 17.—*P. costatus*. Fig. 18.—*P. fiski*. Fig. 19.—*P. nigra*. Fig. 20.—*P. puncticollis*. Fig. 21.—*P. murrayanx*. Fig. 22.—*P. coloradensis*. Fig. 23.—*P. alascensis*. Fig. 24.—*P. rotundatus*.



DISTRIBUTION MAPS OF PISSODES.

Fig. 25.—*P. burkei*. Fig. 26.—*P. piperi*. Fig. 27.—*P. dubius*. Fig. 28.—*P. fraseri*. Fig. 29.—*P. affinis*.
Fig. 30.—*P. curriei*.

TECHNICAL SERIES, No. 20, PART II.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

TECHNICAL PAPERS ON MISCELLANEOUS
FOREST INSECTS.

II. THE GENOTYPES OF THE SAWFLIES AND
WOODWASPS, OR THE SUPERFAMILY
TENTHREDINOIDEA.

BY

S. A. ROHWER,

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ISSUED MARCH 4, 1911.



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C. L. MARLATT, *Entomologist and Acting Chief in Absence of Chief.*
R. S. CLIFTON, *Executive Assistant.*
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A. L. QUAINANCE, *in charge of deciduous fruit insect investigations.*
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FOREST INSECT INVESTIGATIONS.

A. D. HOPKINS, *in charge.*

H. E. BURKE, J. L. WEBB, JOSEF BRUNNER, S. A. ROHWER, T. E. SNYDER, W. D.
EDMONSTON, W. B. TURNER, *agents and experts.*
MARY E. FAUNCE, *preparator.*
WILLIAM MIDDLETON, MARY C. JOHNSON, *student assistants.*

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., October 22, 1910.

SIR: I have the honor to transmit herewith a manuscript entitled "The Genotypes of the Sawflies and Woodwasps, or the Superfamily Tenthredinoidea." These insects belong to this superfamily of the order Hymenoptera and include some of the important enemies of North American forest trees. The true sawflies, in their larval stage, destroy the foliage of coniferous and other trees and forest growths and some of them are exceedingly destructive, as, for example, the larch sawfly, which feeds upon the foliage of the larch timber of Europe and North America. The woodwasps, in their larval stage, bore in the wood of dying and dead standing and felled trees, causing defects and rapid deterioration.

In addition to the large number of species which are native to this country, there are some very destructive species which have found their way here from other countries, so that it is of the greatest importance to know all of the species and to guard against further introductions.

Both the systematic and economic knowledge of these insects is notably limited, especially as regards North American species, and it is of the utmost importance, as a basis for the best results in investigations of these insects in their relation to economic problems, that considerable purely technical work should be done on them.

Mr. Rohwer has been engaged to work on the sawflies on account of his extended expert knowledge of this group of insects and the work he had done on them before he came to the Bureau. As a collaborator of this Bureau, but at his own expense, Mr. Rohwer visited the principal collections of Europe in the summer of 1909 to study the types of described species and genera, all of which puts him in a position to carry on the research work assigned to him in the most thorough manner. Mr. Rohwer has found it necessary to devote considerable time to preliminary work on the entire group and on the genera of the world in order to have an authoritative basis for the further work of a monographic nature on the more

important groups represented by species which depredate on trees and forest growths. The present paper includes the partial results of his preliminary work, which has been prosecuted with such energy as to leave little more to be done in this line. Mr. Rohwer's future papers will deal with special groups which will be treated in a monographic manner in order that a basis may be formed for special papers on the economic features.

I recommend the publication of this manuscript as Technical Series No. 20, Part II, of the Bureau of Entomology.

Respectfully,

L. O. HOWARD,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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TECHNICAL PAPERS ON MISCELLANEOUS FOREST INSECTS.

II. THE GENOTYPES OF THE SAWFLIES AND WOODWASPS, OR THE SUPERFAMILY TENTHREDINOIDEA.

By S. A. ROHWER,
Agent and expert.

INTRODUCTION.

The following paper deals with the sawflies and horntails and comprises the superfamilies Tenthredinoidea and Siricoidea of Ashmead's classification; the Chalastogastra of Rev. F. W. Konow; the Phyllophaga (=Phytophaga) and Xylophaga of Cresson and authors; or the genera *Tenthredo* and *Sirex* of Linnæus. It is divided into two parts; the first part is an alphabetical catalogue of the generic names used in Tenthredinoidea and Siricoidea with their type species; the second part is composed of descriptions of the briefly characterized genera and species described by the late William H. Ashmead.

An effort has been made to include all the generic names used in these two superfamilies. In case of any omissions the author will be most pleased to have these called to his notice.^a

AN ALPHABETICAL CATALOGUE OF THE GENERIC NAMES USED IN THE TENTHREDINOIDEA, WITH THEIR TYPE SPECIES.

THE DESIGNATION OF THE TYPE SPECIES OF GENERA.

The necessity of having the types of genera fixed is now recognized by almost every working systematic entomologist. In the designation of the following genotypes the rulings and recommendations of the International Commission on Zoological Nomenclature have been followed. As these rulings and recommendations have never been finally codified, and there are in a few cases apparently contradictory statements, the personal equation has entered into

^a Address Bureau of Entomology, Department of Agriculture, Washington, D. C.

the interpretation to some extent. In all such cases an effort is made to follow the consensus of opinion. Article 2, page 11, of the International Code of Zoological Nomenclature as applied to medicine^a says: "The scientific designation of animals is uninominal for subgenera and all higher groups, binominal for species, and trinominal for subspecies." Does this mean that a genus can be founded without included species? In article 30, page 26, and the correction in *Science* for October 18, 1907, pages 521-522, it is stated that a genus must have a type and the type must be an included species. In this paper a genus is considered to be without standing until it contains a species; and genera which were founded without species take the first species placed in them as the type and date from the time when that species was placed in them. In such cases the name of the first author of the genus is given first in parentheses, and, following the parenthesis, the name of the author who first included a species.^b

With the exception of monobasic genera the first designation of genotypes in Tenthredinoidea and Siricoidea was done by Latreille in 1810.^c This has been definitely ruled on by the International Commission on Zoological Nomenclature as follows:

The Designation of Genotypes by Latreille 1810.—The "Table des genres avec l'indication de l'espèce qui leur sert de type" in Latreille's (1810) "Considérations Générales" should be accepted as designation of types of the genera in question.^d

The next entomologist to fix the types of genera was John Curtis, in his *British Entomology*, which was published from 1824 to 1839. In this work Curtis says "type of the genus," which makes it very evident that the author endeavored to fix the types of the genera he treated.

J. O. Westwood, in his *Synopsis of the Genera of British Insects*,^e gives after each genus what he calls a "typical species."^f In most cases this species can be taken as the type of the genus in question, and in many it is the first indication of the fixing of a type for many of the genera. Inasmuch as the International Commission on Zoological Nomenclature^g has said "the meaning of the expression 'select type' is to be rigidly construed; mention of a species as an illustration or example of a genus does not constitute a selection of

^a Bul. no. 24, Hygienic Laboratory, Public Health and Marine-Hospital Service of United States, September, 1905.

^b See synonyms of *Hartigia Schiodte* and *Boie*, p. 80.

^c *Considérations Générales sur l'Ordre Naturel des Animaux composant les Classes des Crustacés, des Arachnides et des Insectes*, Paris, 1810.

^d *Science*, n. s. vol. 31, no. 787, p. 150, January 28, 1910.

^e Published as an appendix to "An Introduction to the Modern Classification of Insects," vol. 2, London, 1840.

^f *Synopsis*, p. 1, footnote.

^g *Science*, n. s. vol. 26, no. 668, p. 521, October 18, 1907.

a type," the "typical species" of Westwood are not given as the types of genera except in those cases where no type has been given and the species given by Westwood can be the genotype according to the rules. In the following list, however, the words "Westwood 1840" are placed after the genotypes of certain genera, for the convenience of the student, should any ruling be given on these "typical species."

With the exception of a few types designated by Brullé^a and Shipp,^b few genotypes were named except in the works of the two American writers Ashmead and MacGillivray.

It was hoped to verify every reference given, but in some few cases this was not possible. In such cases the reference is that given by Dalla Torre. The original descriptions of the following genera have not been seen: *Xiphura* Fallén, *Hybonotus* Klug, *Nycteridium* Fischer-Waldheim, *Pompholyx* Freymuth.

RULES OF ZOOLOGICAL NOMENCLATURE FOR THE DESIGNATION OF TYPE SPECIES OF GENERA.

The ruling of the International Commission on Zoological Nomenclature^c is reprinted here for ready reference. Some of the recommendations which do not deal with any cases found in Tenthredinoidea and which are not of general importance have been omitted.

ART. 30. The designation of type species of genera shall be governed by the following rules (a-g), applied in the following order of precedence:

I. Cases in which the generic type is accepted solely upon the basis of the original publication.

(a) When in the original publication of a genus, one of the species is definitely designated as type, this species shall be accepted as type regardless of any other considerations. (Type by original designation.)

(b) If, in the original publication of a genus, *typicus* or *typus* is used as a new specific name for one of the species, such use shall be construed as "type by original designation."

(c) A genus proposed with a single original species takes that species as its type. (Monotypical genera.)

(d) If a genus, without originally designated (see a) or indicated (see b) type, contains among its original species one possessing the generic name as its specific or sub-specific name, either as valid name or synonym, that species or subspecies becomes *ipso facto* type of the genus. (Type by absolute tautonomy.)

II. Cases in which the generic type is not accepted solely upon basis of the original publication:

(e) The following species are excluded from consideration in selecting the types of genera:

(α) Species which were not included under the generic name at the time of its original publication.

^a Histoire Naturelle des Insectes. Hyménoptères, vol. 4, Paris, November, 1846.

^b Entomologist, vol. 27, pp. 339-340, 1894.

^c See Science, n. s. vol. 26, no. 668, pp. 521-522, October 18, 1907.

(*β*) Species which were *species inquirendæ* from the standpoint of the author of the generic name at the time of its publication.

(*γ*) Species which the author of the genus doubtfully referred to it.

(*f*) In case a generic name without originally designated type is proposed as a substitute for another generic name, with or without type, the type of either, when established, becomes *ipso facto* type of the other.

(*g*) If an author, in publishing a genus with more than one valid species, fails to designate (see *a*) or to indicate (see *b, d*) its type, any subsequent author may select the type, and such designation is not subject to change. (Type by subsequent designation.)

The meaning of the expression "select a type" is to be rigidly construed. Mention of a species as an illustration or example of a genus does not constitute a selection of a type.

III. *Recommendations*.—In selecting types by subsequent designation, authors will do well to govern themselves by the following recommendations:

(*h*) In the case of Linnæan genera select as type the most common or the medicinal species.

(*i*) If a genus, without designated type, contains among its original species one possessing as a specific or subspecific name, either as valid name or synonym, a name which is virtually the same as the generic name, or of the same origin or same meaning, preference should be shown to that species in designating the type, unless such preference is strongly contra-indicated by other factors. (Type by virtual tautonomy.)

(*k*) If some of the original species have later been classified in other genera, preference should be shown to the species still remaining in the original genus. (Type by elimination.)

(*n*) Show preference to the best described, best figured, best known, or most easily obtainable species, or to one of which a type specimen can be obtained.

(*o*) Show preference to a species which belongs to a group containing as large a number of the species as possible.

(*q*) All other things being equal, show preference to a species which the author of the genus actually studied at or before the time he proposed the genus.

(*r*) In case of writers who habitually place a certain leading or typical species first as "chef de file," the others being described by comparative reference to this type, this fact should be considered in the choice of the type species.

(*s*) In case of those authors who have adopted the "first species rule" in fixing generic types, the first species named by them should be taken as types of their genera.

(*t*) All other things being equal, page precedence should obtain in selecting a type.

CATALOGUE.

The various genera accredited to Jurine (Nouv. Meth. Hym. Ins., vol. 1, 1807) have been accredited to Panzer (Krit. Revis., vol. 2, 1806). Panzer accredits the genera to Jurine, but they are in none of Jurine's earlier papers, while he treated them rather fully in 1807.

All references to Encyclopédie Méthodique, Insectes, vol. 10. 1825, have been changed to "vol. 10, pt. 2, 1828." Volume 10 came out in two numbers, the second, containing the Tenthredinidæ, appearing in 1828.

The word "isogenotypic" is used when two genera have the same species as the genotype.

The word "monobasic" is used to indicate that a genus was founded on one originally included species,

The plan in the following list is to give the generic name first, the name of the author second, the original reference third, the type species fourth, the authority for the type fifth. In case the genus was monobasic, an asterisk is placed after the type species; in case the genotype was originally designated, the word "designated" is placed in parentheses; in case the genus was not monobasic and no genotype has been designated, the type has been chosen and no authority is given (see *Amauronematus* Konow). Certain apparent synonymy, as in the case of isogenotypic genera, is also given. All such synonymy has been verified, and synonymy not verified is not given.

The list of genera is believed to be complete, in as far as publications have been received in Washington, D. C., up to January 1, 1911. All the new generic names proposed in this paper are included in the alphabetical catalogue with the reference, "see p. —."

Abia Leach, Zool. Misc., vol. 3, p. 113, no. 5, 1817.

Type: *Tenthredo sericea* Linnæus (Curtis, 1825).

Acantholyda A. Costa, Pros. Hym. Ital., vol. 3, p. 232, 1894.

Type: *Tenthredo erythrocephala* Linnæus (Rohwer, 1910).

Acanthoperga Shipp, Ent., vol. 27, pp. 338, 339, 1894.

Type: *Perga cameroni* Westwood (designated).

Acanthoptenos Ashmead, Can. Ent., vol. 30, p. 212, 1898.

Type: *Acanthoptenos weithii* Ashmead (designated).

Acherdocerus W. F. Kirby, List Hym. Brit. Mus., vol. 1, p. 92, no. 42, 1882.

Type: *Acherdocerus fumipennis* W. F. Kirby.*

Acidiophora Konow, Ent. Nachr., vol. 25, p. 361, 1899.

Type: *Acidiophora decora* Konow.*

Acordulecera Say, Bost. Journ. Nat. Hist., vol. 1, no. 3, p. 209, 1836.

Type: *Acordulecera dorsalis* Say.*

Adirus Konow, Ent. Nachr., vol. 25, p. 74, 1899.

Type: *Cephus trimaculatus* Say.*

Agenocimbex Rohwer, Proc. U. S. Nat. Mus., vol. 39, no. 1777, p. 104, 1910.

Type: *Cimbex maculata* Marlatt (designated).

Aglaostigma W. F. Kirby, List Hym. Brit. Mus., vol. 1, p. 325, no. 104, 1882.

Type: *Aglaostigma eburneiguttatum* W. F. Kirby.*

Allantus Panzer, Krit. Revis., vol. 2, p. 25, 1806.

Type: *Tenthredo scrophulariæ* Linnæus (Curtis, 1839; Brullé, 1846; Westwood, 1840).

=*Tenthredo* Linnæus (isogenotypic).

Allomorpha Cameron, Trans. Ent. Soc. Lond., p. 463, 1876.

Type: *Allomorpha incisa* Cameron.*

Amasis Leach, Zool. Misc., vol. 3, p. 114, no. 6, 1817.

Type: *Tenthredo obscura* Linnæus (Westwood, 1840).

Amauronematus Konow, Deutsch. ent. Zeitschr., p. 237, 1890.

Type: *Nematus fallax* Lepeletier.

Ametastegia A. Costa, Rendic. Accad. Sci. Fis. Napoli, vol. 21, pt. 10, p. 198, 1882.

Type: *Ametastegia fulvipes* A. Costa.*

=*Tenthredo glabrata* Fallén.

=*Taxonus* Hartig.

- Anachoreta** Gistel, "Naturgeschichte des Thierreichs," p. ix, 1848 (n. n. for *Lophyrus* Latreille).
Type: *Tenthredo pini* Linnæus.
= **Diprion** Schrank.
- Anapeptamena** Konow, Ent. Nachr., vol. 24, p. 271, 1898.
Type: *Anapeptamena albipes* Konow.*
- Ancyloneura** Cameron, Trans. Ent. Soc. Lond., p. 91, 1877.
Type: *Ancyloneura varipes* Cameron.*
- Aneugmenus** Hartig, Fam. Blatt. Holzwespe., p. 253, 1837.
Type: *Tenthredo (Emphytus) coronata* Klug.*
- Anisoarthra** Cameron, Trans. Ent. Soc. Lond., p. 461, 1876.
Type: *Anisoarthra cœrulea* Cameron.*
(preocc., = **Senoclia** Cameron.)
- Anisoneura** Cameron, Trans. Ent. Soc. Lond., p. 463, 1876.
Type: *Anisoneura stigmatalis* Cameron.*
(preocc., = **Beleses** Cameron.)
- Anoplolyda** A. Costa, Pros. Hym. Ital., vol. 3, p. 233, 1894.
Type: *Lyda alternans* O. Costa (Rohwer, 1910).
- Anoplonyx** Marlatt, U. S. Dept. Agr., Bur. Ent., Tech. Ser. no. 3, p. 18, 1896.
Type: *Nematus pectoralis* Lepeletier.
- Antholcus** Konow, Zeitschr. syst. Hym. Dipt., vol. 4, p. 3, 1904.
Type: *Tenthredo varinervis* Spinola.*
- Aomodactium** Ashmead, Can. Ent., vol. 30, p. 309, December, 1898.
A genus without a species.
- Aphadnurus** O. Costa, Fauna Napoli, Tenthred., p. 40, 1859.
Type: *Aphadnurus tantillus* O. Costa.*
= *Emphytus pumila* Klug.
= **Fenusa** Leach.
- Aphanisus** MacGillivray, Can. Ent., p. 295, August, 1908.
Type: *Aphanisus lobatus* MacGillivray (designated).
- Aphiodactium** Ashmead, Can. Ent., vol. 30, p. 310, 1898.
Type: *Strongylogaster rubripes* Cresson (designated).
- Aprosthemus** Konow, Ent. Nachr., vol. 25, p. 149, 1899.
Type: *Hylotoma brevicornis* Fallén.
- Ardis** Konow, Wien. ent. Zeit., vol. 5, pp. 184, 188, no. 4, 1886.
Type: *Tenthredo (Allantus) bipunctata* Klug.
- Arge** Schrank, Fauna Boica, vol. 2, p. 209, no. 231, 1802.
Type: *Tenthredo enodis* Linnæus.
- Astatus** Jurine, Fauna Insect. Germ., vol. 7, p. 83, fig. 12, 1801.
Type: *Sirex troglodyta* Fabricius.
- Asticta** E. Newman, Ent. Mag., vol. 5, p. 484, 1838.
Type: *Asticta ianthe* E. Newman.*
= *Harpiphorus lepidus* Klug.
= **Harpiphorus** Hartig (isogenotypic).
- Ateuchopus** Konow, Wien. ent. Zeit., vol. 15, p. 174, 1896.
Type: *Ateuchopus armenius* Konow.
- Athalia** Leach, Zool. Misc., vol. 3, p. 128, no. 2, 1817.
Type: *Tenthredo spinarum* Fabricius (Curtis, 1836).
- Athermantus** W. F. Kirby, List Hym. Brit. Mus., vol. 1, p. 54, no. 32, 1882.
Type: *Hylotoma imperialis* F. Smith.*

- Athlophorus** Burmeister, *Athlophorus*, eine neue Gattung der Blattwespen, pp. 1-9, 1847.
Type: *Athlophorus klugii* Burmeister.*
- Atocus** Scudder, *Bul. U. S. Geol. Surv.*, vol. 93, p. 24, pl. 2, fig. 5, 1892.
Type: *Atocus defessus* Scudder.*
- Atomacera** Say, *Bost. Journ. Nat. Hist.*, vol. 1, no. 3, p. 212, 1836.
Type: *Atomacera debilis* Say.*
- Aulacomerus** Spinola, *Ann. Ent. Soc. France*, vol. 9, p. 137, 1840.
Type: *Aulacomerus buquetii* Spinola.*
- Bactroceros** Konow, *Ann. k. k. Hofmus., Wien.*, vol. 12, p. 21, 1897.
Type: *Tenthredo vaser* Linnæus (Rohwer, 1910).
= **Anoplolyda** A. Costa.
- Bathyblepta** Konow, *Zeitschr. syst. Hym. Dipt.*, vol. 6, p. 123, 1906.
Type: *Bathyblepta procer* Konow.*
- Beldonea** Cameron, *Mem. & Proc. Manchester Lit. & Phil. Soc.*, vol. 43, no. 3, p. 35, 1899.
Type: *Beldonea rugifrons* Cameron.*
- Beleses** Cameron, *Trans. Ent. Soc. Lond.*, p. 88, 1877 (n. n. for *Anisoneura* Cameron, 1876).
Type: *Anisoneura stigmatalis* Cameron.*
- Bergiana** Konow, *Anal. Mus. Buenos Aires*, vol. 6, p. 397, 1899.
Type: *Syzygonia cyanocephala* Klug (designated, p. 398).
= **Syzygonia** Klug (isogenotypic).
- Bivena** MacGillivray, *Can. Ent.*, vol. 26, p. 327, 1894.
Type: *Bivena maria* MacGillivray (designated).
= *Tenthredo delta* Provancher.
- Blasticotoma** Klug, *Jahrb. Insectenkunde*, vol. 1, p. 270, no. 7, 1834.
Type: *Blasticotoma filiceti* Klug.*
- Blennocampa** Hartig, *Fam. Blatt. Holzwespen*, p. 266, 1837.
Type: *Tenthredo (Allantus) pusilla* Klug.
- Brachycolus** Konow, *Termes. Fuzetek*, vol. 28, pt. 3, p. 166, 1895.
Type: *Nematus viduatus* Zetterstedt.
- Brachyphatnus** Konow, *Zeitschr. syst. Hym. Dipt.*, vol. 6, p. 250, 1906.
Type: *Brachyphatnus debilicornis* Konow.
- Brachytoma** Westwood, *Thes. Ent. Oxon.*, p. 109, 1874 (non Swainson, 1840).
Type: *Brachytoma funtipennis* Westwood (Ashmead, 1898).
- Brachyxiphus** Philippi, *Stett. ent. Zeit.*, vol. 32, p. 285, 1871.
Type: *Brachyxiphus grandis* Philippi.
- Braunsiola** Konow, *Ent. Nachr.*, vol. 25, p. 312, 1899.
Type: *Braunsiola truculenta* Konow.*
= **Micrarge** Ashmead.
- Busarbia** Cameron, *Mem. & Proc. Manchester Lit. & Phil. Soc.*, vol. 43, no. 3, p. 37, 1899.
Type: *Busarbia viridipes* Cameron.*
- Cacosyndia** W. F. Kirby, *Trans. Ent. Soc. Lond.*, p. 203, 1883 (n. n. for *Pompholyx* Freymuth).
Type: *Pompholyx dimorpha* Freymuth (designated).
- Cænocephus** Konow, *Wien. ent. Zeit.*, vol. 15, p. 151, 1896.
Type: *Cænocephus jakowleffi* Konow.*
- Cænolyda** Konow, *Ann. k. k. Hofmus., Wien.*, vol. 12, p. 15, 1897.
Type: *Tenthredo reticulata* Linnæus (Rohwer, 1910).

- Cænoneura** Thomson, Opusc. Ent., vol. 2, p. 270, 1870.
Type: *Cænoneura dahlbomi* Thomson.*
- Calameuta** Konow, Wien. ent. Zeit., vol. 15, p. 159, 1896.
Type: *Cephus filiformis* Eversmann.
- Caliroa** O. Costa, Fauna Napoli, Tenthred., p. 59, 1859.
Type: *Caliroa sebetia* O. Costa.*
= *Allantus cinzia* Klug.
- Caloptilia** Ashmead, Can. Ent., vol. 30, p. 212, 1898.
Type: *Caloptilia townsendi* Ashmead (designated).
- Calozarca** Ashmead, in Dyar, Journ. N. Y. Ent. Soc., p. 129, 1898; also Can. Ent., vol. 30, p. 252, October, 1898.
Type: *Selandria fascipennis* Norton (designated).
= *Parazarca* Ashmead.
- Camponiscus** E. Newman, Ent., vol. 4, p. 215, 1869.
Type: *Camponiscus healæi* E. Newman.*
= *Tenthredo luridiventris* Fallén.
= *Platycampus* Schiödte.
- Camptoperga** Shipp, Ent., vol. 27, pp. 339-340, 1894.
Type: *Perga cressoni* Westwood (designated).
- Camptoprium** Spinola, Ann. Soc. Ent. France, vol. 9, p. 134, 1840.
Type: *Camptoprium leprieuri* Spinola.*
- Canonias** Konow, Termes. Fuzetek, vol. 24, p. 65, 1901.
Type: *Canonias inopinus* Konow.*
- Celidoptera** Konow, Ann. k. k. Hofmus., Wien., vol. 12, p. 20, 1897.
Type: *Lyda maculipennis* Stein.*
- Cephaleia** Panzer, Fauna Ins. Germ., vol. 8, p. 36, 1805.
Type: *Tenthredo signata* Fabricius (Rohwer, 1910).
- Cephalocera** Klug, Jahrb. Insectenkunde, vol. 1, p. 251, no. 8, 1834.
Type: *Cephalocera pumila* Klug.*
(preocc., = *Corynophilus* W. F. Kirby).
- Cephites** Heer, Denkschr. schweiz. Ges. Naturwiss., vol. 11, p. 173, no. 18, 1850.
Type: *Cephites æningensis* Heer.
- Cephosoma** Gradl, Ent. Nachr., vol. 7, p. 294, 1881.
Type: *Cephosoma syringæ* Gradl.*
= *Hartigia* Schiödte and Boie.
- Cephus** Latreille, Hist. Nat. Crust. Ins., vol. 3, p. 303, 1802.
Type: *Sirex pygmaeus* Linnæus (Latreille, 1810; Brullé, 1846; Westwood, 1840).
- Ceratulus** MacGillivray, Can. Ent., vol. 40, p. 454, 1908.
Type: *Ceratulus spectabilis* MacGillivray (designated).
- Cereales** W. F. Kirby, List Hym. Brit. Mus., vol. 1, p. 31, no. 11, 1882.
Type: *Cereales scutellata* W. F. Kirby.*
- Cerobactrus** O. Costa, Fauna Napoli., Cephid., p. 9, 1860.
Type: *Cerobactrus major* O. Costa.*
= *Astatus satyrus* Panzer.
= *Hartigia* Schiödte and Boie.
- Cerospastus** Konow, Anal. Mus. Buenos Aires, vol. 6, p. 404, 1899.
Type: *Cerospastus volupis* Konow.*
- Chalinus** Konow, Termes. Fuzetek, vol. 20, p. 605, 1897.
Type: *Oryssus plumicornis* Guérin.
- Characophygus** Konow, Ent. Nachr., vol. 25, p. 73, 1899.
Type: *Characophygus moricei* Konow.*

- Cibdela** Konow, Ent. Nachr., vol. 25, p. 76, 1899.
Type: *Hylotoma jantheria* Klug.
- Cimbex** Olivier, Encyl. Méthod., Ins., vol. 5, p. 762, 1790.
Type: *Tenthredo lutea* Linnæus (Latreille, 1810).
- Cladiucha** Konow, Zeitschr. syst. Hym. Dipt., vol. 2, p. 389, 1902.
Type: *Cladiucha insolita* Konow.*
- Cladius** Rossi, Fauna Etrusca, ed. 2^a, vol. 2, p. 27, 1807.
Type: *Tenthredo difformis* Panzer (Latreille, 1810).
- Cladomacra** F. Smith, Ann. Mag. Nat. Hist., (3) vol. 6, p. 256, 1860.
Type: *Cladomacra macropus* F. Smith.*
- Claremontia** Rohwer, Can. Ent., vol. 41, p. 397, November, 1909.
Type: *Claremontia typica* Rohwer (designated).
- Clarissa** W. F. Kirby, Ann. Mag. Nat. Hist., (6) vol. 14, p. 46, 1894.
Type: *Clarissa divergens* W. F. Kirby.*
- Clavellaria** Lamarck, Syst. des Animaux sans vertébrés, p. 264, 1801.
Type: *Tenthredo lutea* Linnæus.*
= **Cimbex** Olivier.
- Clavellarius** Olivier, Encycl. Méthod., vol. 4, p. 22, 1789; vol. 6, p. 18, 1791. No species.
- Clydostomus** Konow, Zeitschr. syst. Hym. Dipt., vol. 8, p. 19, 1908.
Type: *Clydostomus cestatus* Konow.
- Cockerellonis** MacGillivray, Can. Ent., vol. 40, p. 365, October, 1908.
Type: *Cockerellonis occidentalis* MacGillivray (designated).
= **Eriocampidea** Ashmead.
- Colochelyna** Konow, Ent. Nachr., vol. 24, p. 280, 1898.
Type: *Colochelyna magrettii* Konow.
- Conaspidia** Konow, Ent. Nachr., vol. 24, p. 279, 1898.
Type: *Conaspidia sikkemensis* Konow.*
- Corymbas** Konow, Ann. Mus. St. Petersbourg, p. 120, 1903.
Type: *Corymbas koreana* Konow.
- Coryna** Lepeletier, Encyl. Méthod., Ins., vol. 10, pt. 2, p. 567, 1828.
Type: *Tenthredo (Coryna) scapularis* Lepeletier.
= *Tenthredo flavans* Klug.
= **Selandria** Leach.
- Corynia** Imhof et Labram, Insect. Schweiz., vol. 1, pl. 23, 1836.
Type: *Corynia rosarum* Imhof et Labram.
= **Arge** Schrank.
- Corynophilus** W. F. Kirby, List Hym. Brit. Mus., vol. 1, p. 32, no. 15, 1882 (n. n. for *Cephalocera* Klug, non Latreille).
Type: *Cephalocera pumila* Klug.*
- Cræsus** Leach, Zool. Misc., vol. 3, p. 129, no. 1, 1817.
Type: *Tenthredo septentrionalis* Linnæus.*
= **Nematus** Jurine.
- Cryptocampus** Hartig, Fam. Blatt. Holzwespe., p. 221, March, 1837.
Type: *Nematus (Cryptocampus) medullaris* Hartig.
= **Euura** Newman.
- Cryptus** Panzer, Krit. Revis., vol. 2, p. 21, 1806 (non Fabricus, 1804).
Type: *Tenthredo furcata* Villers (Curtis, 1825).
= **Schizocera** Lepeletier (isogenotypic).

- Cyphona** Dahlbom, *Conspect. Tenthred. Scand.*, p. 6, 1835.
Type: *Tenthredo furcata* Villers.
= **Schizocera** Lepeletier.
- Decameria** (Lepeletier) W. F. Kirby, *Lepeletier, Encycl. Méthod., Ins.*, vol. 10, pt. 2, p. 371, 1828; W. F. Kirby, *List Hym. Brit. Mus.*, vol. 1, p. 93, no. 43, 1882.
Type: *Decameria testacea* W. F. Kirby (designated).
- Decatria** Stephens, *Illustr. Brit. Ent., Mandib.*, vol. 7, p. 94, 1835.
Type: *Heterarthus ochropoda* Stephens.
- Derecyrta** F. Smith, *Ann. Mag. Nat. Hist.*, (3) vol. 6, p. 255, 1860.
Type: *Derecyrta pictipennis* F. Smith.*
- Dictynna** Brullé, *Hist. Nat. Ins. Hym.*, vol. 4, p. 662, 1846.
Type: *Dictynna westwoodii* Brullé.*
= **Decameria** (Lepeletier).
- Dictynna** Westwood, *Arcana Ent.*, vol. 1, p. 24, pl. 7, fig. 4, 1841.
Type: *Dictynna laxa* Westwood.*
= **Eurys** Newman.
- Didocha** Konow, *Zeitschr. syst. Hym. Dipt.*, vol. 7, p. 306, 1907.
Type: *Didocha braunsi* Konow.*
- Didymia** Lepeletier, *Encycl. Méthod., Ins.*, vol. 10, pt. 2, p. 574, 1828.
Type: *Hylotoma martini* Lepeletier.*
- Dielocerus** Curtis, *Trans. Linn. Soc. Lond.*, vol. 19, pt. 1, p. 248, 1844.
Type: *Dielocerus ellisii* Curtis.
- Dimorphopteryx** Ashmead, *Can. Ent.*, vol. 30, p. 308, 1898.
Type: *Strongylogaster pinguis* Say (designated).
- Dinax** Konow, *Wien. ent. Zeit.*, vol. 16, p. 182, 1897.
Type: *Dinax jakowleffi* Konow.*
- Dineura** Dahlbom, *Conspect. Tenthred. Scand.*, p. 13, no. 6, 1835.
Type: *Tenthredo degeeri* Klug (Westwood, 1846).
- Diphadnus** Hartig, *Fam. Blatt. Holzwesp.*, p. 225, 1837.
Type: *Nematus fuscicornis* Hartig.*
= *Nematus appendiculatus* Hartig.
- Diphamorphos** Rohwer, *Ent. News*, vol. 22, p. 473, 1910.
Type: *Diphamorphos nigrescens* Rohwer (designated).
- Diprion** Schrank, *Fauna Boica*, vol. 2, pp. 209, 252-254, 1802.
Type: *Tenthredo pini* Linnæus (Rohwer, 1910).
- Dipteromorpha** W. F. Kirby, *List Hym. Brit. Mus.*, vol. 1, p. 324, no. 102, 1882.
Type: *Macrophya rotundiventris* Cameron.*
- Distega** Konow, *Zeitschr. syst. Hym. Dipt.*, vol. 4, p. 224, 1904.
Type: *Distega sjostedti* Konow.*
- Dolerus** Panzer, *Krit. Revis.*, vol. 2, p. 40, 1806.
Type: *Dolerus gonager* Jurine (Latreille, 1810).
- Dosytheus** Leach, *Zool. Misc.*, vol. 3, p. 128, no. 4, 1817.
Type: *Tenthredo eglanteriæ* Fabricius (Brullé, 1846).
= **Dolerus** Panzer.
- Druida** E. Newman, *Ent. Mag.*, vol. 5, p. 484, 1838.
Type: *Druida parviceps* E. Newman.*
= *Phyllotoma nemorata* Fallén.
- Dulophanes** Konow, *Zeitschr. syst. Hym. Dipt.*, vol. 7, p. 132, 1907.
Type: *Dulophanes morio* Konow.*

- Ebolia** O. Costa, Fauna Napoli, Tenthred., p. 105, 1859.
Type: *Ebolia floricola* O. Costa.*
- Electrocephalus** Konow, Ent. Nachr., vol. 23, p. 37, 1897.
Type: *Electrocephalus strahlendorffi* Konow.*
- Emphytoides** Konow, Ent. Nachr., vol. 24, p. 274, 1898.
Type: *Emphytoides perplexus* Konow.
= **Athlophorus** Burmeister.
- Emphytus** Klug, Mag. Ges. naturf. Berlin, vol. 7, p. 273, 1813.
Type: *Tenthredo cincta* Linnæus (Curtis, 1833; Westwood, 1840).
- Empria** Lepeletier, Encycl. Méthod., Ins., vol. 10, pt. 2, p. 571, 1828.
Type: *Dolerus (Empria) pallimacula* Lepeletier (Brullé, 1846).
- Encarsioneura** Konow, Deutsch. ent. Zeitschr., p. 239, 1890.
Type: *Tenthredo sturnii* Klug.*
= **Siobla** Cameron.
- Endelomyia** Ashmead, Can. Ent., vol. 30, p. 256, 1898.
Type: *Monostegia rosæ* Harris (designated).
= *Caliroa æthiops* (Fabricius).
= **Caliroa** O. Costa.
- Eniscia** Thomson, Opusc. Ent., pt. 2, p. 299, 1870.
Type: *Tenthredo consobrina* Klug.
- Entodecta** Konow, Wien. ent. Zeit., vol. 5, pp. 184, 243, 1886.
Type: *Tenthredo (Allantus) pumila* Klug (MacGillivray, 1909).
- Epitactus** Förster, Verh. naturh. Ver. preuss. Rheinl., vol. 11, p. 435, 1854.
Type: *Epitactus præcox* Förster.*
- Ephippinotus** O. Costa, Fauna Napoli, Cephid., p. 10, 1860.
Type: *Ephippinotus luteiventris* O. Costa.
= *Sirex compressus* Fabricius.
- Epitaxonus** MacGillivray, Can. Ent., vol. 40, p. 365, October, 1908.
Type: *Taxonus albidopictus* Norton (designated).
- Eriglenum** Konow, Termes. Fuzetek, vol. 24, p. 60, 1901.
Type: *Eriglenum crudum* Konow.*
- Eriocampa** Hartig, Fam. Blatt. Holzwesp., p. 279, 1837.
Type: *Tenthredo ovata* Linnæus.
- Eriocampidea** Ashmead, Can. Ent., vol. 30, p. 256, 1898.
Type: *Eriocampidea arizonensis* Ashmead (designated).
- Eriocampoides** Konow, Deutsch. ent. Zeitschr., p. 239, 1890.
Type: *Tenthredo limacina* Retzius (MacGillivray, 1908).
- Ermilia** O. Costa, Fauna Napoli, Tenthred., p. 106, 1859.
Type: *Ermilia pulchella* O. Costa.*
= *Tenthredo agrorum* Fallén.
= **Taxonus** Hartig (isogenotypic).
- Erythraspides** Ashmead, in Dyar, Journ. N. Y. Ent. Soc., p. 128, 1898; also Can. Ent., vol. 30, p. 252, 1898.
Type: *Blennocampa pygmæa* Say (designated).
- Eumetabolus** Schulz, Spolia Hymen., p. 211, 1906.
Type: *Sirex troglodyta* Fabricius.
= *Sirex niger* Harris.
= **Astatus** Panzer.

- Euryopsis** W. F. Kirby, List Hym. Brit. Mus., vol. 1, p. 95, no. 45, 1882.
Type: *Euryopsis nitens* W. F. Kirby.*
- Eurys** E. Newman, Ent., p. 90, 1841.
Type: *Eurys wratus* E. Newman.*
- Euura** E. Newman, Ent. Mag., vol. 4, p. 259, January, 1837.
Type: *Euura gallæ* Newman.
- Eversmannella** Jakowlew, Horæ Soc. Ent. Ross., vol. 26, p. 15, no. 3, 1891.
Type: *Cephus cruentatus* Eversmann.*
- Fenella** Westwood, Introd. Mod. Class. Ins., vol. 2, Gen. Synop., p. 54, 1840.
Type: *Fenella nigrita* Westwood.*
- Fenusa** Leach, Zool. Misc., vol. 3, p. 126, no. 4, 1817.
Type: *Tenthredo (Emphytus) pumila* Klug.*
- Fethalia** Cameron, Journ. Bombay Soc. Nat. Hist., vol. 14, p. 439, 1902.
Type: *Fethalia nigra* Cameron.*
- Gongylocorsia** Konow, Ann. k. k. Hofmus., Wien, vol. 12, p. 19, 1897.
Type: *Lyda mandibularis* Zaddach.*
- Gymnia** Spinola, Mem. Accad. Sci. Torino, (2) vol. 13, p. 23, 1851.
Type: *Gymnia apicalis* Spinola.
- Gymniopterus** Ashmead, Can. Ent., vol. 30, p. 213, 1898.
Type: *Gymniopterus singularis* Ashmead (designated).
- Gymnonychus** Marlatt, U. S. Dept. Agr., Div. Ent., Tech. Ser. 3, p. 122, 1896.
Type: *Gymnonychus californicus* Marlatt (designated).
= *Diphadnus* Hartig.
- Haplostegus** Konow, Termes. Fuzetek, vol. 24, p. 70, 1901.
Type: *Haplostegus epimelas* Konow.
- Harpiphorus** Hartig, Fam. Blatt. Holzwespen., p. 253, 1837.
Type: *Tenthredo (Emphytus) lepidus* Klug.*
- Hartigia** (Schiödte) Boie. Schiödte, Kroyers Naturhistorisk Tidsskrift., vol. 2, p. 332, 1838; Boie, Stett. Ent. Zeit., vol. 16, p. 49, 1855.
Type: *Astutus satyrus* Rossi.
- Hemichroa** Stephens, Illustr. Brit. Ent., Mandib., vol. 7, p. 55, no. 18, 1835.
Type: *Tenthredo alni* Linnæus (Westwood, 1840; Brullé, 1846).
- Hemidianeura** W. F. Kirby, List Hym. Brit. Mus., vol. 1, p. 48, no. 28, 1882.
Type: *Hemidianeura nigricornis* W. F. Kirby.
- Hemitaxonus** Ashmead, Can. Ent., vol. 30, p. 311, 1898.
Type: *Taxonus dubitatus* Norton (designated).
- Hennedyia** Cameron, Mem. & Proc. Manchester Lit. Phil. Soc., vol. 4, no. 4, p. 9, 1891.
Type: *Hennedyia annulitarsis* Cameron.*
- Heptacola** Konow, Zeitschr. syst. Hym. Dipt., vol. 5, p. 167, 1905.
Type: *Heptacola buyssoni* Konow.
- Heptamelus** Haliday, Nat. Hist. Rev., vol. 2, p. 60, 1835.
Type: *Melicerta ochroleuca* Stephens.*
- Heterarthus** Stephens, Illustr. Brit. Ent., Mandib., vol. 7, p. 94, no. 25, 1835.
Type: *Tenthredo (Emphytus) ochropoda* Klug.*
- Holcoeceme** Konow, Deutsch. ent. Zeitschr., p. 238, 1890.
Type: *Tenthredo crassa* Fallén.
- Homœoneura** Ashmead, Can. Ent., vol. 30, p. 313, 1898.
Type: *Tenthredo delta* Provancher (designated).
= *Bivena* MacGillivray.

- Hoplocampa** Hartig, Fam. Blatt. Holzwespe., p. 276, 1837.
Type: *Tenthredo (Allantus) brevis* Klug.
- Hybonotus** Klug, Mon. Siric. Germ., p. 8, no. 2, 1803.
Type: *Ichneumon camelus* Linnæus.
= **Xiphydria** Latreille.
- Hylotoma** Latreille, Hist. Nat. Crust. Ins., vol. 3, p. 302, 1802.
Type: *Tenthredo rosæ* Linnæus.*
= **Arge** Schrank.
- Hypargyricus** MacGillivray, Can. Ent., vol. 40, p. 290, August, 1908.
Type: *Hypargyricus infuscatus* MacGillivray (designated).
- Hyperoceros** Konow, Zeitschr. syst. Hym. Dipt., vol. 6, p. 369, 1906.
Type: *Hyperoceros peruanus* Konow.*
- Hypolæpus** W. F. Kirby, List Hym. Brit. Mus., vol. 1, p. 324, no. 103, 1882.
Type: *Hypolæpus abbotii* W. F. Kirby.*
- Hypotaxonus** Ashmead, Can. Ent., vol. 30, p. 311, 1898.
Type: *Strongylogaster pallipes* Say (designated).
- Incalia** Cameron, Trans. Ent. Soc. Lond., p. 143, 1878.
Type: *Incalia hirticornis* Cameron.*
- Ischyrocercæa** Kier, Tromoso Mus. Aarsk., vol. 19, p. 67, 1896 (pub. 1898).
Type: *Ischyrocercæa hyperborea* Kier.*
- Isodyctium** Ashmead, in Dyar, Journ. N. Y. Ent. Soc., p. 127, 1898; Can. Ent., vol. 30, p. 251, October, 1898.
Type: *Isodyctium corycolum* Dyar (designated).
- Itycorsia** Konow, Ann. k. k. Hofmus., Wien, vol. 12, p. 13, 1897.
Type: *Tenthredo hieroglyphica* Christ. (Rohwer, 1910).
- Janus** Stephens, Illustr. Brit. Ent., Mandib., vol. 7, p. 107, no. 30, 1835.
Type: *Janus connectus* Stephens (Westwood, 1840).
= *Janus cynosbati* (Fabricius).
- Jermakia** Jakowlew, Horæ Ent. Soc. Ross., vol. 26, pts. 1-2, p. 58, no. 68, 1891.
Type: *Allantus cephalotes* Jakowlew.*
- Kaliofenusa** Viereck, Ann. Rep. N. J. State Mus., p. 591, 1909 (1910).
Type: *Fenusa ulmi* Sundevall.
- Kaliosysphinga** Tischbein, Stett. ent. Zeit., vol. 7, p. 79, 1846.
Type: *Kaliosysphinga dohrnii* Tischbein.*
= **Fenusa** Leach.
- Kelidoptera** Konow, Ann. k. k. Hofmus. Wien, vol. 12, p. 20, 1897.
Type: *Lyda maculipennis* Stein.*
- Kokujewia** Konow, Rev. Ent. Russe, vol. 2, p. 3, 1902.
Type: *Kokujewia ectrapela* Konow.
- Konowia** Brauns, Wien. ent. Zeit., vol. 3, p. 220, 1884.
Type: *Konowia megapolitana* Brauns.*
- Labidarge** Konow, Ent. Nachr., vol. 25, p. 309, 1899.
Type: *Labidarge bolivari* Konow.
= **Caloptilia** Ashmead.
- Labidia** Provancher, Addit. Faune Can. Hym., p. 21, 1886.
Type: *Labidia columbiana* Provancher.*
= *Allantus opinus* Cresson.
- Lagideus** Konow, Zeitschr. syst. Hym. Dipt., vol. 5, p. 160, 1905.
Type: *Lagideus crinitus* Konow.*

- Lagium** Konow, Zeitschr. syst. Hym. Dipt., vol. 4, p. 246, 1904.
Type: *Tenthredo atrovioleaceum* Norton (designated).
- Laurentia** A. Costa, Rendic. Accad. Sci. Fis., Napoli, (2) vol. 4, p. 173, 1890.
Type: *Laurentia craverii* A. Costa.*
= *Tenthredo gibbosa* Fallén.
- Leptocerca** Hartig, Fam. Blatt. Holzwesp., p. 228, 1837.
Type: *Tenthredo alni* Linnæus.
= **Hemichroa** Stephens.
- Leptocercus** Thomson, Hym. Scand., vol. 1, p. 76, 1871 (an emended spelling of *Leptocerca*).
Type: *Tenthredo alni* Linnæus.
= **Hemichroa** Stephens.
- Leptocimbex** Semenow, Ann. Mus. St. Petersburg, p. 95, 1896.
Type: *Leptocimbex potanini* Semenow.
- Leptopus** Hartig, Fam. Blatt. Holzwesp., p. 104, 1837 (non Latreille, 1809).
Type: *Nematus (Leptopus) hypogastricus* Hartig.*
= *Tenthredo luridiventris* Fallén.
= **Platycampus** Schiödte.
- Liolyda** Ashmead, Can. Ent., vol. 30, p. 209, 1898.
Type: *Lyda frontalis* Westwood (designated).
= **Cephaleia** Panzer.
- Lisconeura** Rohwer, Bul. Amer. Mus. Nat. Hist., vol. 24, p. 529, 1908.
Type: *Scolioneura vexabilis* Brues (designated).
- Lithoryssus** Brues, Bul. Amer. Mus. Nat. Hist., vol. 20, p. 492, fig. 1, 1906.
Type: *Lithoryssus parvus* Brues (designated).
- Lithracia** Cameron, Journ. Bombay Soc., vol. 14, p. 441, 1902.
Type: *Lithracia flavipes* Cameron.*
- Loboceras** W. F. Kirby, List Hym. Brit. Mus., vol. 1, p. 79, no. 35, 1882.
Type: *Loboceras mexicanum* W. F. Kirby.
- Loderus** Konow, Deutsch. ent. Zeitschr., p. 240, 1890.
Type: *Tenthredo pratorum* Fallén.
- Lophyridea** Ashmead, Can. Ent., vol. 30, p. 226, 1898.
Type: *Lophyrus tropicus* Norton (designated).
'= **Lophyroides** Cameron.
- Lophyroides** Cameron, Ent. Monthl. Mag., vol. 19, p. 133, 1882.
Type: *Lophyrus tropicus* Norton (designated).
- Lophyrotoma** Ashmead, Can. Ent., vol. 30, p. 230, 1898.
Type: *Pterygophorus interruptus* Klug (designated).
= **Pterygophorus** Klug.
- Lophyrus** Latreille, Hist. Nat. Crust. Ins., vol. 3, p. 302, 1802 (non Poli).
Type: *Tenthredo pini* Linnæus.*
= **Diprion** Schrank (isogenotypic).
- Lyaota** Konow, Zeitschr. syst. Hym. Dipt., vol. 3, p. 147, 1903.
Type: *Selandria sodalis* Cresson.*
- Lycosceles** Konow, Zeitschr. syst. Hym. Dipt., vol. 5, p. 159, 1905.
Type: *Lycosceles herbsti* Konow.*
- Lyda** Fabricius, Syst. Piez., p. 43, no. 5, 1804.
Type: *Tenthredo sylvatica* Linnæus (Curtis, 1831).
= **Pamphilius** Latreille.

- Lygæonematus** Konow, Deutsch. ent. Zeitschr., p. 238, 1890.
Type: *Nematus pini* Retzius.
- Macgillivraya** Ashmead, Can. Ent., vol. 30, p. 257, 1898 (preoccupied).
Type: *Macgillivraya oregonensis* Ashmead (designated).
= **Macgillivrayella** Ashmead.
- Macgillivrayella** Ashmead, in Smith, Cat. Ins. N. J., p. 606, 1899 (n. n. for *Macgillivraya* Ashmead).
Type: *Macgillivraya oregonensis* Ashmead.
- Macremphytus** MacGillivray, Can. Ent., vol. 40, p. 368, October, 1908.
Type: *Harpiphorus varianus* Norton (designated).
- Macrocephus** Schlechtendal, Ent. Nachr., vol. 4, p. 153, 1878.
Type: *Macrocephus ulmariae* Schlechtendal.*
= *Tenthredo linearis* Schrank, 1781.
= **Hartigia** Schiodte and Boie.
- Macroclada** Konow, Genera Insectorum, Fasc. 29, p. 46, 1906.
(An emended name for *Cladomacra* F. Smith.)
= **Cladomacra** F. Smith.
- Macrophya** Dahlbom, Conspect. Tenthred. Scand., p. 11, no. 3, 1835.
Type: *Tenthredo rusticus* Linnæus (Westwood, 1840).
- Macroxyela** W. F. Kirby, List. Hym. Brit. Mus., vol. 1, p. 351, no. 109, 1882.
Type: *Xyela ferruginea* Say (designated).
- Manoxyela** Ashmead, Can. Ent., vol. 30, p. 206, 1898.
Type: *Manoxyela californica* Ashmead (designated).
= **Pleroneura** Konow.
- Marlattia** Ashmead, Can. Ent., vol. 30, p. 287, 1898.
Type: *Hoplocampa laricis* Marlatt (designated).
- Mastigocera** Klug, 18— Reference unknown, a synonym of *Xyela* by Lepeletier, Encycl. Method., vol. 10, pt. 2, p. 577, 1828.
- Megalodontes** Latreille, Hist. Nat. Crust. et Ins., vol. 3, p. 302, 1802.
Type: *Tenthredo cephalotes* Fabricius (Latreille, 1810).
- Megaxyela** Ashmead, Can. Ent., vol. 30, p. 206, 1898.
Type: *Xyela major* Cresson (designated).
- Melanopus** Konow, Ann. k. k. Hofmus., Wien., vol. 12, p. 12, 1897.
Type: *Tarpa fabricii* Leach.*
- Melanoselandria** (Ashmead) MacGillivray, in Smith, Cat. Ins. N. J., p. 606, 1899; Can. Ent., vol. 41, p. 404, November, 1909.
Type: *Melanoselandria zabriskiei* Ashmead.*
= **Hypargyricus** MacGillivray, 1908.
- Melicerta** Stephens, Illustr. Brit. Ent., Mandib., vol. 7, p. 95, no. 26, 1835 (preocc.).
Type: *Melicerta ochroleucus* Stephens.*
= **Heptamelus** Haliday, 1855.
- Melinia** O. Costa, Fauna Napoli, Tenthred., p. 41, 1859.
Type: *Melinia minutissima* O. Costa.
- Mesoneura** Hartig, Fam. Blatt. Holzwespe., p. 229, 1837.
Type: *Tenthredo opaca* Fabricius.*
- Messa** Leach, Zool. Misc., vol. 3, p. 126, no. 3, 1817.
Type: *Tenthredo (Emphytus) hortulana* Klug.*
- Metallus** Forbes, 14th Rep. St. Ent. Ill. for 1884, p. 87, 1885.
Type: *Metallus rubi* Forbes.*

- Micrarge** Ashmead, Can. Ent., vol. 30, p. 213, 1898.
Type: *Atomocera ruficollis* Norton (designated).
- Miocephala** Konow, Zeitschr. syst. Hym. Dipt., vol. 7, p. 162, 1907.
Type: *Miocephala chalybea* Konow.*
- Micronematus** Konow, Deutsch. ent. Zeitschr., p. 239, 1890.
Type: *Nematus pullus* Förster.
= *Nematus monogynia* Hartig.
- Mocsarya** Konow, Termes. Fuzetek, vol. 20, p. 608, 1897.
Type: *Oryssus metallicus* Mocsary.*
- Mogerus** MacGillivray, Can. Ent., vol. 27, p. 281, October, 1895.
Type: *Tenthredo (Allantus) lineolata* Klug.
= *Periclista* Konow.
- Monoctenus** Dahlbom, Consp. Tenthred. Scand., p. 7, 1835.
Type: *Tenthredo juniperi* Linnæus.*
- Monophadnoides** Ashmead, Can. Ent., vol. 30, p. 253, October, 1898.
Type: *Monophadnus rubi* Harris (designated).
- Monophadnus** Hartig, Fam. Blatt. Holzwesp., p. 271, 1837.
Type: *Tenthredo albipes* Gmelin (Ashmead, 1898).
- Monoplopus** Konow, Wien. ent. Zeit., vol. 15, p. 173, 1896.
Type: *Tenthredo saltuum* Linnæus.
- Monosoma** Viereck, Ann. Rep. N. J. State Mus., p. 583, 1909 (1910).
Type: *Pæcilstoma inferentia* Norton.*
= **Monsoma** MacGillivray.
- Monostegia** O. Costa, Fauna Napoli, Tenthred., p. 60, 1859.
Type: *Tenthredo abdominalis* Fabricius (MacGillivray, 1908).
- Monsoma** MacGillivray, Can. Ent., vol. 40, p. 368, October, 1908.
Type: *Pæcilstoma inferentia* Norton (designated).
- Nematoceros** Konow, Wien. ent. Zeit., vol. 15, pp. 54, 52, 1896.
Type: *Tenthredo luteola* Klug.*
= **Monostegia** Costa (isogenotypic).
- Nematoneura** E. André, Spec. Hym. Europe, vol. 1, pt. 2, p. 576, no. 7^b, 1881.
Type: *Nematoneura violaceipennis* André.*
- Nematinus** Rohwer, see p. 99.
Type: *Tenthredo abdominalis* Panzer (designated).
- Nematus** Panzer, Krit. Revis., vol. 2, p. 44, 1806.
Type: *Tenthredo septentrionalis* Linnæus (Latreille, 1810).
- Neoharactus** MacGillivray, Can. Ent., vol. 40, p. 293, August, 1908.
Type: *Neoharactus bakeri* MacGillivray (designated).
- Neoeurys** Rohwer, Ent. News, vol. 22, p. 472, 1910.
Type: *Neoeurys metallica* Rohwer (designated).
- Neopareophora** MacGillivray, Can. Ent., vol. 40, p. 289, August, 1908.
Type: *Neopareophora martini* MacGillivray (designated).
- Neoperga** Ashmead, Can. Ent., vol. 30, p. 232, 1898.
Type: *Perga amenaïda* Kirby (designated).
- Neoptilia** Ashmead, Can. Ent., vol. 30, p. 213, 1898.
Type: *Neoptilia mexicana* Ashmead (designated).
- Neopus** Viereck, Ann. Rep. N. J. State Mus., p. 585, 1909 (1910).
Type: *Tenthredopsis quatuordecimpunctata* Norton.
- Neotomostethus** MacGillivray, Can. Ent., vol. 40, p. 290, August, 1908.
Type: *Neotomostethus hyalinus* MacGillivray (designated).

- Nesodiprion** Rohwer, Proc. U. S. Nat. Mus., vol. 39, no. 1777, p. 104, 1910.
Type: *Lophyrus japonicus* Marlatt (designated).
- Nesoselandria** Rohwer, Proc. U. S. Nat. Mus., vol. 38, no. 1722, p. 657, 1910.
Type: *Paraselandria imitatrix* Ashmead (designated).
- Nesotaxonus** Rohwer, Proc. U. S. Nat. Mus., vol. 39, no. 1777, p. 111, 1910.
Type: *Phyllotoma? flavescens* Marlatt (designated).
- Nesotomostethus** Rohwer, Proc. U. S. Nat. Mus., vol. 39, no. 1777, p. 106, 1910.
Type: *Blennocampa religiosa* Marlatt (designated).
- Netroceros** Konow, Wien. ent. Zeit., vol. 15, p. 51, 1896.
Type: *Eriocampa (Netroceros) rufiventris* Konow.
- Neurotoma** Konow, Ann. k. k. Hofmus., Wien, vol. 12, p. 18, 1897.
Type: *Tenthredo flaviventris* Linnæus (Rohwer, 1910).
- Nortonella** Rohwer, Bul. Amer. Mus. Nat. Hist., vol. 24, p. 582, 1908.
Type: *Nortonella typica* Rohwer (designated).
- Nycteridium** Fischer-Waldheim, Mém. Soc. Nat. Moscou, vol. 1, p. 286, 1806.
Type: *Nycteridium fischeri* Fischer.
- Odontophyes** Konow, Wien. ent. Zeit., vol. 18, p. 42, 1899.
Type: *Pleroneura avingrata* Dyar.*
- Ophrynopus** Konow, Termes. Fuzetek, vol. 20, p. 605, 1897.
Type: *Ophrynopus andrei* Konow.
- Opisthoneura** Ashmead, Can. Ent., vol. 30, p. 287, 1898.
Type: *Opisthoneura crevecoeuri* Ashmead (designated).
= *Hoplocampa montana* Cresson.
= *Zaschizonyx* Ashmead.
- Oryssus** Latreille, Préc. Car. Génér. Ins., p. 111, no. 10, 1796.
Type: *Oryssus coronatus* Fabricius (Latreille, 1810).
- Pachycephus** J. P. Stein, Stett. ent. Zeit., vol. 37, p. 60, 1876.
Type: *Pachycephus smyrnensis* Stein.*
- Pachylosticta** Klug, Ent. Mon., p. 171, 1824.
Type: *Pachylosticta tibialis* Klug.
- Pachyloata** Westwood, Arc. Ent., vol. 1, p. 24, pl. 7, fig. 3, 1841.
Type: *Pachyloata audouinii* Westwood.*
- Pachynematus** Konow, Deutsch. ent. Zeitschr., p. 238, 1890.
Type: *Nematus capreæ* Panzer.
= *Nematus trisignatus* Förster.
- Pachyrotasis** Hartig, Fam. Blatt. Holzwesp., p. 295, 1837.
Type: *Tenthredo rapæ* Linnæus (Westwood, 1840).
- Palæotaxonus** Brues, Bul. Mus. Comp. Zool., vol. 51, no. 10, p. 266, March, 1908.
Type: *Palæotaxonus typicus* Brues (designated).
- Pamphilius** Latreille, Hist. Nat. Crust. Ins., vol. 3, p. 303, 1802.
Type: *Tenthredo silvatica* Linnæus.*
- Pampsilota** Konow, Ent. Nachr., vol. 25, p. 76, 1899.
Type: *Pampsilota afer* Konow.
- Parabatus** MacGillivray, Ann. Ent. Soc. Amer., vol. 2, p. 262, 1909.
Type: *Parabates histrionicus* MacGillivray (designated).
- Parabia** Semenow, Horæ. Soc. Ent. Ross., vol. 25, p. 174, 1890.
Type: *Parabia jokowlewi* Semenow (designated).
- Paracharactus** MacGillivray, Can. Ent., p. 292, August, 1908.
Type: *Paracharactus obscuratus* MacGillivray (designated).

- Paralypia** W. F. Kirby, List. Hym. Brit. Mus., vol. 1, p. 33, no. 17, 1882.
Type: *Paralypia picipes* Kirby.*
- Paraperga** Ashmead, Can. Ent., vol. 30, p. 232, 1898.
Type: *Perga jucunda* Kirby (designated).
- Paraselandria** Ashmead, Can. Ent., vol. 30, p. 255, 1898.
Type: *Tenthredo flavans* Klug (designated).
= *Selandria* Leach.
- Parasiobla** Ashmead, Can. Ent., vol. 30, p. 308, 1898.
Type: *Strongylogaster rufocinctus* Norton (designated).
- Parastatis** W. F. Kirby, Ent. Monthly Mag., vol. 18, p. 107, 1881.
Type: *Parastatis indica* W. F. Kirby.*
- Parasyzygonia** Rohwer (see p. 102).
Type: *Syzygonia cyanoptera* Klug (designated).
- Parataxonus** MacGillivray, Can. Ent., vol. 40, p. 367, October, 1908.
Type: *Taxonus multicolor* Norton (designated).
= *Aphilodyctium* Ashmead.
- Parazarca** Ashmead, in Dyar, Journ. N. Y. Ent. Soc., p. 128, 1898; also Can. Ent., vol. 30, p. 252, October, 1898.
Type: *Parazarca fumipennis* Ashmead (designated).
- Paremphtytus** Brues, Bul. Mus. Comp. Zool., vol. 51, no. 10, p. 264, March, 1908.
Type: *Paremphtytus ostentus* Brues.*
- Pareophora** Konow, Wien. ent. Zeit., vol. 5, pp. 184, 187, no. 3, 1886.
Type: *Pareophora luridiventris* Konow.
= *Tenthredo* (*Allantus*) *nigripes* Klug.
- Paururus** Konow, Wien. ent. Zeit., vol. 15, p. 43, 1896.
Type: *Sirex juvenicus* Linnæus.
- Pectinia** Brullé, Hist. Nat. Ins. Hym., vol. 4, p. 664, 1846.
Type: *Tenthredo* (*Allantus*) *aterrima* Klug (designated).
= *Phymatocera* Dahlbom.
- Pelmatopus** Hartig, Fam. Blatt. Holzwesp., p. 244, 1837.
Type: *Dolerus* (*Pelmatopus*) *minutus* Hartig.*
- Perantherix** Westwood, Thes. Ent. Oxon., p. 109, 1874.
Type: *Perantherix pumilio* Westwood.*
- Perga** Leach, Zool. Misc., vol. 3, p. 115, 1817.
Type: *Perga dorsalis* Leach (Shipp, 1894).
- Pergadopsis** Shipp, Ent., vol. 27, pp. 339, 340, 1894.
Type: *Perga dahlbomi* Westwood (designated).
- Periclista** Konow, Wien. ent. Zeit., vol. 5, pp. 184, 186, no. 2, 1886.
Type: *Tenthredo* (*Allantus*) *lineolata* Klug.
- Periclistoptera** Ashmead, Can. Ent., vol. 30, p. 255, 1898.
Type: *Monostegia quercus-alba* Norton (designated).
Ashmead gave the type as *alba*.
= *Eriocampoides* Konow.
- Perineura** Hartig, Fam. Blatt. Holzwesp., p. 303, 1837.
Type: *Tenthredo rubi* Panzer.*
- Peronistilus** Chigi, Ann. Mus. Zool. R. Univ. Napoli, n. s. vol. 1, no. 21, p. 26, 1904.
Type: *Cephus politissimus* A. Costa.*
- Perreyia** Brullé, Hist. Nat. Ins. Hym., vol. 4, p. 661, 1846.
Type: *Perreyia lepida* Brullé.*
- Pëus** Konow, Zeitschr. syst. Hym. Dipt., vol. 3, p. 315, 1903.
Type: *Pëus privus* Konow.*

- Phænusa** Cameron, Ent. Monthly Mag., vol. 12, p. 131, 1875.
Type: *Phænusa albipes* Cameron.
= **Messa** Leach.
- Philomastix** Froggatt, Proc. Linn. Soc. N. S. Wales, (2) vol. 5, p. 467, 1890.
Type: *Philomastix naucarrowi* Froggatt.
- Phlebotrophia** MacGillivray, Can. Ent., p. 345, October, 1909.
Type: *Phlebotrophia mathesoni* MacGillivray (designated).
- Phenacoperga** Cockerell, Science, n. s. vol. 27, p. 113, 1908.
Type: *Perga coloradensis* Cockerell (designated).
- Phrontosoma** MacGillivray, Can. Ent., vol. 40, p. 366, October, 1908.
Type: *Phrontosoma atrum* MacGillivray (designated).
- Phylacteophaga** Froggatt, Proc. Linn. Soc. N. S. Wales, vol. 24, p. 130, 1899.
Type: *Phylacteophaga eucalypti* Froggatt.*
- Phyllæcus** E. Newman, Ent. Mag., vol. 5, p. 485, 1838.
Type: *Phyllæcus faunus* E. Newman.
= **Janus** Stephens.
- Phyllotoma** Fallén, Mon. Tenthred. Suec., p. 25, 1829.
Type: *Phyllotoma vagans* Fallén.
- Phymatocera** Dahlbom, Conspect. Tenthred. Scand., p. 11, no. 2, 1835.
Type: *Tenthredo (Allantus) aterrima* Klug.*
- Pinicola** Brébisson, Bul. Soc. Philom. Paris, p. 116, 1818 (non Vieillot, 1805).
Type: *Pinicola julii* Brébisson.
= **Xyela** Dalman.
- Plagiocera** Klug, Jahrb. Insectenkunde, vol. 1, p. 227, no. 2, 1834.
Type: *Plagiocera thoracica* Klug.*
- Plagioperga** Shipp, Ent., vol. 27, pp. 339, 340, 1894.
Type: *Perga mayrii* Westwood (designated).
- Platycampus** Schiödte, Mag. Zool., vol. 9, p. 20, 1839 (footnote).
Type: *Nematus (Leptopus) hypogastricus* Hartig.
- Pleroneura** Konow, Ent. Nachr., vol. 23, p. 56, 1897.
Type: *Xyela dahli* Hartig.
- Pæcilosoma** Thomson, Scand. Hym., vol. 1, p. 227, 1871.
Emended spelling of *Pæcilstoma*.
- Pæcilstoma** Dahlbom, Conspect. Tenthred. Scand., p. 13, no. 8, 1835.
Type: *Tenthredo guttatum* Fallén.
= **Empria** Lepeletier.
- Pæcilstomidea** Ashmead, Can. Ent., vol. 30, p. 256, 1898.
Type: *Pæcilstoma maculata* Norton (designated).
= **Empria** Lepeletier.
- Polybates** MacGillivray, Ann. Ent. Soc. Amer., vol. 2, p. 264, 1909.
Type: *Polybates slossonæ* MacGillivray (designated).
- Polyclonus** W. F. Kirby, List Hym. Brit. Mus., vol. 1, p. 97, no. 48, 1882.
Type: *Polyclonus atratus* W. F. Kirby.*
- Polystichophagus** Ashmead, Can. Ent., vol. 30, p. 310, 1898.
Type: *Tenthredo filicis* Klug (designated).
= **Pseudotaxonus** A. Costa.
- Pompholyx** Freymuth, Protoc. 47^{me} Séance Soc. Anthrop. Moscou, vol. 8, p. 216, 1870.
Type: *Pompholyx dimorpha* Freymuth.*
preocc., = **Cacosyndia** Kirby.

- Pontania** O. Costa, Fauna Napoli, Tenthred., p. 20, 1859.
Type: *Nematus gallicola* Stephens (Marlatt, 1896).
- Poppia** Konow, Zeitschr. syst. Hym. Dipt., vol. 4, p. 263, 1904.
Type: *Poppia athaloides* Konow.*
- Praia** (Wankowitz) André, Spec. Hym. Europe et Algérie, vol. 1, pt. 6, 1880; p. 572, n. 3^b, 1881.
Type: *Praia taczanowskii* (Wankowitz) André.*
- Priophorus** Dahlbom, Conspect. Tenthred. Scand., p. 4, no. 1, 1835.
Type: *Priophorus pilicornis* Dahlbom.
= *Tenthredo padi* Linnæus.
- Pristiphora** Latreille, Consid. Générales, p. 294, 1810.
Type: *Pteronus testaceus* Jurine (designated).
- Pristis** Brullé, Hist. Nat. Ins. Hym., vol. 4, p. 665, 1846.
Type: *Tenthredo punctigera* Lepeletier.
= *Tenthredo opaca* Fabricius.
= *Mesoneura* Hartig.
- Probleta** Konow, Zeitschr. syst. Hym. Dipt., vol. 8, p. 161, 1908.
Type: *Probleta langei* Konow.
- Prototaxonus** Rohwer, Can. Ent., vol. 42, p. 49, February, 1910.
Type: *Prototaxonus typicus* Rohwer (designated).
- Protemphytus** Rohwer, Can. Ent., vol. 41, p. 92, March, 1909.
Type: *Emphytus coloradensis* Weldon (designated).
- Pseudabia** Schrottky, Ent. Rundschau, vol. 27, no. 23, p. 168, December 1, 1910.
Type: *Pseudabia fusca* Schrottky (designated).
- Pseudoclavellaria** Schultz, Spolia Hym., p. 87, 1906.
Type: *Tenthredo amerinæ* Linnæus.
- Pseudocimbex** Rohwer, Bul. Amer. Mus. Nat. Hist., vol. 24, p. 526, 1908.
Type: *Pseudocimbex clavatus* Rohwer (designated).
- Pseudocyphona** Ashmead, Can. Ent., vol. 30, p. 211, 1898.
Type: *Pseudocyphona mexicana* Ashmead (designated).
- Pseudodineura** Konow, Wien. ent. Zeit., vol. 4, p. 297, 1885.
Type: *Tenthredo (Allantus) parvula* Klug.
- Pseudoperga** Guérin, Icon. Regne Anim., vol. 7, Insectes, p. 398, 1845.
Type: *Perga lewisii* Westwood (Shipp, 1894).
- Pseudoperga** Ashmead, Can. Ent., vol. 30, p. 232, 1898 (non Guérin).
Type: *Perga polita* Leach (designated).
- Pseudosiobla** Ashmead, Can. Ent., vol. 30, p. 308, 1898.
Type: *Macrophya excavata* Norton (designated).
- Pseudosirex** Weyenbergh, Arch. Mus. Teyler, vol. 3, p. 238, 1873.
Type: *Pseudosirex darwinii* Weyenbergh.
- Pseudotaxonus** A. Costa, Proc. Sist. Imenott. Ital., p. 157, 1894.
Type: *Tenthredo filicis* Klug.*
- Ptenos** Norton, Trans. Amer. Ent. Soc., vol. 4, p. 77, 1872.
Type: *Ptenos niger* Norton.
- Pteronidea** Rohwer (see p. 98).
Type: *Nematus ventralis* Say (designated).
- Pteronus** Panzer, Krit. Revis., vol. 2, p. 46, 1806
Type: *Tenthredo pini* Linnæus.
= *Diprion* Schrank.

- Pterygophorus** Ashmead, Can. Ent., vol. 30, p. 230, September, 1898.
Type: *Pterygophorus analis* O. Costa (designated).
=**Pterygophorus** Klug.
- Pterygophorus** Klug, Mag. Ges. naturf. Freunde Berlin, vol. 6, p. 276, 1812.
Type: *Pterygophorus cinctus* Klug (Ashmead, 1898).
- Ptilia** Lepeletier, Mon. Tenthred., p. 49, 1823.
Type: *Ptilia braziliensis* Lepeletier.
- Rethrax** Cameron, Mem. & Proc. Manchester Lit. Phil. Soc., vol. 43, no. 3, p. 32, 1899.
Type: *Rethrax carinata* Cameron.*
- Rhadinocera** Konow, Wien. ent. Zeit., vol. 5, pp. 184, 211, no. 5, 1886.
Type: *Tenthredo (Allantus) micans* Klug.
- Rhagonyx** Konow, Zeitschr. syst. Hym. Dipt., vol. 3, p. 108, 1903.
Type: *Rhagonyx lituratus* Konow.*
- Rhipidioceros** Konow, Ann. k.k. Hofmus., Wien., vol. 12, p. 2, 1897.
Type: *Tarpa flabellicornis* Germar.
- Rhogogaster** Konow, Deutsch. ent. Zeitschr., p. 338, 1884.
Type: *Tenthredo viridis* Linnæus.
- Rhogogastera** Konow, Wien. ent. Zeit., vol. 4, p. 123, 1885.
(An emended spelling for *Rhogogaster*.)
- Rhopographus** Konow, Ent. Nachr., vol. 25, p. 79, 1899 (n. n. for *Rhoproceros*).
Type: *Rhoproceros procinctus* Konow.
- Rhoproceros** Konow, Ent. Nachr., vol. 24, p. 276, 1898.
Type: *Rhoproceros procinctus* Konow.*
preocc., =**Rhopographus** Konow.
- Rusobria** Cameron, Trans. Ent. Soc. Lond., p. 150, 1878.
Type: *Rusobria carinata* Cameron.
- Schizocera** Lepeletier, Encycl. Méthod., Ins., vol. 10, pt. 2, p. 572, 1828.
Type: *Hylotoma fuscata* Villers (Westwood, 1840).
- Sciapteryx** Stephens, Illustr. Brit. Ent., Mandib., vol. 7, p. 56, no. 19, 1835.
Type: *Tenthredo costalis* Fabricius.*
Sciapteryx is an incorrect spelling.
- Scobina** Lepeletier, Encycl. Méthod., Ins., vol. 10, pt. 2, p. 574, 1828.
Type: *Hylotoma melanocephala* Lepeletier.*
- Scolioneura** Konow, Deutsch. ent. Zeitschr., p. 249, 1890.
Type: *Tenthredo (Allantus) betuleti* Klug (MacGillivray, 1909).
- Selandria** Leach, Zool. Misc., vol. 3, p. 126, no. 3, 1817.
Type: *Tenthredo serva* Fabricius (Brullé, 1846).
- Senoclia** Cameron, Trans. Ent. Soc. Lond., p. 88, 1877 (n. n. for *Anisoarthra* Cameron).
Type: *Anisoarthra cærulea* Cameron.
- Sericocera** Brullé, Hist. Nat. Ins. Hym., vol. 4, p. 669, 1846.
Type: *Sericocera spinolæ* Brullé.
- Siobla** Cameron, Trans. Ent. Soc. Lond., p. 88, 1877.
Type: *Siobla mooreana* Cameron (Ashmead, 1898).
- Sirex** Linnæus, Fauna Suec., ed. 29, p. 396, 1761.
Type: *Sirex gigas* Linnæus.
- Sjoestedtia** Konow, Schwed. Zool. Exp., Kilimandjaro, p. 1, 1907.
Type: *Sjoestedtia meruensis* Konow.*
- Sphæcophilus** Provancher, Addit., Faun. Canad., p. 427, 1889.
Type: *Sphæcophilus crawii* Provancher.*

- Stevenia** Brullé, Hist. Nat. Ins. Hym., vol. 4, p. 667, 1846.
No species.
- Stirocorsia** Konow, Ent. Nachr., vol. 23, p. 372, 1897.
Type: *Stirocorsia kohli* Konow.*
- Stelidarge** Konow, Termes. Fuzetek, vol. 24, p. 58, 1901.
Type: *Stelidarge diptycha* Konow.*
- Stromboceros** Konow, Wien. ent. Zeit., vol. 4, pp. 19, 20, 1885.
Type: *Tenthredo delicatulus* Fallén.
- Strongylogaster** Dahlbom, Conspect. Tenthred. Scand., p. 13, no. 7, 1835.
Type: *Tenthredo cingulata* Fabricius (MacGillivray, 1908).
- Strongylogasteroidea** Ashmead, Can. Ent., vol. 30, p. 308, 1898.
Type: *Strongylogaster aprilis* Say (designated).
- Sunoza** Cameron, Mem. & Proc. Manchester Lit. Phil. Soc., vol. 43, no. 3, p. 39, 1899.
Type: *Sunoza purpureifrons* Cameron.*
- Synairema** Hartig, Fam. Blatt. Holzwesp., p. 314, 1837.
Type: *Tenthredo delicatula* Klug.*
- Synaptoneura** Konow, Zeitschr. syst. Hym. Dipt., vol. 8, p. 160, 1908.
Type: *Synaptoneura boliviensis* Konow.*
- Syrista** Konow, Wien. ent. Zeit., vol. 15, p. 152, 1896.
Type: *Cephus parreyssi* Spinola.*
- Syzygonia** Klug, Ent. Monogr., p. 175, 1824.
Type: *Syzygonia cyanocephala* Klug (Ashmead, 1898).
- Syzygonidea** Ashmead, Can. Ent., vol. 30, p. 230, September, 1898.
Type: *Syzygonia cyanea* Brullé (designated).
- Tanymeles** Konow, Zeitschr. syst. Hym. Dipt., vol. 6, p. 244, 1906.
Type: *Tanymeles hilarulus* Konow.*
- Tanyphatna** Konow, Zeitschr. syst. Hym. Dipt., vol. 6, p. 187, 1906.
Type: *Tanyphatna pellos* Konow.
- Tarpa** Fabricius, Syst. Piez., p. 19, no. 2, 1804.
Type: *Tarpa cephalotes* Fabricius (Westwood, 1840).
= **Megalodontes** Latreille.
- Taxonus** Hartig, Fam. Blatt. Holzwesp., p. 297, 1837.
Type: *Tenthredo (Allantus) nitida* Klug (= *Tenthredo agorum* Fallén) (Konow, 1896).
Rohwer's remarks (Proc. U. S. Nat. Mus., vol. 39, no. 1777, p. 111, 1910) are incorrect. The type must be *Tenthredo agorum* Fallén. *Ermilia* O. Costa is a synonym, being isogenotypic with *Taxonus*.
- Tenthredella** Rohwer, Proc. U. S. Nat. Mus., vol. 39, no. 1777, p. 117, 1910.
Type: *Tenthredo atra* Linnæus (designated).
= **Tenthredo** authors, not Linnæus.
- Tenthredina** Rohwer, Proc. U. S. Nat. Mus., vol. 39, no. 1777, p. 116, 1910.
Type: *Tenthredo flavida* Marlatt (designated).
- Tenthredo** Linnæus, Syst. Nat., ed. 10, vol. 1, p. 343, no. 213, p. 555, no. 214, 1758.
Type: *Tenthredo scrophulariæ* Linnæus (Latreille, 1810).
- Tenthredopsis** O. Costa, Fauna Napoli, Tenthred., p. 98, 1859.
Type: *Tenthredo tessellata* Klug.
- Teredon** Norton, Trans. Amer. Ent. Soc., vol. 2, p. 366, 1869.
Type: *Tremex cubensis* Cresson.
- Teredonia** W. F. Kirby, List Hym. Brit. Mus., vol. 1, p. 386, no. 7, 1882 (n. n. for *Teredon* Norton).
Type: *Tremex cubensis* Cresson.

- Tetratneura** Ashmead, Can. Ent., vol. 30, p. 256, 1898.
Type: *Monostegia ignota* Norton (designated).
=*Empria* Lepeletier.
- Themus** Norton, Trans. Amer. Ent. Soc., vol. 1, p. 58, no. 19, 1867.
Type: *Themus hyalinus* Norton.*
- Thomsonia** Konow, Deutsch. ent. Zeitschr., p. 227, 1884.
Type: *Perineura thomsonia* Konow.
- Thrinax** Konow, Wien. ent. Zeit., vol. 4, pp. 19, 22, 1885.
Type: *Strongylogaster contigua* Konow (MacGillivray, 1908).
- Thulea** Say, Bost. Journ. Nat. Hist., vol. 1, no. 3, p. 214, 1836.
Type: *Thulea nigra* Say.*
- Tomostethus** Konow, Wien. ent. Zeit., vol. 5, pp. 184, 214, no. 7, 1886.
Type: *Tenthredo nigrita* Fabricius.
- Topotrita** W. F. Kirby, List Hym. Brit. Mus., vol. 1, p. 48, no. 27, 1882.
Type: *Hylotoma (Schizocera) leucocephala* Klug.*
- Trachelus** Jurine, Nouv. Méthod. Class. Hym., p. 70, pl. 2, fig. 9, 1807.
Type: *Sirex tabidus* Fabricius.
- Trailia** Cameron, Trans. Ent. Soc. Lond., p. 148, 1878.
Type: *Trailia analis* Cameron.
- Tremex** Jurine, Nouv. Méthod. Class. Hym., p. 80, 1807.
Type: *Sirex fuscicornis* Fabricius (Latreille, 1810).
- Trichiocampus** Hartig, Fam. Blatt. Holzwespen., p. 176, 1837.
Type: *Nematus grandis* Lepeletier.
=*Tenthredo viminalis* Fallén.
- Trichiosoma** Leach, Zool. Misc., vol. 3, p. 108, no. 2, 1817.
Type: *Tenthredo lucorum* Linnæus (Curtis, 1824).
- Trichiosomites** Brues, Bul. Mus. Comp. Zool., vol. 51, no. 10, p. 259, March, 1908.
Type: *Trichiosomites obliviosus* Brues.*
- Trichorhachus** W. F. Kirby, List Hym. Brit. Mus., vol. 1, p. 39, no. 21, 1882.
Type: *Trichorhachus nitidus* W. F. Kirby.
- Trichorrhachus** Konow, Genera Insectorum, fasc. 29, p. 15, 1906.
Misspelling of *Trichorhachus*.
- Trichotaxonus** Rohwer, Proc. Ent. Soc. Wash., vol. 12, p. 30, 1910.
Type: *Trichotaxonus readi* Rohwer (designated).
- Tristactus** Konow, Ann. k. k. Hofmus., Wien., vol. 12, p. 12, 1897.
Type: *Lyda judaicus* Lepeletier.*
- Tristegus** Konow, Zeitschr. syst. Hym. Dipt., vol. 6, p. 370, 1906.
Type: *Tristegus mimarius* Konow.*
- Tritokreion** Schilling, Übers. Arbeit. schles. Ges. Vaterl. cultur., i, j, p. 43, 1825.
No species.
- Trochophora** Konow, Zeitschr. syst. Hym. Dipt., vol. 5, p. 158, 1905.
Type: *Trochophora duckei* Konow.*
- Urocerites** Heer, Denkschr. schweiz. Ges. Natur., vol. 22, p. 36, 1867.
Type: *Urocerites spectabilis* Heer.
- Urocerus** (Geoffroy) Latreille. Geoffroy, Hist. Abr. Ins., vol. 2, p. 264, 1762;
Latreille, Hist. Nat. Crust. Ins., p. 304, 1802.
Type: *Sirex gigas* Linnæus (Westwood, 1840).
=*Sirex* Linnæus.
- Waldheimia** Brullé, Hist. Nat. Ins. Hym., vol. 4, p. 665, 1846.
Type: *Waldheimia braziliensis* Lepeletier (designated).

- Xenapates** W. F. Kirby, List. Hym. Brit. Mus., vol. 1, p. 180, no. 67, 1882.
Type: *Dineura* (?) *africana* Cameron.*
- Xeris** A. Costa, Prosp. Sist. Imenn. Ital., vol. 3, p. 259, 1894.
Type: *Ichneumon spectrum* Linnæus.*
- Xiphidion** Provancher, Nat. Can., vol. 7, p. 374, 1875.
Type: *Xiphidion canadense* Provancher.*
=*Xiphidria provancheri* Cresson.
- Xiphiura** Fallén, Spec. Nov. Hym. Disp. Method, p. 11, no. 7, 1813.
No species included.
- Xiphidria** Latreille, Hist. Nat. Crust. Ins., vol. 3, p. 304, 1802.
Type: *Ichneumon camelus* Linnæus.*
- Xyela** Dalman, Svensk. Vet.-Akad. Handl., vol. 40, p. 122, no. 3, pl. 6, figs. 1-11, 1899.
Type: *Xyela pusilla* Dalman (Curtis, 1824).
- Xylocermatium** L. Heyden, Berl. ent. Zeitschr., vol. 12, p. 227, 1868, (n. n. for
Xyloterus Hartig, non Erichson).
Type: *Sirex fuscicornis* Fabricius.
=**Tremex** Jurine.
- Xyloperga** Shipp, Ent., vol. 27, pp. 339, 340, 1894.
Type: *Perga hallidayi* Westwood (designated).
- Xyloterus** Hartig, Fam. Blatt. Holzwespe., p. 385, 1837 (non Erichson, 1836).
Type: *Sirex fuscicornis* Fabricius.
=**Tremex** Jurine.
- Zaræa** Leach, Zool. Misc., vol. 3, p. 113, no. 4, 1817.
Type *Tenthredo fasciata* Linnæus.*
- Zarca** Cameron, Trans. Ent. Soc. Lond., p. 142, 1878.
Type: *Zarca apicalis* Cameron.*
- Zaschizonyx** Ashmead, Can. Ent., vol. 30, p. 257, 1898.
Type: *Hoplocampa montana* Cresson (designated).

AN INDEX TO THE GENOTYPES.

EXPLANATORY.

The following index includes (1) the name of the species, (2) the name of its author, (3) the name of the genus in which it was originally described, and (4) the name of the genus of which it is the genotype. When a species given in the index is a synonym of another genotype, a cross-reference is given to the genotype of which it is a synonym. When a species was originally placed in the genus of which it is the genotype, only one generic name is given. Species placed in subgenera by older writers are cited in the subgenus only.

abbotii W. F. Kirby (Hypolæpus).	agrorum Fallén (Tenthredo, Ermilia).
abdominalis Fabricius (Tenthredo, Monostegia).	"alba" Norton (Monostegia, Periclistoptera).
abdominalis Panzer (Tenthredo, Nematinus).	albipes Cameron (Phænusa).
ætatus Newman (Eurys).	albipes Konow (Anapeptamena).
æthiops Fabricius (Tenthredo, Endelomyia).	albipes Gmelin (Tenthredo, Monophadnus).
afer Konow (Pampsilota).	albiventris Klug (Allantus, Periclista).
africana Cameron (Dineura?, Xenapates).	albodictus Norton (Taxonus, Epitaxonus).

- alni* Linnæus (*Tenthredo*, *Hemichroa*).
alni Linnæus (*Tenthredo*, *Leptocerca* [= *Hemichroa*]).
alni Linnæus (*Tenthredo*, *Leptocercus* [= *Hemichroa*]).
alternans A. Costa (*Anoplolyda*).
amenaida W. F. Kirby (*Perga*, *Neoperga*).
amerinæ Linnæus (*Tenthredo*, *Pseudoclavellaria*).
analis Cameron (*Trailia*).
analis O. Costa (*Pterygophorus*, *Pterygophorinus*).
andrei Konow (*Ophrynopus*).
annulitarsis Cameron (*Hennedyia*).
apicalis Cameron (*Zarca*).
apicalis Say (*Strongylogaster*, *Strongylogasteroidea*).
apicalis Spinola (*Gymnia*).
armenius Konow (*Ateuchopus*).
arizonensis Ashmead (*Eriocampidea*).
arizonensis Ashmead (*Eriocampidea*, *Cockerellonis* [= *Eriocampidea*]).
aterrima Klug (*Allantus*, *Pectinia*).
athalioides Konow (*Poppia*).
atra Linnæus (*Tenthredo*, *Tenthredella*).
atratus W. F. Kirby (*Polyclonus*).
atroviolaceum Norton (*Tenthredo*, *Lagium*).
atrum MacGillivray (*Phrontosoma*).
aterrima Klug (*Allantus*, *Phymatocera*).
audouinii Westwood (*Pachylota*).
avingrata Dyar (*Pleroneura*, *Odontophyes*).
bakeri MacGillivray (*Neocharactus*).
betuleti Klug (*Allantus*, *Scolioneura*).
bipunctata Klug (*Allantus*, *Ardis*).
boliviensis Konow (*Synaptoneura*).
bolivari Konow (*Labidarge*).
braunsi Konow (*Didocha*).
braziliensis Lepeletier (*Ptilia*).
braziliensis Lepeletier (*Waldheimia*).
brevicornis Fallén (*Hylotoma*, *Aprosthema*).
brevis Klug (*Allantus*, *Hoplocampa*).
buquetii Spinola (*Aulacomerus*).
buyssoni Konow (*Heptacola*).
californica Ashmead (*Manoxyela*).
californicus Marlatt (*Gymnonychus*).
camelus Linnæus (*Ichneumon*, *Hybonotus*).
camelus Linnæus (*Ichneumon*, *Xiphodria*).
cameroni Westwood (*Perga*, *Acanthoperga*).
canadense Provancher (*Xiphidion*).
capræ Panzer (*Tenthredo*, *Pachynematus*).
carinata Cameron (*Rethrax*).
carinata Cameron (*Rusobria*).
cephalotes Fabricius (*Tarpa*).
cephalotes Fabricius (*Tenthredo*, *Megalodontes*).
cephalotes Jakowlew (*Allantus*, *Jermakia*).
cestatus Konow (*Clydostomus*).
chalybea Konow (*Miocephala*).
cinctus Klug (*Pterygophorus*).
cinctus Linnæus (*Tenthredo*, *Emphytus*).
cingulata Fabricius (*Tenthredo*, *Strongylogaster*).
cinxia Klug (*Allantus*, *Caliroa*).
clavatus Rohwer (*Pseudocimbex*).
cœrulea Cameron (*Anisoarthra* [*Senoclia*]).
cœrulea Cameron (*Anisoarthra*, *Senoclia*).
coloradensis Cockerell (*Perga*, *Phenacoperga*).
coloradensis Weldon (*Emphytus*, *Protemphytus*).
columbiana Provancher. (*Labidia*. See *opimus* Cresson.)
compressus Fabricius (*Sirex*, *Ephippinotus*).
connectens Stephens (*Janus*).
consobrina Klug (*Tenthredo*, *Eniscia*).
contigua Konow (*Strongylogaster*, *Thrinax*).
coronatus Fabricius (*Tenthredo*, *Orysus*).
coronatus Klug (*Emphytus*, *Aneugmenus*).
corycolum Dyar (*Isodyctium*).
costalis Fabricius (*Tenthredo*, *Sciapteryx*).
crassa Fallén (*Tenthredo*, *Holcocneme*).
craverii A. Costa (*Laurentia*).
crawii Provancher (*Sphacophilus*).
cressoni Westwood (*Perga*, *Camptoperga*).
crevecoeuri Ashmead (*Opisthoneura*. See *montana* Cresson).
crintinus Konow (*Lagideus*).
crudum Konow (*Erigenum*).
cruentatus Eversmann (*Cephus*, *Eversmannella*).
cubensis Cresson (*Tremex*, *Teredon* [= *Teredonia*]).
cubensis Cresson (*Tremex*, *Teredonia*).
cyanea Brullé (*Syzygonia*, *Syzygonidea*).

- cycanocephala* Klug (*Syzygonia*).
cycanocephala Klug (*Syzygonia*, *Bergi-ana*).
cyanoptera Klug (*Syzygonia*, *Parasyzygonia*).
cynosbati Linnæus (*Cephus*, *Janus*).
cynosbati Linnæus (*Cephus*, *Phyllæcus* [=*Janus*]).
dahlbomi Thomson (*Cænoneura*).
dahlbomi Westwood (*Perga*, *Pergadopsis*).
dahli Hartig (*Xyela*, *Pleroneura*).
darwinii Weyenbergh (*Pseudosirex*).
debilicornis Konow (*Brachyphatnus*).
debilis Say (*Atomacera*).
decora Konow (*Acidiophora*).
defessus Scudder (*Atocus*).
degeeri Klug (*Allantus*, *Dineura*).
delicatulus Fallén (*Tenthredo*, *Stromboceros*).
delicatula Klug (*Tenthredo*, *Synairema*).
delta Provancher (*Tenthredo*, *Bivena*).
delta Provancher (*Tenthredo*, *Homœoneura* [=*Bivena*]).
difformis Panzer (*Tenthredo*, *Cladius*).
dimorpha Freymuth (*Pompholyx* [=*Cacosyndia*]).
dimorpha Freymuth (*Pompholyx*, *Cacosyndia*).
diptycha Konow (*Stelidarge*).
divergens W. F. Kirby (*Clarissa*).
dohrnii Tischbein (*Kaliosysphinga*).
dorsalis Say (*Acordulecera*).
dorsalis Leach (*Perga*).
dubitatus Norton (*Taxonus*, *Hemitaxonus*).
duckeii Konow (*Trochophora*).
eburneiguttatum W. F. Kirby (*Aglao-stigma*).
ectrapela Konow (*Kokujewia*).
eglanteriae Fabricius (*Tenthredo*, *Dosytheus*).
ellisii Curtis (*Dielocerus*).
epimelas Konow (*Haplostegus*).
equiseti Fallén (*Tenthredo*, *Taxonus*).
erythrocephala Linnæus (*Tenthredo*, *Acantholyda*).
eucalypti Froggatt (*Phylacteophaga*).
excavata Norton (*Macrophya*, *Pseudosio-bla*).
fabricii Leach (*Tarpa*, *Melanopus*).
fallax Lepeletier (*Nematus*, *Amaurone-matus*).
fasciata Linnæus (*Tenthredo*, *Zaræa*).
fascipennis Norton (*Selandria*, *Calozarca*).
faunus Newman. (*Phyllæcus*. See *cynosbati* Linnæus).
ferruginea Say (*Xyela*, *Macroxyela*).
filiceti Klug (*Blasticotoma*).
filiformis Eversmann (*Cephus*, *Calameuta*).
filicis Klug (*Tenthredo*, *Polystichophagus* [=*Pseudotaxonus*]).
filicis Klug (*Tenthredo*, *Pseudotaxonus*).
flabellicornis Germar (*Tarpa*, *Rhipidoceros*).
flavescens Marlatt (*Phyllotoma*?, *Nesotaxonus*).
flavida Marlatt (*Tenthredo*, *Tenthredina*).
floricola O. Costa (*Ebolia*).
flavens Klug (*Tenthredo*, *Paraselandria*).
flavipes Cameron (*Lithracia*).
flaviventris Linnæus (*Tenthredo*, *Neuro-toma*).
frontalis Westwood (*Lyda*, *Liolyda*).
fulvipes A. Costa (*Amestastegia*).
fumipennis Ashmead (*Parazarca*).
fumipennis Westwood (*Brachytoma*).
fumipennis W. F. Kirby (*Acherdocerus*).
furcata Fabricius (*Hylotoma*, *Cyphona*).
furcata Villers (*Hylotoma*, *Schizocera*).
fusca Schrottky (*Pseudabia*).
fuscicornis Hartig (*Diphadnus*).
fuscicornis Fabricius (*Sirex*, *Tremex*).
fuscicornis Fabricius (*Sirex*, *Xylæcer-matium* [=*Tremex*]).
fuscicornis Fabricius (*Sirex*, *Xyloterus* [=*Tremex*]).
gallicola Stephens (*Nematus*, *Pontania*).
gallæ Newman. (*Euura*. See *medullaris* Hartig).
gigas Linnæus (*Sirex*).
gigas Linnæus (*Sirex*, *Urocera* [=*Sirex*]).
gonager Jurine (*Dolerus*).
grandis Lepeletier. (*Trichocampus*. See *viminalis* Fallén.)
grandis Philippi (*Brachyxiphus*).
guttatum Fallén (*Tenthredo*, *Pœcilo-stoma*).
hallidayi Westwood (*Perga*, *Xyloperga*).
healæi E. Newman. (*Camponiscus*. See *luridiventris* Fallén.)
herbsti Konow (*Lycosceles*).
hieroglyphica Christ (*Tenthredo*, *Itycorsia*).
hilarulus Konow (*Tanymeles*).
hirticornis Cameron (*Incalia*).
histrionicus MacGillivray (*Parabates*).

- hortulana* Klug (Emphytus, Messa).
hyalinus MacGillivray (Neotomostethus).
hyalinus Norton (Themos).
hyperborea Kiaer (Ischyroceræa).
hypogastricus Hartig. (See *luridiventris* Fallén.)
ianthe E. Newman (Fenusia, Asticta).
ignota Norton (Monostegia, Tetratneura).
imitatrix Ashmead (Paraselandria, Nesoselandria).
imperialis Smith (Hylotoma, Athermanthus).
incisa Cameron (Allomorpha).
indica W. F. Kirby (Parastitis).
inferentia Norton (Pœcilostoma, Monsoma).
inferentia Norton (Pœcilostoma, Monsoma [=Monsoma]).
infuscatus MacGillivray (Hypargyricus).
inopenus Konow (Canonias).
insolita Konow (Cladiucha).
interruptus Klug (Pterygophorus, Lophyrotoma).
jakowleffi Konow (Cænocephus).
jakowleffi Konow (Dinax).
jakowlewi Semenow (Parabia).
jantheria Klug (Hylotoma, Cibdela).
japonica Marlatt (Lophyrus, Nesodiprion.)
jucunda W. F. Kirby (Perga, Paraperga).
judaicus Lepeletier (Lyda, Tristactus).
julii Brébisson (Pinicola [=Xyela]).
julii Brébisson (Pinicola, Xyela).
juniperi Linnæus (Tenthredo, Monocentus).
juvencus Linnæus (Sirex, Paururus).
klugii Burmeister (Athlophorus).
kohli Konow (Stirocorsia).
koreana Konow (Corymbas).
læta Westwood (Dictynna).
langei Konow (Probleta).
laricis Marlatt (Hoplocampa, Marlattia).
lepida Brullé (Perreyia).
lepidus Klug (Emphytus, Asticta [=Harpiphorus]).
lepidus Klug (Emphytus, Harpiphorus).
leprieurii Spinola (Camptoprium).
leucocephala Klug (Schizocera, Topotrita).
lewisi Westwood (Perga, Pseudoperga).
limacina Retzius (Tenthredo, Eriocampoides).
lituratus Konow (Rhagonyx).
lobatus MacGillivray (Aphanisus).
lucorum Linnæus (Tenthredo, Trichiosoma).
luridiventris Fallén (Tenthredo, Camponicus [=Platycampus]).
luridiventris Fallén (Tenthredo, Leptopus [=Platycampus]).
luridiventris Fallén (Tenthredo, Platycampus).
luridiventris Konow. (Pareophora. See *nigripes* Klug.)
lutea Linnæus (Tenthredo, Clavellaria).
lutea Linnæus (Tenthredo, Cimbex).
luteola Klug (Tenthredo, Nematoceros).
luteiventris O. Costa. (Ephippinotus. See *compressus* Fabricius.)
macropus Smith (Cladomacra).
maculata Marlatt (Cimbex, Agenocimbex).
maculata Norton (Pœcilostoma, Pœcilostomidea).
maculipennis Stein (Lyda, Celidoptera).
maculipennis Stein (Lyda, Kelidoptera).
magrettii Konow (Colochelyna).
major Cresson (Xyela, Megaxyela).
major O. Costa. (See *satyrus* Panzer.)
mandibularis Zaddach (Lyda, Gongylocorsia).
maria MacGillivray. (Bivena. See *delta* Provancher.)
martini Lepeletier (Hylotoma, Didymia).
martini MacGillivray (Neopareophora).
mathesoni MacGillivray (Phlebotrophia).
mayrii Westwood (Perga, Plagioperga).
medullaris Hartig (Cryptocampus).
megapolitana Brauns (Konowia).
melanoccephala Lepeletier (Hylotoma, Scobina).
meruensis Konow (Sjoestedtia).
metallica Rohwer (Neoeurys).
metallicus Mocsary (Oryssus, Mocsarya).
mexicana Ashmead (Neoptilia).
mexicana Ashmead (Pseudocyphona).
mexicanum W. F. Kirby (Laboceras).
nigripes Klug (Allantus, Pareophora).
mimarius Konow (Tristegus).
minutissima O. Costa. (Melina. See *nigrita* Westwood.)
minutus Hartig (Pelmatoptus).
montana Cresson (Hoplocampa, Opisthoneura [=Zaschizonyx]).
montana Cresson (Hoplocampa, Zaschizonyx).
mooreana Cameron (Siobla).
moricei Konow (Characophygus).

- morio Konow (Dulophanes).
 multicolor Norton (Taxonus, Parataxonus).
 naucarrowi Froggatt (Philomastix).
 nemorata Fallén (Phyllotoma, Druida).
 niger Norton (Ptenos).
 nigra Cameron (Fethalia).
 nigra Say (Thulea).
 nigrescens Rohwer (Diphamorphos).
 nigrita Fabricius (Tenthredo, Tomostethus).
 nigrita Westwood (Fenella).
 nigrita Westwood (Fenella, Melinia).
 nigricornis W. F. Kirby (Hemidianeura).
 nitens W. F. Kirby (Euryopsis).
 nitidus W. F. Kirby (Trichorhachus).
 obliviosus Brues (Trichiosomites).
 obscura Linnæus (Tenthredo, Amasis).
 obscuratus MacGillivray (Paracharactus).
 occidentalis MacGillivray. (Cockerellonis. See arizonensis Ashmead.)
 ochroleucus Stephens (Melicerta [=Hep-tamelus]).
 ochroleuca Stephens (Melicerta, Hep-tamelus).
 ochropoda Stephens (Heterarthus, Decatria).
 ochropoda Klug (Emphytus, Heterarthus).
 ceningensis Heer (Cephites).
 opaca Fabricius (Tenthredo, Mesoneura).
 opaca Fabricius (Tenthredo, Pristis [=Mesoneura]).
 opimus Cresson (Allantus, Labidia).
 oregonensis Ashmead (Macgillivraya [=Macgillivrayella]).
 oregonensis Ashmead. (Macgillivraya, Macgillivrayella).
 ostentus Brues (Paremphytus).
 ovata Linnæus (Tenthredo, Eriocampa).
 padi Linnæus (Tenthredo, Priophorus).
 parreyssi Spinola (Cephus, Syrista).
 pallimacua Lepeletier (Empria).
 pallipes Say (Strongylogaster, Hypotaxonus).
 parviceps Newman. (See nemorata Fallén.)
 parvulus Klug (Allantus, Pseudodineura).
 parvus Brues (Lithoryssus).
 pectoralis Lepeletier (Nematus, Anoplonyx).
 pellos Konow (Tanyphatna).
 perplexus Konow (Emphyoides).
 peruanus Konow (Hyperoceros).
 picipes W. F. Kirby (Paralyptia).
 pictipennis Smith (Derecyrtia).
 pilicornis Dahlbom. (Priophorus. See padi Linnæus.)
 pinguis Say (Strongylogaster, Dimorphopteryx).
 pini Linnæus (Tenthredo, Anachoreta [=Diprion]).
 pini Linnæus (Tenthredo, Diprion).
 pini Linnæus (Tenthredo, Lophyrus [=Diprion]).
 pini Retzius (Nematus, Lygæonematus).
 plumicornis Guérin (Oryssus, Chalinus).
 polita Leach (Perga, Pseudoperga).
 politissimus A. Costa (Cephus, Peronistilus).
 pratorum Fallén (Tenthredo, Loderus).
 præcox Föerster (Epitactus).
 privus Konow (Pëus).
 procer Konow (Bathyblepta).
 procinctus Konow (Rhoproceros [=Rhopographus]).
 procinctus Konow (Rhoproceros, Rhopographus).
 pulchella O. Costa. (Ermilia. See agorum Fallén.)
 pullus Föerster (Nematus, Micronematus).
 pumila Klug (Allantus, Entodecta).
 pumila Klug (Cephalocera [=Corynophilus]).
 pumila Klug (Cephalocera, Corynophilus).
 pumila Klug (Emphytus, Aphadnurus [=Fenusa]).
 pumila Klug (Emphytus, Fenusa).
 pumilio Westwood (Perantherix).
 punctigera Lepeletier. (Pristis. See opaca Fabricius.)
 purpureifrons Cameron (Sunoxa).
 pusilla Dalman. (Xyela. See julii Brébisson).
 pusilla Klug (Allantus, Blennocampa).
 pygmæus Linnæus (Sirex, Cephus).
 pygmæa Say (Blennocampa, Erythraspides).
 quattuordecimpunctata Norton (Tenthredo, Neopus).
 rapæ Linnæus (Tenthredo, Pachyrotasis).
 reedi Rohwer (Trichotaxonus).
 reitteri Konow (Rhadinoceræa).
 religiosa Marlatt (Blennocampa, Nesotomostethus).
 reticulata Linnæus (Tenthredo, Cænolyda).

- rosæ* Harris. (Endelomyia. See *æthiops* Fabricius.)
rosæ Linnæus (Tenthredo, Corynia [=Hylotoma]).
rosæ Linnæus (Tenthredo, Hylotoma).
rosarum Imhof et Labram. (See *rosæ* Linnæus.)
rotundiventris Cameron (Macrophya, Dipteromorpha).
rubi Forbes (Metallus).
rubi Harris (Hoplocampa, Monophadnoides).
rubi Panzer (Tenthredo, Perineura).
rubripes Cresson (Strongylogaster, Aphilydectium).
rufocinctus Norton (Strongylogaster, Parasibla).
ruficollis Norton (Atomacera, Micrarge).
rufiventris Konow (Netroceros).
rugifrons Cameron (Beldonea).
rusticus Linnæus (Tenthredo, Macrophya).
saltuum Linnæus (Tenthredo, Monoplopus).
satyrus Panzer (Astatus, Cerobactrus [=Hartigia]).
satyrus Panzer (Astatus, Hartigia).
scapularis Lepeletier (Coryna).
scrophulariæ Linnæus (Tenthredo).
scrophulariæ Linnæus (Tenthredo, Allantus [=Tenthredo]).
scutellata W. F. Kirby (Cerealces).
sebetia O. Costa (Caliroa).
septentrionalis Linnæus (Tenthredo, Cresus [=Nematus]).
septentrionalis Linnæus (Tenthredo, Nematus).
sericea Linnæus (Tenthredo, Abia).
serva Fabricius (Tenthredo, Selandria).
signata Fabricius (Tenthredo, Cephaleia).
sikkemensis Konow (Conaspidia).
singularis Ashmead (Gymniopterus).
sjustedti Konow (Distega).
slossonæ MacGillivray (Polybates).
smyrnensis Stein (Pachycephus).
sodalis Cresson (Selandria, Lycaota).
spectabilis Heer (Urocerites).
spectabilis MacGillivray (Ceratulus).
spectrum Linnæus (Ichneumon, Xeris).
spinarum Fabricius (Tenthredo, Athalia).
spinolæ Brullé (Seriocera).
stigmatalis Cameron (Anisoneura [=Beleses]).
stigmatalis Cameron (Anisoneura, Beleses).
strahlendorffi Konow (Electrocephalus).
sturnii Klug (Tenthredo, Encarsioneura).
sylvatica Linnæus (Tenthredo, Lyda [=Pamphilus]).
sylvatica Linnæus (Tenthredo, Pamphilus).
syringæ Gradl (Cephosoma).
tabidus Fabricius (Sirex, Trachelus).
taczanowskii André (Praia).
tantillus O. Costa (Aphadnurus).
tessellata Klug (Tenthredo, Tenthredopsis).
testaceus Jurine (Pteronus, Pristiphora).
testacea W. F. Kirby (Decameria).
thomsoni Konow (Perineura, Thomsonia).
thoracica Klug (Plagiocera).
tibialis Klug (Pachylosticta).
trimaculatus Say (Cephus, Adirus).
troglydites Klug (Astatus).
tropicus Norton (Lophyrus, Lophyridea [=Lophyroides]).
tropicus Norton (Lophyrus, Lophyroides).
truculenta Konow (Braunsiola).
townsendi Ashmead (Caloptilia).
typica Rohwer (Claremontia).
typica Rohwer (Nortonella).
typicus Brues (Palæotaxonus).
typicus Rohwer (Prototaxonus).
ulmi Sundevall (Fenusia, Kaliofenusia).
vafer Linnæus (Tenthredo, Bactroceros).
vagens Fallén (Phyllotoma).
varianus Norton (Harpiphorus, Macremphytus).
varinervis Spinola (Tenthredo, Antholeus).
varipes Cameron (Ancylooneura).
ventralis Say (Nematus, Pteronidea).
vexabilis Brues (Scolioneura, Lisconeura).
viduatus Zetterstedt (Nematus, Brachycolus).
viminalis Fallén (Tenthredo, Trichio-campus).
violaceipennis André (Nematoneura).
viridipes Cameron (Busarbia).
viridis Linnæus (Tenthredo, Rhogogaster).
volupis Konow (Cerospastus).
ulmarie Schlechtendal (Macrocephus).
ustulatus Linnæus (Tenthredo, Cryptus).
weithii Ashmead (Acanthoptenos).
westwoodii Brullé (Dictynna).
zabriskiei Ashmead (Melanoselandria).

SYNONYMY OF CERTAIN GENERA.

By cross-reference in the index to the genotypes it was found that certain genera were isogenotypic. In some of these cases new names were needed. New names and certain synonymy are given below.

THE SYNONYMS OF HARTIGIA SCHIÖDTE AND BOIE.

Schiödte (Kroyers Naturhistorisk Tidsskrift, vol. 2, p. 332, 1838) gave the name *Hartigia* for a certain cephid insect which differed from *Cephus pygæmus* in characters of the antennæ. This species was not named, however, so the genus was without standing until 1855, when F. Boie (Stett. ent. Zeit., vol. 16, p. 49) stated that *Astatus satyrus* was the species which Schiödte had. This gives *Hartigia* standing and makes *satyrus* the type—the genus being monobasic.

The genotypes of the genera *Cerobactrus* O. Costa and *Cephosoma* Grادل are identical specifically with *satyrus*; consequently these generic names fall to the older name *Hartigia*. The species *satyrus* is also congeneric with *Macrocephus ulmarix* Schlechtendal (= *Tenthredo linearis* Schrank), so *Macrocephus* is a synonym of *Hartigia*. The synonymy, therefore, is as follows:

Hartigia Schiödte and Boie, 1855.

Cerobactrus O. Costa, 1860.

Macrocephus Schlechtendal, 1878.

Cephosoma Grادل, 1881.

PTERONUS Panzer=DIPRION Schrank.

Panzer, in the original description of *Pteronus*, included the following species in the order named: *Hylotoma frutetorum* Fabricius, *Hylotoma dorsata* Fabricius, *Hylotoma juniperi* Fabricius, *Tenthredo pini* Linnæus, and *Tenthredo difformis* Panzer. As the present-day conception of *Pteronus* has to be changed, no species originally included belonging to *Pteronus* Konow and authors, *Tenthredo pini* Linnæus has been chosen as the type, making *Pteronus* Panzer and *Diprion* Schrank isogenotypic. *Diprion* is the older name, so *Pteronus* Panzer is a synonym of *Diprion* Schrank.

Diprion Schrank, 1802.

Pteronus Panzer, 1806.

PTERONIDEA, N. N. FOR PTERONUS Konow and authors.

Pteronus Panzer being a synonym of *Diprion* Schrank, *Pteronus* Konow and authors is without a name. For this the name PTERONIDEA may be used. The type of *Pteronidea* is *Nematus ventralis* Say, which is congeneric with Konow's interpretation of *Tenthredomyosotides* Fabricius.

THE SYNONYMS OF PLATYCAMPUS SCHIÖDTE.

Hartig, in 1837 (Fam. Blatt. Holzwesp., p. 184), described the subgenus *Leptopus* for a new species, *hypogastricus*, which has proved to be the same as *Tenthredo luridiventris* Fallén (1808). The name *Leptopus* had already (Latreille, 1809) been used for a genus of Hemiptera. Schiödte (Magasin de Zool., vol. 9, p. 20, footnote, 1839) proposed the name *Platycampus* for *Leptopus* Hartig.

E. Newman (Ent., vol. 4, pp. 215-217, 1869) describes the larva and adult of a sawfly under the name *Camponiscus healæi*. The adult is very poorly characterized and unrecognizable, but in 1873 (Ent. Monthl. Mag., vol. 10, p. 84) P. Cameron says he has reared the same larva as Newman describes, and that the adult is the same as *Nematus* (*Leptopus*) *hypogastricus* Hartig. This synonymy establishes the genus *Camponiscus* and makes it the same as *Leptopus* Hartig, the two genera being isogenotypic.

F. W. Konow (Genera Insectorum, Fasc. 29, p. 48, 1906) uses the name *Leptocercus* Thomson (a changed spelling for *Leptocerca* Hartig) for this genus, but in this he is wrong, because Thomson divides *Leptocercus* into *Leptocercus* s. s., which contains *Tenthredo alni* Linnæus, *Tenthredo rufa* Panzer, and *Leptocercus nigriceps* Thomson, and is Hartig's genus *Leptocerca*. The second division of Thomson's *Leptocercus* is *Leptopus* Hartig and contains *Tenthredo luridiventris* Fallén. The *Leptocercus* Thomson s. s. is *Leptocerca* Hartig, not *Leptopus* Hartig as Konow would have it.

The synonymy of this group is as follows:

Platycampus Schiödte, 1839.

Leptopus Hartig, 1837 (non Latreille, 1809).

Camponiscus E. Newman, 1869.

Leptocercus Konow, 1906 (non Thomson, 1871).

CRÆSUS Leach=NEMATUS Jurine.

Latreille (Considérations Générales, p. 435, 1810) fixed the type of *Nematus* as *Tenthredo septentrionalis* Jurine. *Nematus septentrionalis* Jurine is the same as *Tenthredo septentrionalis* Linnæus. Leach (Zool. Misc., vol. 3, p. 129, no. 1, 1817) based his genus *Cræsus* on *Tenthredo septentrionalis* Linnæus; so *Cræsus* Leach is a synonym of *Nematus*, the genera being isogenotypic.

Nematus Jurine, 1807.

Cræsus Leach, 1817.

NEMATINUS, N. N. FOR NEMATUS Konow.

The fixing the type of *Nematus* as *Tenthredo septentrionalis* Linnæus and making *Cræsus* synonym of it necessitates a new name for *Nematus* of Konow and authors. For *Nematus* Konow and authors the name **NEMATINUS** may be used.

The type of *Nematinus* is *Tenthredo abdominalis* Panzer.

GYMNONYCHUS Marlatt=**DIPHADNUS** Hartig.

In 1837 Hartig (Fam. Blatt. Holzwesp., p. 225) formed a new subgenus (*Diphadnus*) of *Nematus* for a species he called *fuscicornis*. Later European writers have proved that *Nematus* (*Diphadnus*) *fuscicornis* Hartig is an aberrant form of his *Nematus appendiculatus*, which for some time was placed in the genus *Pristiphora*.

Mr. C. L. Marlatt,^a in his Revision of the Nematinae of North America, described a new genus, *Gymnonychus*, for certain species near *Pristiphora*, which have simple tarsal claws. *Nematus appendiculatus* Hartig belongs to this genus, but in 1837 a generic name was given to an aberrant form of this species, so Mr. Marlatt's name must fall as a synonym of *Diphadnus* Hartig.

Diphadnus Hartig, 1837.

Gymnonychus Marlatt, 1896.

CALIROA O. Costa AND **ERIOCAMPOIDES** Konow.

In 1859 (Fauna Napoli, Tenthred., p. 59) O. Costa described the genus *Caliroa* and included one species, *C. sebetia* O. Costa, which is therefore the genotype. Later it was proved that *Caliroa sebetia* is the same as *Tenthredo* (*Allantus*) *cinxia* Klug.

Rev. F. W. Konow in 1890 (Deutsch. ent. Zeitschr., 1890, p. 239) described his genus *Eriocampoides* and in his list of species, page 248, considers *sebetia* O. Costa as a synonym of *cinxia* Klug, but makes no mention of the genus *Caliroa*.

Dr. William H. Ashmead in 1898 (Can. Ent., p. 256) divided Konow's genus *Eriocampoides* into two genera, naming *Monostegia rosæ* Harris as the type of his new genus *Endelomyia*.

The group of species placed in the genus *Eriocampoides* by Konow can well be separated into two distinct sections, one of which, Konow to the contrary notwithstanding (for he says *Caliroa* was founded on a male and not sufficiently characterized, Genera Insectorum, Fasc. 29, p. 75, 1906), must be called *Caliroa*. The type of *Eriocampoides* being the common pear slug *limacina*, that subgenus will contain those species which have the clypeus emarginate, the pedicel subequal in length with the scape, and the hind wings with usually two closed discal cells in the female. The type of *Endelomyia* Ashmead is *Monostegia rosæ* Harris, which is the same as the European rose slug *æthiops* Fabricius. The subgenus *Endelomyia* is characterized as having the clypeus truncate, the pedicel shorter than the scape (much wider than long), and the hind wings with usually only one discal cell in the female. *Endelomyia* is, however, a synonym of *Caliroa*, their genotypes being strictly congeneric.

^a U. S. Dept. Agr., Div. Ent., Tech. ser. 3, 1896.

The differences between these two groups are hardly of generic importance and could better be treated as subgenera, the arrangement being as follows:

Genus **Caliroa** O. Costa, 1859.

Subgenus **Caliroa** O. Costa, 1859.

Endelomyia Ashmead, 1898.

Subgenus **Eriocampoides** Konow, 1890. (See *Periclistoptera*, p. 86.)

CIMBEX AND ALLIES.

Olivier (Encycl. Méthod., vol. 4, p. 22, 1789) characterized his genus *Clavellarius*, but included no species in it. No species was ever placed in the genus, but in 1791 (Encycl. Méthod., vol. 6, p. 18) Olivier says that he changed the name to *Cimbex* because of the resemblance to the botanical genus *Clavaria*. In the Encyclopédie Méthodique, volume 5, page 764, 1790, the genus *Cimbex* is described and sixteen species are placed in it. Since *Clavellarius* had no standing until 1791 it must rank as a synonym of *Cimbex* as Olivier would have it.

Lamarck (Système des Animaux sans vertébrés, p. 264, 1801) characterized the genus *Clavellaria*, accrediting it to Olivier, but Olivier's genus was *Clavellarius*. The only species placed in *Clavellaria* by Lamarck was *Tenthredo lutea* Linnæus, the genus being monobasic with *Tenthredo lutea* as the type. Latreille (Considérations Générales, 1810), however, gave, as the type of *Cimbex*, *Tenthredo lutea* Linnæus, so *Clavellaria* Lamarck is a synonym of *Cimbex*, the genera being isogenotypic.

W. A. Schultz (Spolia Hymenopterologica, p. 87, 1906) proposed the name *Pseudoclavellaria* for *Clavellaria* Leach and authors.

The synonymy is as follows:

Cimbex Olivier (Encycl. Méthod., vol. 5, p. 764, 1790).

Clavellarius Olivier (Encycl. Méthod., vol. 4, p. 22, 1789; Encycl. Méthod., vol. 6, p. 18, 1791).

Clavellaria Lamarck (Syst. Anim. sans. Vert., p. 264, 1801).

Pseudoclavellaria Schultz (Spolia Hym., p. 87, 1906).

Clavellaria Leach (Zool. Misc., vol. 3, p. 111, 1817; and authors).

The above conclusions differ somewhat from those reached by Schultz (Spolia Hym., 1906), but it is believed that they are correct.

SYZYGONIA AND ALLIES.

Klug (Ent. Mon., p. 175, 1824) described his genus *Syzygonia* and included two species, *cyanoptera* Klug and *cycanocephala* Klug. Dr. William H. Ashmead (Can. Ent., p. 230, September, 1898) fixed the type of Klug's genus as *cycanocephala* and described a genus which he called *Syzygonidea* for *Syzygonia cyanea* Brullé. Brullé (Hist. Nat. Ins. Hym., vol. 4, p. 671, 1846), in his remarks on *Syzygonia*, mentions no species, but refers to plate 48 (fig. 2), where he figures *Syzygonia*

cyanea and accredits it to Klug, but Klug described no such species and the figure must stand as a description of *cyanea* Brullé, as it does not agree with any described species.

Rev. F. W. Konow (Anal. Mus. Buenos Aires, vol. 6, pp. 397, 398, 1899) argues that *Syzygonia cyanoptera* Klug should be taken as the type of *Syzygonia*, as this species came first in the list and forms the first group. On these grounds he makes a new genus, *Bergiana*, for *Syzygonia cyanocephala* Klug. *Bergiana* and *Syzygonia* are isogenotypic, so *Bergiana* falls as a synonym of *Syzygonia*.

PARASYZYGONIA, N. N. FOR SYZYGONIA Konow.

Since *Bergiana* Konow is a synonym of *Syzygonia*, *Syzygonia* Konow must have a new name, as it is different from *Syzygonidea* Ashmead. For *Syzygonia* Konow PARASYZYGONIA may be used.

The above-mentioned genera may be separated in the following manner:

- Radial cell of the fore wings not appendiculate (four cubital cells, the second and third each receiving a recurrent nervure; antennæ 6-jointed, the third joint longer than the fourth, and the club gradually formed)
Syzygonidea Ashmead.
- Radial cell of the fore wings distinctly appendiculate.
Antennæ 5-jointed; third cubital cell receiving the second recurrent nervure.....*Syzygonia* Klug.
Antennæ 6-jointed; the second recurrent nervure interstitial with the second transverse cubitus.....*Parasyzygonia* Rohwer.
- Syzygonidea** Ashmead.
Syzygonia cyanea Brullé.
- Syzygonia** Klug (Syn., *Bergiana* Konow).
Syzygonia cyanocephala Klug.
- Parasyzygonia** n.
Syzygonia cyanoptera Klug (type).
Syzygonia xenea Perty.

THE WORK OF WILLIAM H. ASHMEAD ON THE TENTHREDINOIDEA.

The late Dr. William H. Ashmead's work on Tenthredinoidea was confined almost entirely to the genera, very little being done on the species. It was Doctor Ashmead's desire to give generic tables to all the genera of Hymenoptera. Such an enormous task would never have been undertaken by one less enthusiastic or energetic than Doctor Ashmead. With all the routine duties connected with the position held by this untiring worker there was but a limited time for his researches, so of necessity a great deal of the work was done in a hurry. This hurry caused mistakes, and the founding of genera on what would seem to be trivial characters; but the greater number of the genera founded by Ashmead are at least of subgeneric importance. In unpublished manuscript many of the mistakes and omis-

sions were corrected by Doctor Ashmead, and it is most unfortunate that these were not left in condition in which they could be published.

In the tables of the genera of Tenthredinoidea many genera were described as new, and some of these were based on species hitherto undescribed. The characters given in the tables are sufficient to satisfy the technical requirements, so the generic and specific names should date from their publication in the tables. Various writers have considered the characters given in the tables to be of no value, and in some cases this is correct. On this basis they have sunk into the synonymy genera which have as good standing as many which they recognize.

In the present paper the new genera founded on new species in the tables in the Canadian Entomologist for 1898 are characterized more completely, and a list of all the genera described, with the synonymy, as far as it has been determined, is given. Unless otherwise stated the types have been studied, and the conclusions based on these studies.

AN ALPHABETICAL LIST OF THE GENERA OF TENTHREDINOIDEA DESCRIBED BY WILLIAM H. ASHMEAD, WITH THE DETERMINED SYNONYMY.

1. *Acanthoptenos* Ashmead. (= *Arge* Schrank.)
2. *Aomodactium* Ashmead. (A genus without a species.)
3. *Aphilodactium* Ashmead. (Syn.: *Parataxonus* MacGillivray.)
4. *Caloptilia* Ashmead. (Syn.: *Labidarge* Konow.)
5. *Calozarca* Ashmead. (= *Parazarca* Ashmead.)
6. *Dimorphopteryx* Ashmead.
7. *Endelomyia* Ashmead. (= *Caliroa* O. Costa.)
8. *Eriocampidea* Ashmead. (Syn.: *Cockerellonnis* MacGillivray.)
9. *Erythraspides* Ashmead.
10. *Gymniopterus* Ashmead. (Type species lost.)
11. *Hemitaxonus* Ashmead.
12. *Homœoneura* Ashmead. (= *Bivena* MacGillivray.)
13. *Hypotaxonus* Ashmead.
14. *Liolyda* Ashmead. (= *Cephaleia* Panzer.)
15. *Lophyridea* Ashmead. (= *Lophyroides* Cameron.)
16. *Lophyrotoma* Ashmead. (= *Pterygophorus* Klug.)
17. *Macgillivraya* Ashmead. (= *Macgillivrayella* Ashmead.)
18. *Macgillivrayella* Ashmead.
19. *Manoxyela* Ashmead. (= *Pleroneura* Konow.)
20. *Marlattia* Ashmead.
21. *Megaxyela* Ashmead.
22. *Melanoselandria* Ashmead. (= *Hypargyricus* MacGillivray.)

Listed in Catalogue of Insects from New Jersey and without standing until 1909, when Doctor MacGillivray stated that it was a synonym of *Hypargyricus* MacGillivray. The synonymy is:

Melanoselandria (Ashmead) MacGillivray, 1909, = *Hypargyricus* MacGillivray, 1908.

23. *Micrange* Ashmead. (Syn.: *Braunsiola* Konow.)
24. *Monophadnoides* Ashmead.

25. *Neoperga* Ashmead.
26. *Neoptilia* Ashmead.
27. *Opisthoneura* Ashmead. (= *Zaschizonyx* Ashmead.)
28. *Paraperga* Ashmead.
29. *Paraselandria* Ashmead. (= *Selandria* Leach.)
30. *Parasiobla* Ashmead.
31. *Parazarca* Ashmead. (Syn.: *Calozarca* Ashmead.)
32. *Periclistoptera* Ashmead. (= *Eriocampoides* Konow.)
33. *Pœcilstomidea* Ashmead. (= *Empria* Lepeletier.)
34. *Polystichophagus* Ashmead. (= *Pseudotaxonus* A. Costa.)
35. *Pseudoperga* Ashmead (non Guérin).
36. *Pseudosiobla* Ashmead.
37. *Pterygophorinus* Ashmead. (= *Pterygophorus* Klug.)
38. *Strongylogasteroidea* Ashmead.
39. *Syzygonidea* Ashmead.
40. *Tetratneura* Ashmead. (= *Empria* Lepeletier.)
41. *Zaschizonyx* Ashmead.

In all, Ashmead described 41 genera of Tenthredinoidea. Of these 41 genera, 17 have been determined to be synonyms of older genera and 5 have later genera for synonyms. Some of the segregates of *Perga* defined by Ashmead will be classed as synonyms of the segregates formed by Shipp. These will be discussed in a later paper.

BIBLIOGRAPHY OF THE MORE IMPORTANT WRITINGS OF WILLIAM H. ASHMEAD ON TENTHREDINOIDEA.

- Table of genera of Xyelidæ. < In Dyar: *Psyche*, vol. 8, p. 214, 1898.
 A generic table of the Blennocampinæ. < In Dyar: *Journ. N. Y. Ent. Soc.*, vol. 6, pp. 127-129, 1898.
 Classification of the horn-tails and sawflies, or the suborder Phytophaga. In 7 parts.
 < *Can. Ent.*, vol. 30, 1898 (1), pp. 141-145; (2) pp. 177-188; (3) pp. 205-213; (4) pp. 225-232; (5) pp. 249-257; (6) pp. 280-287; (7) pp. 305-316.
 Order Hymenoptera. < In Smith: *Insects of New Jersey*, pp. 501-613, 1900.
 A new oryssid from Chatham Islands, Bismarck Archipelago. < *Psyche*, vol. 10, p. 73, 1903.
 Two new phytophagous Hymenoptera. < *Can. Ent.*, vol. 35, p. 233, 1903.
 Descriptions of four new horn-tails. < *Can. Ent.*, vol. 36, pp. 63-64, 1904.

DESCRIPTION OF THE GENERA AND SPECIES.

MANOXYELA Ashmead=PLERONEURA Konow.

The type of *Manoxyela californica* Ashmead belongs to the genus *Pleroneura* Konow, so *Manoxyela* is a synonym of *Pleroneura*.

Pleroneura Konow, *Ent. Nachr.*, vol. 23, p. 56, 1897.

Manoxyela Ashmead, *Can. Ent.*, vol. 30, p. 206, 1898.

PLERONEURA CALIFORNICA (Ashmead).

Manoxyela californica Ashmead, *Can. Ent.*, vol. 30, p. 206, 1898.

Length to the end of the second abdominal segment, 2.5 mm.; length of fore wing, 4 mm. Lateral angles and middle production of the clypeus rounded; antennal furrows wanting above the anterior ocellus; middle foveæ elongate; anterior ocellus in a slightly depressed basin, which is sharply angled above; postocellar line slightly

shorter than the ocellocular line, but longer than the ocellocapital line; right mandible with 2 inner teeth; head and parts of the thorax irregularly granular; tarsal claws with a long bristle near the middle; stigma more than twice as long as wide, angled below; venation very like *Xyela julii*; four posterior legs and abdomen beyond the third segment wanting. Black; antennæ, palpi, and legs reddish-yellow; wings hyaline, venation pallid.

Type locality.—Alameda County, California. One specimen collected in June.

Type.—Cat. No. 8887, U. S. National Museum.

Related to *Pleroneura fulvicornis* Rohwer.

ACANTHOPTENOS Ashmead=ARGE Schrank.

Ashmead (Can. Ent., p. 212, 1898) described his genus *Acanthoptenos* for *Acanthoptenos weithii* Ashmead. The genus is founded upon an aberrant specimen of *Arge macleayi* authors, the intercostal vein being absent in the only perfect fore wing. *Acanthoptenos* is therefore a synonym of *Arge*.

Arge Schrank, 1802.

Acanthoptenos Ashmead, 1898.

CALOPTILIA Ashmead.

Caloptilia Ashmead, Can. Ent., vol. 30, p. 212, 1898.

Type.—*Caloptilia townsendi* Ashmead.

Ashmead placed his genus *Caloptilia* in his subfamily Schizocerinae, but in this he is wrong. The type of *Caloptilia townsendi* Ashmead has the cross-vein in the intercostal cell present and belongs to his Hylotominae. It is the same as *Labidarge* Konow.

LABIDARGE Konow=CALOPTILIA Ashmead.

The error of Doctor Ashmead in placing *Caloptilia* in the Schizocerinae caused Rev. F. W. Konow to form a new genus *Labidarge* for the same group of species. As Konow's genus was described a year later than Ashmead's, it must rank as a synonym of *Caloptilia*.

Caloptilia Ashmead, Can. Ent., vol. 30, p. 212, 1898.

Labidarge Konow, Ent. Nachr., vol. 25, p. 309, 1899.

CALOPTILIA TOWNSENDI Ashmead.

Caloptilia townsendi, Can. Ent., vol. 30, p. 212, 1898.

Reddish-yellow; head, spot on lateral lobe, four posterior tibiae and tarsi, and apex of abdomen black; wings dusky hyaline with a broad yellow band behind the stigma.

Female.—Length, 8 mm. Labrum arcuately emarginate anteriorly; clypeus with a V-shaped notch in the middle; supra-clypeal area in cross section triangular; the usual frontal basin sharply defined, the middle foveal area separated from the upper area by a low, complete, transverse carina; the middle fovea with a spherical tubercle; postocellar furrow angled; the postocellar area with longitudinal impressed line; flagellum hairy, very slightly thickening apically; transverse median vein received beyond the middle of the first discoidal cell; stigma elongate, rounded on the lower

margin; saw with regular triangularly-shaped teeth; sheath at the apex obliquely truncate. Reddish-yellow; flagellum, head (labrum and palpi excepted), a spot on the lateral lobe of the mesonotum, four posterior tibiae and tarsi, and apical four abdominal segments black; anterior tarsi dusky. Wings dusky hyaline, with a broad yellow band behind the stigma; venation in the dusky part brown, in the yellow part yellowish, basal part of the stigma yellowish.

Male.—Length, 8 mm. The male agrees with the characters given for the female except that the supraclypeal area and clypeus are pale. Hypopygidium rounded apically.

Type locality.—San Rafael, Jicoltepec, Mexico. Five females and one male collected by C. H. T. Townsend (from the Ashmead collection). Also two females from Cordoba, Mexico, collected by Mr. Frederick Knab.

Type.—Cat. No. 13134, U. S. National Museum.

PSEUDOCYPHONA Ashmead.

Pseudocyphona Ashmead, Can. Ent., vol. 30, p. 211, 1898.

Type.—*Pseudocyphona mexicana* Ashmead.

This genus belongs to the Schizocerinae and is related to *Schizocera*, but is readily separated from *Schizocera* and allies by the toothed tarsal claws. Habitus similar to *Schizocera*. Clypeus and labrum emarginate; antennal carina present; eyes elongate oval, slightly converging to the clypeus; malar space almost wanting; ocelli in a low triangle, the lateral ones very little before the supraorbital line; antennae inserted near the middle of the face, the third joint simple in the female and somewhat flattened; thorax and abdomen normal for the group; tibiae without lateral spurs; post-basitarsis shorter than the following joints; claws with an erect inner tooth near the middle; radial cell not appendiculate; four cubital cells, the second receiving both recurrent veins; basal vein joining the subcosta at the origin of the cubitus; transverse median received near the middle of the first discoidal cell; anal cell broadly contracted; radial cell of the hind wings open at the apex; two closed discal cells in the hind wing; the anal cell longly petiolate, the petiole longer than the cell.

PSEUDOCYPHONA MEXICANA Ashmead.

Pseudocyphona mexicana Ashmead, Can. Ent., vol. 30, p. 211, 1898.

Black; mesonotum, scutellum, and upper part of the pleurae reddish; legs black; wings dark.

Female.—Length, 7 mm. Labrum and clypeus very slightly arcuately emarginate; supraclypeal area convex, triangular in outline, meeting the prominent middle carina between the antennae; antennal foveae large and joining the supraclypeal fovea; antennal furrows not well defined; ocellar basin represented by a gently depressed area; postocellar furrow almost wanting; postocellar line shorter than the ocellular line; antennae short, the third joint broad, flattened; thorax normal; transverse median slightly beyond the middle of the first discoidal cell; third cubital cell about one-third longer on the radius than on the cubitus; stigma robust, broadest at the base; sheath with the lower margin marginate; saw with very small, close teeth. Black; pronotum, mesonotum, scutellum, tegulae, and upper part of the mesopleurae reddish; wings and venation blackish-brown.

Type locality.—San Rafael, Jicoltepec, Mexico. One female from the Ashmead collection, collected by Mr. C. H. T. Townsend.

Type.—Cat. No. 13135, U. S. National Museum.

NEOPTILIA Ashmead.

Neoptilia Ashmead, Can. Ent., vol. 30, p. 213, 1898.

Type.—*Neoptilia mexicana* Ashmead.

Belongs to the Schizocerides of Konow, and runs, in Konow's tables (Genera Insectorum, Fasc. 29, p. 13, 1906), in with *Hemidianeura* W. F. Kirby and *Ptilia* Lepeletier, or to *Rhagonyx* Konow. Elongate, robust species; head not especially small or transverse, not as wide as the thorax, much broader than high; clypeus and labrum emarginate anteriorly; ocelli in a curved line, the lateral ones in front of the supraorbital line; eyes slightly converging to the clypeus; malar space very narrow, antennal furrows present; ocellocular line subequal with the postocellar line; antennæ inserted in the middle of the face, ciliate, furcate in the male, simple in the female and scarcely thickening apically; tibiæ without lateral spurs; post-basitarsis not as long as the following joints; tarsal claws cleft, the inner tooth larger and shorter in the female; thorax normal for the group. Venation of females as follows: Intercostal cell without a cross-vein; radial cell with a strong appendiculation; four cubital cells, the second receiving both recurrent veins, the second near the middle, the first near the base; basal vein slightly basad of the origin of the cubitus, bent basally and not exactly parallel with the first recurrent; transverse median slightly basad of the middle of the first discoidal; anal cell very broadly contracted; in the hind wings the radial cell is long and not closed at the apex; two closed discal cells, the upper one much longer; transverse median at right angles with the anal vein; anal cell shorter than the rest of the anal vein. The venation of the male differs from that of the female in the absence of the second transverse cubitus. Basal plate with a narrow longitudinal suture.

Rhagonyx Konow (Zeitschr. syst. Hym. Dipt., vol. 3, p. 108, 1903) has the claws cleft, and is perhaps related to *Neoptilia* Ashmead.

NEOPTILIA MEXICANA Ashmead.

Neoptilia mexicana Ashmead, Can. Ent., vol. 30, p. 213, 1898.

Colored similarly to *Hylotoma biramosa* Klug, which has been placed in different genera by different authors. There are some minor differences, however, and the standing of *biramosa* is so uncertain that *mexicana* should be held distinct until Klug's type can be studied.

Female.—Length, 11 mm. Labrum deeply arcuately emarginate; clypeus with a deep V-shaped notch; labrum, clypeus, and supraclypeal area with rather large punctures; front with small well-separated punctures; vertex impunctate; supraclypeal area broadly convex, triangular; carina between the antennæ high but not sharp; postocellar area parted, with a median furrow, wider than the cephalocaudal length; postocellar furrow not sharply defined; postocellar line subequal with the ocellocular line; thorax shining; third cubital cell more than twice as long on the radius as on cubitus. Black; angles of the pronotum broadly pallid; abdomen, except the black second and third dorsal segments, pallid at the base and reddish yellow at the apex; legs, except the anterior tibiæ at base beneath, black; wings beyond the basal nervure distinctly brown, basad hyaline; venation black; head with pale hair.

Male.—Length, 9.5 mm. The male differs from the female in the usual sexual characters and the arcuately emarginate clypeus. Hypopygidium very large, apex truncate.

Type locality.—San Rafael, Jicoltepec, Mexico. Three females and one male in the collection of Dr. William H. Ashmead.

Type.—Cat. No. 13133, U. S. National Museum.

MARLATTIA Ashmead.

Marlattia Ashmead, Can. Ent., vol. 30, p. 287, 1898.

Type.—*Hemichroa laricis* Marlatt.

Clypeus shallowly emarginate; malar space present; pentagonal area present; antennæ slender, filiform, fourth joint longer than the third; thorax normal for the group; legs normal except for the simple tarsal claws; venation normal except the intercostal vein, which is interstitial with the basal, and the third cubital cell, which is short as in *Pteronus*.

Easily known from *Hemichroa* by the simple tarsal claws.

OPISTHONEURA Ashmead=**ZASCHIZONYX** Ashmead.

The type of *Opisthoneura crevecoeuri* Ashmead is the same as *Hoplocampa montana* Cresson, which is the type of *Zaschizonyx* Ashmead.

Zaschizonyx Ashmead, Can. Ent., vol. 30, p. 257, 1898.

Opisthoneura Ashmead, Can. Ent., vol. 30, p. 287, 1898.

PARAZARCA Ashmead.

Parazarca Ashmead, in Dyar, Journ. N. Y. Ent. Soc., p. 128, 1898; Can. Ent., p. 252, October, 1898. (*Type*, *Parazarca fumipennis* Ashmead.)

Calozarca Ashmead, in Dyar, Journ. N. Y. Ent. Soc., p. 129, 1898; Can. Ent., p. 252, October, 1898. (*Type*, *Selandria fascipennis* Norton.)

Eyes large, subparallel or slightly converging to clypeus; malar space very narrow so as to be nearly wanting; clypeus truncate, rather large as is the labrum; lateral ocelli below the supraorbital line, the posterior orbits therefore rather narrow; antennæ hairy, pedicellum much longer than wide, third joint the longest, apical joints short and narrowing apically; mesosternum with a distinct, triangular-shaped præsternum; mesopleuræ without a suture separating off a prepectus, metanotum with a distinct "scutellum;" tarsal claws with a large inner tooth appearing cleft, also a small post-basal tooth, basitarsis subequal with the following joints; wings of the normal blennocampid type; transverse median in the middle of first discoidal cell; third cubital cell longer on the radius than the first and third combined; radial cell of the hind wings appendiculate; no closed discal cell in the hind wings and the anal cell distinctly petiolate.

PARAZARCA FUMIPENNIS Ashmead.

Parazarca fumipennis Ashmead, through Dyar, Journ. N. Y. Ent. Soc., p. 128, 1898.

Female.—Length, 7 mm. Lateral angles of the clypeus rounded; frontal foveæ broad, shallow, the lateral ones somewhat circular in outline; the middle fovea joining with the ocellar basin and forming a broad, shallow, depressed area; antennal furrows obsolete; postocellar furrow faintly indicated; lateral boundaries of the postocellar area sharply defined; postocellar line a very little shorter than the ocelloccipital line; stigma broadest at base, tapering gradually to the apex; second recurrent vein quite free from the second transverse cubitus; sheath very robust, straight above, the apex truncate, the oblique lower part emarginate; saw obliquely ribbed, the teeth small; sharp, and regular. Shining reddish yellow; flagellum, spot inclosing ocelli, apex of saw, and four posterior legs below middle of tibiae black; anterior tarsi brownish, wings brown, venation brownish black.

Male.—Length, 6 mm. Almost exactly as in female. Hypopygidium one and one-fourth times as long as wide, the apex gently rounded.

Type locality.—Frontero, Tabasco, Mexico. A male and female from the Ashmead collection.

Type.—Cat. No. 13136, U. S. National Museum.

COCKERELLONIS MacGillivray=**ERIOCAMPIDEA** Ashmead.

Comparison of a specimen, from the original lot collected by Prof. T. D. A. Cockerell and sent to the U. S. National Museum, of *Cockerellonis occidentalis* MacGillivray proves that this species is the same as *Eriocampidea arizonensis* Ashmead. *Cockerellonis* MacGillivray is therefore a synonym of *Eriocampidea* Ashmead.

Eriocampidea Ashmead, Can. Ent., vol. 30, p. 256, 1898.

Cockerellonis MacGillivray, Can. Ent., vol. 30, p. 365, 1908.

Inasmuch as MacGillivray has described *Cockerellonis occidentalis* (Can. Ent., p. 365, 1908) completely, a description of *Eriocampidea arizonensis* is not given here.

HYPOTAXONUS Ashmead.

Rohwer^a gave this genus as a synonym of *Ermilia* O. Costa. As his remarks on the type of *Taxonus* Hartig^b are incorrect, this is wrong, and for the present *Hypotaxonus* should be treated as a good subgenus.

^a Proc. U. S. Nat. Mus., vol. 38, no. 1739, p. 203, 1910.

^b Proc. U. S. Nat. Mus., vol. 39, no. 1777, p. 111, 1910.



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TECHNICAL SERIES, No. 20, PART III.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

TECHNICAL PAPERS ON MISCELLANEOUS
FOREST INSECTS.

III. A REVISION OF THE POWDER-POST BEETLES
OF THE FAMILY LYCTIDÆ OF THE
UNITED STATES AND EUROPE.

BY

E. J. KRAUS,

Expert Preparator, Forest Insect Investigations.

APPENDIX.

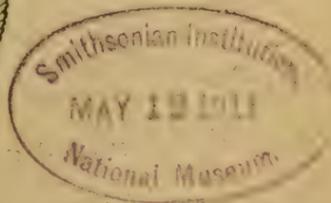
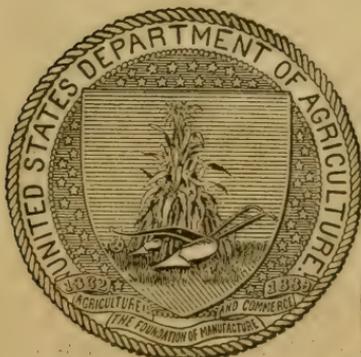
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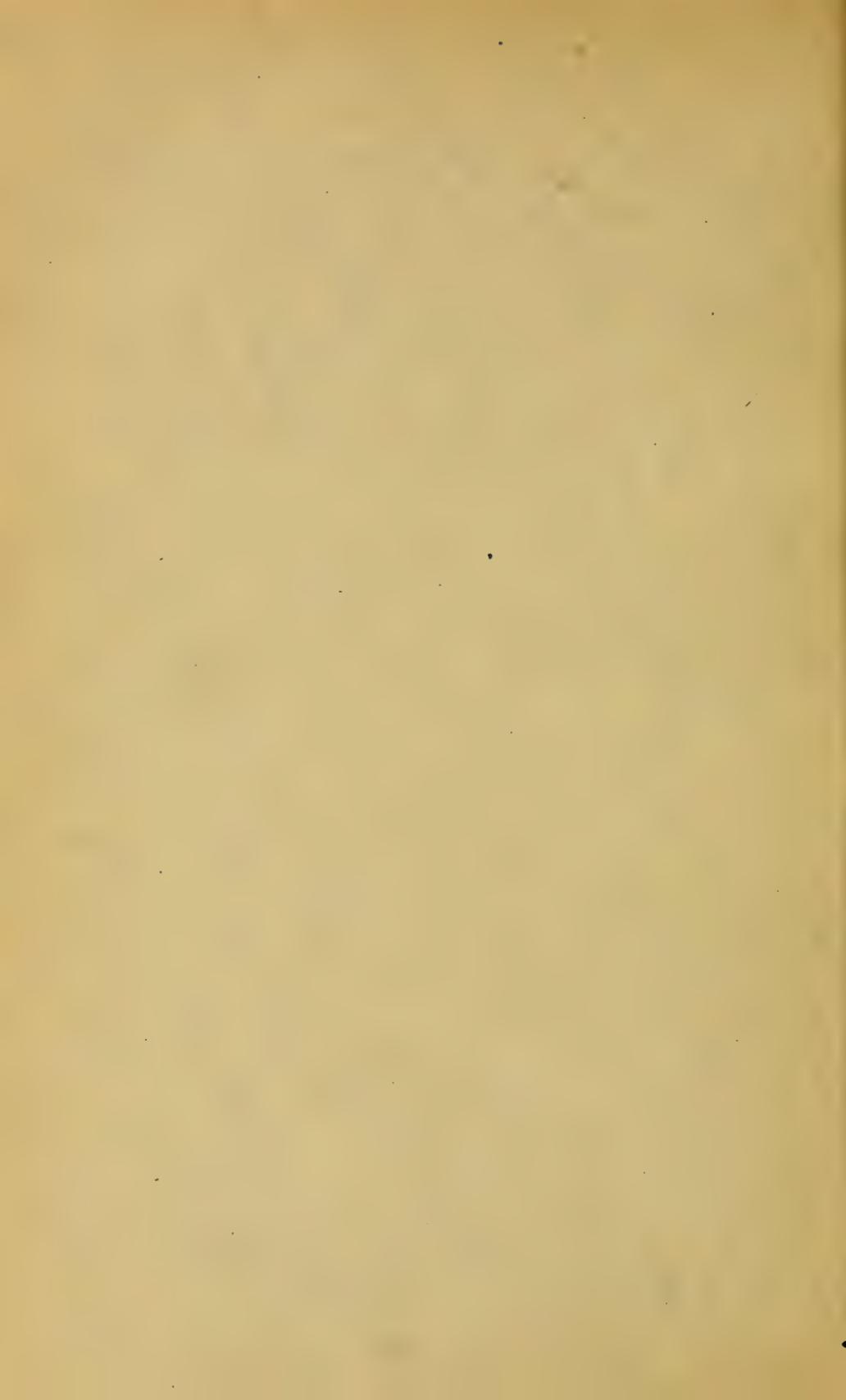
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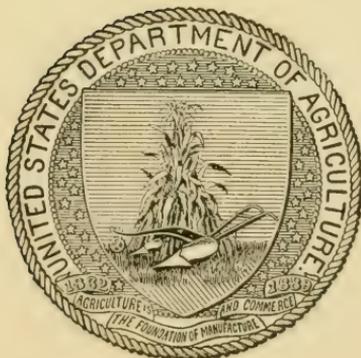
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^a Resigned June 19, 1909.

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INTRODUCTORY NOTE.

[By A. D. HOPKINS.]

This contribution by Mr. Kraus is based on a study (1) of the material in the forest insect collection and general collections of the Bureau of Entomology and of the United States National Museum and (2) of the types of species described by Doctor Le Conte and Colonel Casey, and of specimens of European species submitted by Mr. Edmund Reitter, of Austria. The family Lyctidæ is represented in North America by certain species which are of special economic importance as causing the injury to seasoned wood products known as "powder post." These species have been the subject of extended investigation by the writer and his associates to determine their habits, seasonal history, and practical methods of control. There has, therefore, been special need of a revision of the group to bring the knowledge of systematic facts up to date and to furnish a reliable basis for working up the biological data.

INTRODUCTION.

Much has been written regarding the members of the family Lyctidæ, especially with respect to their economic importance. There has, however, been considerable doubt as to the correct identity of some of the species, perhaps more especially on account of their enormous variability. In this paper the author has attempted to point out the more prominent specific characters and give something of the range of variation within the species as he has recognized them. For the determination of some of the species he has had occasion to examine a series of several hundred specimens.

Through the courtesy of Col. T. L. Casey, the author has been permitted to examine the types of his species. Mr. Samuel Henshaw, of the Museum of Comparative Zoology at Cambridge, Mass., has kindly permitted him to make a personal examination of the Le Conte types; Dr. Henry Skinner, of the Academy of Natural Sciences, Philadel-

phia, has generously afforded him a like privilege with the Horn collection, and Mr. Edmund Reitter, of Paskau, Austria, has sent him representatives of some of the European species.

In this connection the author desires to express his appreciation of the facilities offered by Mr. E. A. Schwarz, of the Bureau of Entomology, of the valuable assistance rendered by him in the study of the material in the U. S. National Museum, and of his helpful advice in the systematic work, and by Dr. A. D. Hopkins in allowing unlimited use of the large series of specimens and notes of the forest insect collection of the Bureau of Entomology.

HISTORY.

The genus *Lyctus* and allied genera constitute a group which has always been a source of perplexity to systematists, and the opinions as to their relationship have been almost as many and varied as the number of writers who have ventured them, as may in a general way be gained from the following summary:

The first reference to an insect belonging to the present family Lyctidæ was made by Geoffroy (1762), whose description reads thus:

Dermestes oblongus fuscus, elytris striatis. Le dermeste levrier à stries.

The next reference is by Goeze (1777), who described the same insect as *Dermestes linearis*. In 1783 Herbst again described and figured the species as *Dermestoides unipunctatus*. Olivier, first in 1790, and again in 1792, describes it as *Ips oblonga* and gives a very good figure of it. Fabricius (1792) erected the genus *Lyctus* and referred to it 13 species, only one of which, *L. canaliculatus* Fabricius (*linearis* Goeze), belongs to the genus as now recognized. *L. linearis* (Goeze) is therefore the type of the genus. Herbst (1793) erected the genus *Bitoma*, to which he referred his *Dermestoides unipunctatus*, together with three other species. Latreille (1803) placed *Lyctus*, together with *Bostrichus* and several other genera, in the family Xylophages, and in 1807 under the Bostrichini. In 1830 Stephens described another species, *brunneus*, and erected for it the genus *Xylotrogus*, and referred both this genus and *Lyctus* to the Engidæ, to which family Melsheimer (1844) also referred several new species of *Lyctus* and *Xylotrogus* (*Trogoxylon*) described by him. Wollaston (1854), after comparison and dissection, considered *Xylotrogus* as synonymous with *Lyctus* and placed it in the Colydiadæ. Lacordaire (1857) considered *Lyctus*, including *Xylotrogus* Stephens, under the Cissides, but remarked that the forms are in many ways aberrant and not well placed there, especially because of the 5-segmented tarsi. He placed (*Xylotrogus*) *Trogoxylon parallelipedus* Melsheimer in *Pycnomerus* under the Colydiidæ. Mellié (1848), in his monograph of the old genus *Cis*, does not mention *Lyctus*. Thomson (1863), in his sequence

of families, followed the Bostrichidæ with the Lyctidæ, of which he gives the following synopsis:

Caput pone oculos rotundos valde prominulos in collum globosum constrictum; sulcis antennariis nullis; clypeo sutura frontali discreta; mento magno lato. Trochanteres apice fere recta truncato. Antennæ sub tuberculo frontali insertæ, clava 2-3 articulata, compressa, prothoracis basin haud attingentes. Mesopleura coxas intermedias haud attingentia. Coxæ anticæ subglobosæ, parum exsertæ, contiguae, posticæ marginem elytrorum attingentes, transversæ, parum distantes. Episterna metathoracis linearis, libera. Tibiæ calcari antico uncinato. Tarsi 5-articulati, compressi, articulo 1:0 obsoleto, 5:0 reliquis simul sumtis longiore.

He divided the family into two tribes, Dinoderina and Lyctina, the latter of which he diagnosed thus:

Antennæ 11-articulatæ, clava biarticulata. Labrum transversum, apice emarginato, libero. Coxæ anteriores rotundæ parum, posticæ, latius distantes. Tibiæ externe haud denticulatæ. Acetabula antica oclusa.

Pascoe (1863) described the genus *Minthea* and remarked that in Erichson's arrangement this genus, owing to the position of the coxæ and the large basal abdominal segment, would be placed with *Bothrideres* and *Sosylus* in the Colydiidæ. Redtenbacher (1874) placed *Lyctus* in the Cryptophagides. In 1877 Kiesenwetter, in his revision of the Anobiadæ, divides the family into the Bostrichini, Anobiini, and Ptinini, and again divides the Bostrichini into five groups, Psoini, Sphindini, Lyctini, Bostrichini veri, and Hendecatomini. *Lyctus*, in which he included *Xylotrogus* Stephens, was the only representative of the Lyctini. He further remarked that while this group is related to the Bostrichini it might well be considered as a connection between the Anobiadæ and the Colydii, but that it was widely separated from *Cis* by its mouthparts and the antennal and tarsal structure, and that eventually a separate family might well be erected for it. He probably had not seen Thomson's work. The following year (1878) Reitter published an article, "Beitrag zur Kenntniss der Lyctidæ." He assigned no characters to the family, but referred to it *Lyctus* Fabricius, *Trogoxylon* Le Conte, *Lyctoaxylon* Reitter, new genus, and *Lyctopholis* Reitter, new genus (*Minthea* Pascoe), and described several new species. Le Conte and Horn (1883) divided the Ptinidæ into four subfamilies, Ptininae, Anobiinae, Bostrichinae, and Lyctinae. To the Lyctinae are assigned *Lyctus* Fabricius and *Trogoxylon* Le Conte. In 1885 Reitter again gave a synopsis of the European species of *Lyctus* and *Trogoxylon* and assigns them as before to the family Lyctidæ. Casey (1890) described several new species of *Lyctus* under the Ptinidæ, but in the appendix of the same paper referred the genus to his more broadly conceived Cucujidæ, and gave a discussion on its apparent relationship to other families and genera. Lesne (1896-1898), in his revision of the Bostrichidæ, divided that family into four tribes—

Psoinæ, Polycaninæ, Dinoderinæ, and Bostrychinæ, but made no mention of *Lyctus*. Kolbe (1901) has retained the Lyctidæ as a family and placed it in his Heterorrhaden under the suborder Heterophaga; and Ganglbauer (1903) placed the family between the Anobiidæ and Sphindidæ in his Diversicornia under the suborder Polyphaga. Reitter, in 1906, has the family between the Bostrychidæ and the Anobiidæ.

Without doubt the family Lyctidæ is a valid one, its members possessing characters which will not readily admit of their being placed in any other family. The family Ptinidæ of Le Conte and Horn is a composite one, and the subfamilies Ptininæ, Anobiinæ, Bostrichinæ, and Lyctinæ are deserving of family rank and in fact have already been so treated by European coleopterists. While it is not intended to treat extensively on the exact position of the Lyctidæ, it may be said that the family is apparently most closely allied to the Bostrychidæ, especially by the pentamerous tarsi with the first segment very short, the method and point of insertion of the antennæ, and the only too well-known destructive habits of the larvæ, which bore into the solid wood. The larva possesses three pairs of well-developed prothoracic legs, and in form and structure is scarcely to be distinguished from the bostrychid larva, but is totally different from any scolytid larva to which it has been likened, the resemblance being scarcely even superficial. The mouthparts of the adult *Lyctus* are very similar to those of *Dinoderus*, especially in the structure of the labium, maxillæ, and the broad mentum. The family has very little in common with the Cucujidæ. As pointed out above, the larva is of a wholly different character in form and habits, and the adults, while agreeing in one character or another with those found in certain other genera included by Colonel Casey in his broadly conceived Cucujidæ, have probably derived those characters independently of any real connection with them. The family seems best placed as in the latest (1906) edition of the *Catalogus Coleopterorum Europæ*, i. e., immediately after the Bostrychidæ and preceding the Ptinidæ.

THE PRINCIPAL CHARACTERS OF THE FAMILY LYCTIDÆ.

Mentum large, transverse, corneous; glossa coriaceous, ciliated; palpi with 3 flexible segments.

Maxillæ not exposed at base; galea subchitinous, densely ciliate at apex, more strongly chitinized at base; lacinia subchitinous, fringed with long ciliæ; palpi moderately short, with four rather stout segments.

Antennæ at the sides of the head beneath the produced frontal angles and before the eyes, eleven-segmented, clavate, the club two-segmented and without porous sensitive areas.

Head prominent, constricted behind the eyes; oral organs small; epistoma distinct, labrum distinct.

Prothorax with the episterna and epimera fused; lateral margin distinct or obsolete; coxal cavities rounded, closed behind.

Mesosternum small, surrounding the coxæ anteriorly and at the sides; mesepisternum and mesepimeron not attaining the coxa.

Metasternum long.

Elytra entire, completely covering the abdomen, epipleuræ narrow.

Abdomen with five visible ventral segments, the first ^a always longer than the second.

Anterior coxæ subcontiguous or widely separated, subglobose, moderately prominent; middle coxæ similar to anterior; posterior coxæ widely separated, transverse, subprominent internally, externally grooved for the reception of the thighs.

Legs not contractile, slender; tibiæ slender; tarsi five-segmented, the first segment very short.

SYNOPSIS OF GENERA.

At present but three distinct genera belonging to this family are recognized. They may be separated as follows:

Antennal club with both segments subequal, neither decidedly elongated; pronotum varying in shape from subquadrate with all angles acute to cordate with the angles rounded; elytra punctate, the punctures confused or distinctly seriate; pubescence confused or seriate; anterior tibiæ slender, acutely produced externally; tarsi slender.....*Lyctus* Fabricius.

Antennal club with both segments very strongly elongated, the segments much longer than broad, the terminal one very much narrower than the preceding; sides of head with three hooklike teeth; the prothorax as in *Lyctus* (*Trogoxylon*), the margins, however, clothed with bristles; elytra punctured in not very regular rows, the pubescence, however, scarcely in rows; anterior tibiæ on either side strongly widened into a tooth externally, with a large tooth, straight at the base and hooklike at the apex; tarsi rather slender; claw-segment simple.....*Lyctoxylon* Reitter.

Antennal club with terminal segment elongate, sides of head with three weak teeth at either side; margins of pronotum denticulated and, like the margins of the body, with bristles; elytra striately punctured, with rows of erect bristles. Tibiæ at the outer angle unequal, curved, the anterior widened into a tooth at the apex, with a somewhat large curved spine; tarsal segments short, claw segment strongly clavately thickened, claws simple, rather small; form of body and prothorax as in *Lyctus*.....*Minthea* Pascoe.

REVISIONAL NOTES.

In the foregoing generic synopsis *Trogoxylon* Le Conte has been placed with *Lyctus*, as has been done by Colonel Casey (1891). Le Conte, in separating the genera, did so on the ground that *Trogoxylon* did not have the anterior tibiæ prolonged at the outer apical

^a The first visible ventral segment in the Lyctidæ is the third abdominal sternite. (See Hopkins, Tech. Ser. 17, Pt. I, Bur. Ent., U. S. Dept. Agr., p. 55, fig. 38, 1909.)

angle. As stated by Reitter, later by Casey, and as is easily seen, they are produced and in some species as strongly as in any true *Lyctus*. Reitter in his synopsis states that in *Trogoxylon* the sides of the head are provided with three hooklike teeth, that the pronotum has all its angles sharp, and that the elytra are without rows of punctures or hairs, but that these are irregularly disposed. As a matter of fact, *Lyctus (Trogoxylon) impressus* Comolli does have the three elevations mentioned, but in all the species so far recognized in the United States not only the tooth over the eye is obsolete, but the posterior angles and margin of the epistoma are closely joined to the angles of the front, so that the epistoma is but slightly depressed below the level of the front, and the two elevations seen in many species of *Lyctus* are not traceable—a character also observable in *L. (Xylotrogus) politus* n. sp. The shape of the pronotum is of little value; in *L. brunneus* Stephens all the angles are acute. The elytral punctures in *L. (Trogoxylon) californicus* Casey are decidedly striate and there is a tendency to the same thing in *L. curtulus* Casey.

The first visible ventral segment in most species which would fall in *Trogoxylon* is as long as the second and third combined, but in others it is not longer than the second and one-half of the third.

Xylotrogus has long since been shown by Wollaston (1854) and other writers to be synonymous with *Lyctus*, and *Trogoxylon* must also be so considered, though it might well be regarded as representing a well-marked subgenus.

The species of the family Lyctidæ are very variable, especially in size. Well-developed individuals are frequently four or five times larger than others, the difference in size perhaps depending largely on food supply; for the offspring of those individuals which have bred in the same piece of wood for four, five, or six generations are very much smaller and quite different in some of the structural details from the first individuals reared. Accompanying the decrease in size are found such changes as in the shape and punctation of the pronotum and the punctation and pubescence of the elytra. As a result, one must allow for much variation within the limits of the species, and characters which might be of specific importance in groups more constant in character can only be held to be individual.

SYNOPSIS OF SPECIES OF THE GENUS LYCTUS.

- Elytral pubescence confused over the entire surface or sometimes in single rows, never in double series separated by wide intervals; apical angles of the prothorax usually decidedly prominent—if not, at least subprominent and the sides of pronotum decidedly convergent posteriorly Division I, pages 117–119.
- Elytral pubescence always arranged in distinct series, the series at the sides at least separated by a double row of fine, deep punctures or a single row of large, shallow, circular punctures Division II, pages 119–120.

DIVISION I.

- Elytral punctures confused, or somewhat striate, but if so, the series never impressed.
 Subdivision A, pages 117-118.
- Elytral punctures distinctly seriate, the series distinctly impressed.
 Subdivision B, pages 118-119.

SUBDIVISION A. (*Trogoxylon* Le Conte.)

- Head with a distinct tubercle over the eye; pronotum quadrate, with the sides not convergent posteriorly Section a1, page 117.
- Head without tubercle over the eye; pronotum with the sides more or less convergent posteriorly Section a2, page 117.

Section a1.

Length 3 to 4.5 mm.; ferruginous. Pronotum opaque, very densely, evenly punctured; anterior margin slightly trisinate; sides sinuate, scarcely convergent posteriorly; anterior and posterior angles very prominent, right, not at all rounded; median impression narrow, deep near the center of the disk, broadly expanded toward anterior and posterior margins. Elytra subparallel, just visibly wider at base than prothorax, extremely finely, densely, confusedly punctured; pubescence fine, decumbent, confused. Head with front subconvex, densely, evenly punctured; frontal angles very prominent, narrowly rounded; side margins of epistoma forming an acute, slightly reflexed tooth; antennæ slender, club feeble, ovate. Abdomen slightly shiny below, excessively minutely punctured.

impressus Comolli, page 121.

Section a2.

- Pronotum broader than long, the vestiture very short, coarse, and bristling; prosternum distinctly punctured throughout Subsection b1, page 117.
- Prothorax as long or longer than wide anteriorly, the pubescence rather long, fine, and decumbent or subdecumbent; prosternum not punctured or but very feebly so near its side margins Subsection b2, page 117.

Subsection b1.

Length 3 mm.; body nigro-piceous, short, broad, stout, subconvex, densely clothed with short, stiff bristles. Prothorax feebly shiny; side margins strongly convergent posteriorly; anterior margin broadly rounded; punctures large, deep, more dense posteriorly; median impression shallow, broad; pro-episternal area coarsely, distinctly punctured. Elytra broad, shiny, subparallel, densely, coarsely punctured, the punctures feebly seriate. Head with front subconvex, densely, evenly punctured; epistoma slightly depressed, side margins scarcely reflexed, with a dense fringe of coarse bristles, which also occur on the angles of the front; antennæ stout. Abdomen subopaque below.

punctatus Le Conte, page 121.

Subsection b2.

- Elytral punctures in distinct series; epistoma with side margins strongly reflexed.
 Series c1, page 117.
- Elytral punctures confused, without distinct serial arrangement; epistoma not reflexed at sides Series c2, page 118.

Series c1.

Length 2.2 to 2.5 mm.; very slender, parallel, compressed, castaneous throughout, strongly shining. Prothorax with side margins rather strongly convergent posteriorly; anterior margin strongly arcuate; anterior angles strongly rounded,

posterior obtusely rounded; median impression very broad and shallow; punctures coarse, rather dense, sparser and finer anteriorly. Elytra elongate, the punctures small and arranged in distinct series, becoming confused toward suture and base, the pubescence sparse and recumbent. Head with front scarcely convex, densely, finely punctured; epistoma depressed, side margins strongly reflexed; antennæ slender. Abdomen shiny below, densely, exceedingly finely punctured..... *californicus* Casey, page 121.

Series c2.

Length 2 to 4 mm.; elongate, rather slender, ferruginous to nigro-piceous. Prothorax with side margins strongly convergent posteriorly; anterior margin strongly trisinate; anterior angles acutely rounded; posterior right, not at all rounded; median impression very shallow, broad, deeper posteriorly; punctures fine and dense. Elytra subparallel, slightly narrowed posteriorly; punctures very fine, dense, confused; pubescence yellowish, fine, and dense. Head with front subconvex, finely, densely punctured, the pubescence very short, reflexed at the sides; antennæ slender, the club large and prominent. Abdomen subopaque below, densely, coarsely punctured..... *parallelopedus* Melsheimer, page 121.

Length 2.7 to 3.3 mm.; stout, comparatively broad, castaneous to nigro-piceous. Prothorax with the sides slightly convergent posteriorly; anterior margin broadly rounded or faintly trisinate; anterior angles acutely rounded; posterior obtuse and blunt; median impression broad, rather deep, more so posteriorly; punctures coarse and dense, less so anteriorly. Elytra stout, slightly narrowed toward the base; punctures coarse, dense, faintly, subseriately arranged toward sides; pubescence rather coarse, sparse, decumbent, and arranged in faint series. Head with front convex, densely, subrugosely punctured, the pubescence short and fine; epistoma nearly flat, coarsely punctured, side margins very faintly reflexed; antennæ stout, the club robust, small, oval. Abdomen polished below, extremely finely and sparsely punctured..... *cutulus* Casey, page 122.

SUBDIVISION B. (*Xylotrogus* Stephens.)

Length 2.5 to 3.5 mm.; castaneous throughout. Pronotum shiny, strongly punctured posteriorly, the punctures becoming very small or obsolete anteriorly; side margins strongly sinuate; anterior angles very broadly rounded. Elytra with the sides nearly parallel; stria punctures fine, close-set, confused near suture; interspaces flat; pubescence fine, decumbent, sparse. Head with front densely, evenly punctured, feebly shiny, scarcely impressed before the eyes; epistoma convex, finely punctured, not at all elevated at lateral margins.

politus n. sp., page 122.

Length 3 to 5 mm.; rufo-fuscous throughout. Pronotum subopaque; side margins nearly straight, densely, finely serrulate and strongly convergent posteriorly; anterior angles acute, slightly prominent, blunt, but scarcely rounded; punctures more dense posteriorly, finer, not becoming obsolete anteriorly. Elytra with the sides nearly parallel; stria punctures fine, impressed; interspaces, especially toward sides, subconvex; pubescence fine, decumbent. Head with front densely, rather coarsely punctured, convex, strongly impressed at the sides before the eyes; epistoma subconvex, its anterior angles distinctly elevated.

brunneus Stephens, page 123.

Length 4.5 to 5 mm.; rufo-testaceous, head and prothorax piceous. Pronotum opaque, punctato-scabrous; anterior margin very broadly curved; side margins feebly sinuate, rather strongly convergent posteriorly; anterior angles subprominent, obtuse, very broadly rounded, posterior obtuse, not rounded; median impression merely a narrow, feebly impressed furrow extending from near anterior

margin to posterior margin. Elytra shiny, subparallel, a little broader than prothorax; punctures large, distinct, deep, circular, strongly seriate, the series impressed; interspaces slightly convex; pubescence fine, sparse, seriate. Head with front convex, opaque, densely, rugosely punctate; epistoma strongly depressed, not at all elevated at the sides; antennæ stout, the club large, elongate oval..... *pubescens* Panzer, page 123.

DIVISION II.

Elytral striæ composed of a double or sometimes a single row of fine, elongate, deeply impressed punctures.....Subdivision C, pages 119-120.

Elytral striæ each composed of a single row of large, shallow, circular punctures. Subdivision D, page 120.

SUBDIVISION C.

Prothorax anteriorly distinctly narrower than the elytra at base. Section a3, pages 119-120.

Prothorax fully as wide anteriorly as the elytra at their base....Section a4, page 120.

Section a3.

Pronotum distinctly longer than wide, its anterior angles not at all prominent, very broadly rounded; median impression merely a narrow, faintly impressed groove from anterior to posterior margins; elytral interspaces frequently subconvex, especially toward sides.....Subsection b1, page 119.

Pronotum quadrate or subquadrate; anterior angles distinct, subprominent but not acute; median impression large, broadly oval, deep; elytral interspaces not at all or but feebly convex.....Subsection b2, pages 119-120.

Subsection b1.

Length 2.1 to 4 mm.; castaneous. Pronotum opaque, punctato-scabrous; anterior margin broadly rounded; side margins straight or slightly sinuate and convergent posteriorly; anterior angles subobsolete; posterior sharp, everted. Elytra slightly narrowed toward base; interspaces toward the sides feebly to rather strongly elevated; punctures coarse, elongate, and in double series between the interspaces; pubescence fine, short, dense, decumbent. Head with front strongly convex, densely punctured and granulose; epistoma narrow, depressed, side margins strongly divergent posteriorly, anterior deeply emarginate, its anterior angles not elevated; antennæ slender, the club stout, narrowly oval. Abdomen subopaque below, densely, finely, granulately punctured.

opaculus Le Conte, pages 123-124.

Subsection b2.

Length 3 to 5 mm.; ferruginous, head and prothorax slightly darker. Pronotum opaque, punctate, scabrous; anterior margin broadly rounded; side margins nearly straight, finely denticulate, acute, parallel or very faintly convergent posteriorly; anterior angles subprominent, obtuse, blunt; posterior angles right, prominent, not rounded; median impression broadly oval, deep. Elytra subparallel, scarcely narrower anteriorly, convex but not more noticeably so at their middle; stria punctures very fine, elongate, arranged in single or sometimes in double series, especially toward sides; pubescence seriate, fine, sparse, decumbent. Head with front strongly convex, opaque, densely punctato-granulate, sides slightly elevated over the eye; epistoma strongly depressed, narrow, its anterior angles not elevated; antennæ stout, the club strong, oval. Abdomen subopaque below, densely, finely punctured....*saturalis* Faldermann, page 124.

Length, 3.5 to 4.5 mm.; ferruginous. Pronotum shiny, rather densely, but not at all scabrous or rugosely punctured, the punctures smaller and less dense anteriorly; median impression broadly oval, deep, not approaching anterior margin; anterior margin broadly rounded, sides parallel, straight or faintly sinuate; anterior angles obtusely rounded; posterior angles right, prominent, not at all or very feebly rounded. Elytra broad, distinctly narrowed toward base, more strongly convex at about their middle; interspaces not at all elevated; punctures very fine, elongate, seriate as in *opaculus*; pubescence of medium length, fine, decumbent, strongly seriate in arrangement. Head with front strongly convex, smooth, shiny, evenly but not densely punctured; epistoma depressed, its anterior margin broadly emarginate, the anterior angles elevated and with coarse pubescence; antennæ very slender, the club weak, narrowly oval. Abdomen feebly shiny below, exceedingly finely, densely punctured.

cavicollis Le Conte, page 124.

Section a4.

Length, 2.5 to 5.5 mm.; black. Pronotum shiny, rather densely but not at all rugosely punctured, median impression broad, shallow, narrow from posterior margin to middle, where it becomes broadly, gradually expanded to the anterior margin, rarely deep, suboval and scarcely expanded anteriorly; anterior margin broadly rounded; side margins strongly arcuate and convergent posteriorly or nearly straight and subparallel; anterior angles broadly rounded, not at all prominent, posterior obtuse and feebly rounded or subrectangular and sharp. Elytra elongate, convergent toward base, the interspaces flat or just visibly convex; punctures very fine, seriate as in *opaculus*; pubescence fine, sparse, decumbent, distinctly seriate. Head with front strongly convex, densely, subrugosely punctured; epistoma depressed, anterior margin broadly emarginate, anterior angles not elevated; antennæ stout, club prominent; abdomen shiny below, densely, finely punctured. *planicollis* Le Conte, pages 124-125.

Length, 2.4 to 4.7 mm.; black. Pronotum opaque, punctato-scabrous; median impression reduced to a shallow, narrow line from anterior to posterior margin; anterior margin very strongly, broadly arcuate; side margins strongly curved and convergent posteriorly; anterior angles very broadly, obtusely rounded; posterior angles obtuse, not rounded. Elytra narrowed toward base; interspaces noticeably convex; punctures coarse, narrow, elongate, deep, seriate; pubescence fine, sparse, seriate. Head with front strongly convex, scabrous; epistoma small, depressed; anterior margin broadly emarginate; antennæ slender, club strong, compact, oval. Abdomen subopaque below, very densely, finely punctured.

parvulus Casey, page 125.

SUBDIVISION D.

Length 2.5 to 5 mm.; ferruginous. Pronotum opaque; surface very finely granulate and pubescent; median impression oval, deep, extending from anterior fourth to posterior fourth and thence very narrowly to posterior margin; anterior margin strongly arcuate, sides straight or feebly sinuate, not at all or but scarcely narrowed behind; anterior angles obtuse, broadly rounded; posterior angles right, not at all rounded. Elytra just visibly narrowed toward base; interspaces flat; punctures shallow, circular, arranged in single series except at costal border, where they are in double series; pubescence sparse, fine, decidedly seriate in arrangement. Head with front strongly convex, side margins distinctly elevated over the eye, densely, finely granulato-punctate; epistoma narrow, its anterior margin broadly, deeply emarginate; anterior angles not elevated; antennæ slender, noticeably pubescent, club large and prominent. Abdomen feebly shiny below, densely, finely punctate. *linearis* Goeze, pages 125-126.

SYSTEMATIC NOTES.

Genus **LYCTUS** Fabricius.

Lyctus Fabricius, 1792, p. 502.

Xylotrogus Stephens, 1830, pp. 116-117.

Trogoxylon Le Conte, 1861, p. 209.

Lyctus impressus Comolli.

Lyctus impressus Comolli, 1837, pp. 40-85; Seidlitz, 1875, p. 160; Erichson, 1877, p. 17.

Trogoxylon impressus (Comolli) Reitter, 1885, p. 100.

This species is the largest of the *Trogoxylon* group which the author has seen. It is very distinct in the quadrate prothorax and in the possession of the three elevations at the sides of the head, one over the eye, another just before it at the frontal angle, and another at the lateral angle of the epistoma.

Material examined.—A series of 5 specimens, very constant in character, except in size. The species occurs in southern Europe, but has not as yet been recorded from the United States.

Lyctus punctatus (Le Conte).

Trogoxylon punctatum Le Conte, 1866, p. 104.

Lyctus punctatus (Le Conte) Casey, 1891, pp. 13, 16.

This species is easily known by its short, broad form, coarse punctation of the pronotum and elytra, and the stiff, short, almost squamose pubescence.

Material examined.—A single specimen from Santa Rosa, Lower California, and Le Conte's type, which is from Cape San Lucas, Lower California.

Lyctus californicus Casey.

Lyctus californicus Casey, 1891, p. 14.

This species is readily recognized by its elongate, highly polished body, and by the finely but definitely striated punctures of the elytra, the pubescence of which is fine and sparse. It is easily distinguished from *L. curtulus*, to which it is probably most closely allied, by its more slender, parallel, elongate form, finer elytral punctures, and other minor details. There is some variation in size and density of color, but other characters are quite constant.

Material examined.—A series of 5 specimens from Santa Rosa, Lower California. Colonel Casey's specimens are from Fort Yuma, Cal.

Lyctus parallelopedus (Melsheimer).

Xylotrogus parallelopedus Melsheimer, 1844, p. 112.

Trogoxylon parallelopedum (Melsheimer) Le Conte, 1861, p. 209; Le Conte and Horn, 1883, p. 229.

Lyctus parallelopedus (Melsheimer) Casey, 1891, p. 13.

Most readily recognized by the very finely, densely, confusedly punctured elytra, with the pubescence long, dense, fine, and decumbent, and the margin of the prothorax strongly trisinuate.

There is great variation in size, as usual. The side margins of the prothorax are generally straight, sometimes slightly curved inward, and the prothoracic punctures are generally fine.

Material examined.—A series of more than 100 specimens. Distributed throughout the eastern and southeastern United States.

***Lyctus curtulus* Casey.**

Lyctus curtulus Casey, 1891, p. 15.

One of the smaller species, easily separated from *parallelopipedus* Melsheimer by its coarse elytral punctation, average smaller size, and prothoracic structure, and from *californicus* Casey by its much shorter, robust form, denser elytral pubescence, coarser and less sinuate arrangement of elytral punctures, and in being much less shiny.

There is considerable variation, more especially in size and coloration, and likewise in the density and size of the prothoracic and elytral punctures, in the convergence of the sides of pronotum, in the sinuation of its anterior margin (the latter sometimes becoming feebly trisinuate), and in the degree of depression of the epistoma. A single specimen from Bonner, Mont., differs quite noticeably in several respects from the more typical examples of *curtulus*, and may represent an undescribed species. However, it is placed here until more specimens show it to be distinct.

Material examined.—A series of more than 300 specimens. Distributed throughout the southwestern United States.

***Lyctus politus* n. sp.**

Type.—Cat. No. 7432, United States National Museum; U. S. Department of Agriculture, No. 7414; one of 21 specimens collected and reared by Dr. F. H. Chittenden from licorice at Washington, D. C.

This species is readily separated from *brunneus* Stephens by its much shorter, broader form, more shiny, finely and less densely punctured prothorax, and by the structure of the front as outlined in the synopsis (p. 118).

There is considerable variation in size, and to a less extent in the convergence of the sides of the prothorax posteriorly, and in the pronotal punctation.

It is possible that this species has been already described, but the author has been unable to place it in any of the species of which he has had specimens or descriptions and has, in consequence, described it as being new.

Lyctus brunneus (Stephens).

Lyctus parasiticus Stephens, 1829, p. 94.

Xylotrogus brunneus Stephens, 1830, p. 116, pl. 18, fig. 4; Seidlitz, 1875, p. 160.

Lyctus glycyrrhizæ Chevrolat, 1829-1838, pp. 191-192, pl. 41, fig. 3.

Lyctus rugulosus Montrouzier, 1861, p. 266.

Lyctus brunneus (Stephens) Wollaston, 1854, p. 152; Erichson, 1877, p. 17; Reitter, 1885, p. 100; Reitter, 1906, p. 423.

Lyctus carolinæ Casey, 1891, pp. 13-14.

This species, while allied to *L. politus* n. sp., is readily distinguished by its larger size and coarser structure throughout and more acute anterior angles of prothorax; the epistoma also is more depressed, its posterior angles as in *planicollis* Le Conte. The series of specimens is very constant, except that there is the usual variation in size and color. A single specimen from Philadelphia, Pa., is more slender, the prothorax narrower and more constricted behind, with the sides straight, and the anterior margin more strongly arcuate. It is probably best placed here for the present. A series of 3 specimens from Mr. Reitter shows considerable variations, more especially in the shape of the prothorax, and one individual has the pronotum much more coarsely punctured.

Material examined.—A series of 14 specimens. The species is widely distributed throughout the world.

Lyctus pubescens Panzer.

Lyctus pubescens Panzer, 1793, fasc. 4, fig. 17; Erichson, 1877, p. 16; Reitter, 1878, p. 196; Reitter, 1885, p. 99.

Lyctus bicolor Comolli, 1837, p. 41; Seidlitz, 1875, p. 160.

Lyctus caucasicus Tournier, 1874, p. 412; Reitter, 1878, p. 196; Reitter, 1885, p. 99.

Lyctus pubescens v. *caucasicus* (Tournier) Reitter, 1906, p. 423.

The species is very distinct. It is perhaps more closely allied to *brunneus* Stephens than any other, both in elytral and prothoracic structure, though very distinct from it. It is remarkable in having the prothorax very much darker than the elytra, a character seldom met with in this family.

Material examined.—Two specimens from Mr. Reitter are labeled "Silesia, on Willow." One of them has the prothorax strongly narrowed posteriorly, the other much less, although distinctly so. The species occurs in Europe, but up to the present time it has not been recorded from the United States.

Lyctus opaculus Le Conte.

Lyctus opaculus Le Conte, 1866, p. 103; Casey, 1890, p. 324; Casey, 1891, p. 13.

This species is remarkably distinct and easily separated by the narrow, convex prothorax, the anterior angles being very broadly rounded, the side margins strongly convergent posteriorly, the surface opaque and very densely subrugosely punctured, the median

impression long, shallow, and narrow, and the stria punctures of the elytra deep and coarse.

There is considerable variation, more especially in size, in the acuteness of the posterior angles of the prothorax, in the convergence of its side margins posteriorly, and in the elevation of the elytral interspaces.

Material examined.—A series of 60 specimens. The species is distributed throughout the eastern United States.

***Lyctus suturalis* Faldermann.**

Lyctus suturalis Faldermann, 1837, p. 225; Reitter, 1878, p. 196; Reitter, 1885, p. 99; Reitter, 1906, p. 423.

Lyctus deyrollei Tournier, 1874, p. 411.

This species is related to *linearis* Goeze in prothoracic structure, but is wholly different in elytral structure, resembling, in this respect, *planicollis* Le Conte, though quite different in that for the most part the striae are made up of but a single row of exceedingly fine punctures.

The specimens are quite constant in character, though there is considerable variation in the prominence and roundness of the anterior angles of the prothorax.

Material examined.—A series of four specimens from Mr. Reitter. The species occurs in the Caucasus. Up to the present time it has not been recorded from the United States.

***Lyctus cavicollis* Le Conte.**

Lyctus cavicollis Le Conte, 1866, p. 103; Casey, 1890, p. 324; Casey, 1891, p. 13.

This species is very distinct, and is readily separated from the other species by the shining, narrow, subquadrate, subconvex prothorax with the sides parallel, the posterior angles sharply rectangular, and the form generally stout. It is not closely allied to any other species. It resembles *planicollis* Le Conte in elytral structure, but the prothorax is totally different. There is some variation in size, but the structural details are quite constant.

Material examined.—A series of 25 specimens, all from California.

***Lyctus planicollis* Le Conte.**

Lyctus planicollis Le Conte, 1858, p. 74; Le Conte, 1866, p. 103; Dugès, 1883, pp. 54-58; Casey, 1890, p. 324; Casey, 1891, p. 13.

(?) *Lyctus carbonarius* Waltl, 1832, p. 167.

This species is extremely variable; perhaps more so than any others of the genus. Individuals range in length from 2.5 to 5.5 mm. The prothorax varies from broader than long, with the side margins strongly sinuate and convergent posteriorly, to subquadrate and the sides parallel; it is, however, always as wide anteriorly as the elytra at base, the anterior angles always rounded, the posterior never so.

The pronotum may be densely, evenly punctured over the entire surface, or have the punctures less dense and the surface polished anteriorly, but is never scabrous; the median impression varies from very deep and becoming broadly expanded anteriorly, with a small circular impression at either side, to subobsolete in the smaller specimens.

Whether this species and *carbonarius* Waltl are synonymous the author can not say, since he has not seen Waltl's description. However, he has 2 specimens which Mr. E. A. Schwarz tells him are from Mexico, received through Dr. E. Dugès from Guanajuato. These specimens are probably from among the series on which Doctor Dugès based his "Metamorphoses du *Lyctus planicollis*." They differ in some of the minor details from *planicollis*, more especially in having the pronotal punctures coarser and less dense; and the median impression is deep, oval, and not broadly expanded anteriorly. Should these characters prove constant in a larger series they might well be considered as representing a distinct species, probably *carbonarius* Waltl, very closely allied to *planicollis*.

Material examined.—A series of over 500 specimens. The species is found widely distributed throughout the entire United States at least.

Lyctus parvulus Casey.

Lyctus parvulus Casey, 1884, p. 175; Casey, 1890, p. 325; Casey, 1891, p. 13.

This species is remarkably distinct and is separated at once from the other species by the broad cordate prothorax and its dense, coarse, subrugose punctation.

There is great variation in size and to a less degree in the shape of the prothorax and in the acuteness of the posterior angles. In general form it resembles *planicollis* Le Conte, but in structural details resembles *opaculus* Le Conte. It is readily separated from either, and is far removed from *linearis* Goeze, with which species it has very little in common.

Material examined. A series of about 50 specimens. Distributed throughout the western and southwestern United States.

Lyctus linearis (Goeze).

Dermestes oblongus fuscus, elytris striatis, Geoffroy, 1762, p. 103.

Dermestes linearis Goeze, 1777, p. 148; Thunberg, 1784, p. 4, no. 4.

Lyctus linearis (Goeze) Reitter, 1906, p. 423.

Dermestes oblongus (Olivier) Fourcroy, 1785, p. 19, no. 9.

Ips oblonga Olivier, 1790, vol. 2, no. 18, sp. 8, pl. 1, fig. 5, a, b; 1792, p. 405, no. 9.

Lyctus oblongus (Olivier) Latreille, 1804, p. 241; Latreille, 1807, p. 16, sp. 1; Stephens, 1830, p. 117.

Dermestoides unipunctatus Herbst, 1783, p. 40, pl. 21, fig. H, h.

Bitoma unipunctata Herbst, 1793, p. 26, pl. 46, fig. 3.

Lyctus unipunctatus (Herbst) Kiesenwetter, 1877, p. 15; Reitter, 1885, p. 99.

Lyctus canaliculatus Fabricius, 1792, p. 504, no. 11; Panzer, 1793, fasc. 4, fig. 16; Paykull, 1800, p. 332, no. 9; Fabricius, 1801, vol. 2, p. 562, no. 13; Gyllenhal, 1813, vol. 1, pt. 3, pp. 408-409, no. 1; Thomson, 1863, vol. 5, p. 204; Tournier, 1874, vol. 6, p. 411, no. 103.

Synchita canaliculata (Fabricius) Hellwig, 1792, vol. 4, p. 405, no. 8.

Lyctus striatus Melsheimer, 1844, vol. 2, p. 112; Casey, 1890, vol. 5, p. 324; Casey, 1891, vol. 6, p. 13.

Lyctus axillaris Melsheimer, 1844, vol. 2, p. 113.

Lyctus pubescens Duitschmid, 1825, vol. 3, p. 148.

Lyctus fuscus Seidlitz, 1875, p. 16.

This species is at once and easily recognized by its peculiar, large, shallow, circular punctures of the elytral striæ, not observable in any other of our species. There is considerable variation in size, but in other respects the species is quite constant.

Material examined.—A series of several hundred specimens. Occurs throughout the United States, Europe, and probably the entire world.

Genus **LYCTOXYLON** Reitter.

Lyctoxyton Reitter, 1878.

Lyctoxyton japonum Reitter.

Lyctoxyton japonum Reitter, 1878, p. 199.

Subdepressed, ferruginous, feebly shiny, rather densely clothed with very short subsquamose bristles. Segments 1-4 of the antennæ subelongate, 5-9 subtransverse, club strongly elongate, cylindrical, segments nearly three times as long as broad, the terminal one a little narrower than the preceding. Head and prothorax densely confusedly punctured, the punctures subpapillate. Prothorax a little broader than long, more narrow toward the base, anterior angles obtuse, posterior right, the sides setulose-ciliate, at the middle of the dorsum longitudinally foveately impressed and with a short, strongly excavate line before the scutellum. Elytra a little broader than prothorax, parallel, more than twice as long as wide, either elytron seriatly, near the suture irregularly punctured, with short, dense, just visibly seriate, subsetulose scales. Length 1.5 to 2 mm. [Reitter.]

Material examined.—A series of 4 specimens from New Jersey, reared from Japanese cane. The species was described from specimens from Japan and China.

Genus **MINTHEA** Pascoe.

Minthea Pascoe, 1863, p. 97; Reitter, 1906, p. 423.

Lyctopholis Reitter, 1878, p. 196; Everts, 1899, p. 565.

***Minthea rugicollis* (Walker).**

Ditoma rugicollis Walker, 1858, p. 206.

Minthea similata Pascoe, 1863, p. 141.

Minthea rugicollis (Walker) Waterhouse, 1894, p. 68; Arrow, 1904, pp. 35-36; Reitter, 1906, p. 423.

Eulachus hispidus Blackburn, 1885, p. 141.

Lycopholis foveicollis Reitter, 1878, p. 199.

Prothorax at the middle of the dorsum with an oblong-oval, deeply impressed foveola. Subcylindrical, ferruginous, feebly shiny, somewhat densely clothed with erect, white, subsquamoso bristles thickened at the apex. First segment of club of antennæ subquadrately transverse, the terminal half again as long as it, elongate oval. Prothorax somewhat densely punctate, the punctures scarcely separated, not at all deeply impressed; elytra a little wider than prothorax, parallel, lightly seriatly punctured, the punctures very feebly impressed, interspaces just visibly rugose, feebly shining, the alternate ones with erect seriate bristles. Length about 2 mm. [Translated from Reitter's original description of *foveicollis*.]

***Minthea stichothrix* (Reitter).**

Lycopholis stichothrix Reitter, 1878, p. 199.

Thorax with the dorsum scarcely excavated, but with an almost obsolete longitudinal line at the middle, becoming less anteriorly at the apex. Subcylindrical, ferruginous, rather densely clothed with long, white, erect setæ thickened at the apex. First segment of antennal club transverse, the terminal segment three times as long as the former, subcylindrical. Head and thorax confusedly, rugosely punctured, opaque, the sides of the latter evidently denticulate and ciliate; elytra seriatly punctate, interspaces densely, rather strongly, rugosely punctured, the alternate ones with seriate erect setæ. Length 2.7 mm. [Reitter.]

Described from specimen from Bogota, Colombia. The species occurs also in Europe.

Material examined.—One specimen from Mr. Reitter, labeled "Styria;" another in the Horn collection, without name, labeled "N. Y.," and with light-green square.

Representatives of the genus occur throughout the world, *M. rugicollis* Walker being recorded from the West Indies, Ceylon, Malay Archipelago, Hawaiian Islands, and Europe. The single specimen in the Horn collection, mentioned above, is, so far as the author is aware, the only record of the genus in the United States.

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APPENDIX.

NOTES ON HABITS AND DISTRIBUTION, WITH LIST OF DESCRIBED SPECIES.^a

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HABITS.

So far as known, the species of the family Lyctidæ live in dead and dry wood of natural growth, in the seasoned sapwood of commercial products, and in the pith of vines and the dried roots of herbaceous plants, but do not infest the wood of coniferous trees.

Some of the species appear to prefer the dead and dry wood of standing trees, shrubs, and vines under natural conditions, and therefore are rarely found in the commercial articles; for this reason they are not subject to temporary or permanent removal from the natural range of the species. The other species, which infest commercial products, are subject to wide distribution over the world.

The following notes relate to species represented in the collections of the United States National Museum and United States Department of Agriculture, the habits of which have been observed by the writer or recorded in connection with the specimens.^b

THE GENUS LYCTUS

DIVISION I.

SUBDIVISION A.

SECTION a1.

L. impressus Comolli.—This species has been found in an umbrella handle, in which it was evidently introduced into Mississippi.

SECTION a2.

Subsection b1.

L. punctatus (Le Conte).—Habits not recorded.

^a This portion of the paper was prepared some months after Mr. Kraus submitted his manuscript and includes data on additional specimens.

^b The primary and secondary divisions, sections, and genus are included under "habits" and "distribution" in order to aid in the comparison of facts concerning allied groups and species.

Subsection b2.

Series c1.

L. californicus Casey.—Recorded as breeding in adobe wall.

L. præustus Erichson.—Habits not recorded.

Series c2.

L. parallelopipedus (Melsheimer).—Extensive observations have been made on the habits of this species. It infests the seasoned sapwood of commercial products made from persimmon, hickory, ash, oak, and bamboo; it also lives in the dead wood or natural growth of osage orange, sassafras, and fig.

L. curtulus Casey.—Common in dead wood or natural growth of mesquite, *Parkinsonia*, mimosa, hackberry, cotton stems, and fig.

SUBDIVISION B.

L. politus Kraus.—Found in dried licorice roots.

L. brunneus (Stephens).—In seasoned wood and dried herbaceous roots.

L. pubescens Panzer.—Habits not recorded in connection with specimen.

SUBDIVISION C.

SECTION a3.

Subsection b1.

L. opaculus Le Conte.—In pith of dead grapevines.

Subsection b2.

L. suturalis Faldermann.—Habits not recorded.

L. cavicollis Le Conte.—In commercial products, seasoned orange wood and hickory, tanbark oak, and cordwood of live oak.

SECTION a4.

L. cinerius Blanchard.—Habits not recorded.

L. planicollis Le Conte.—Extensive observations have been made on the habits of this species. It is common in commercial products of seasoned ash, oak, hickory, persimmon, and sycamore. Rearing records show that it may breed continually in the same wood during a period of at least six years, or until all the wood tissue has been converted into powder.

L. carbonarius Waltl.—In seasoned oak and bamboo, in natural growth and in commercial products.

L. parvulus Casey.—In dead and dry wood of locust (*Robinia neomexicana*), according to Schwarz.

DIVISION II.

SUBDIVISION D.

L. linearis (Goeze).—Extensive observations have been made on the habits of this species. It is common in commercial products of seasoned hickory, oak, walnut, and ash, and occasionally in poplar, wild cherry, and locust. It is not recorded from natural growth in this country, but is said to infest such growth, as well as commercial products, in Europe.

THE GENUS LYCTOXYLON.

L. japonum Reitter.—Found in walking stick from Japan and in commercial articles made from bamboo in China.

THE GENUS MINTHEA.

M. rugicollis (Walker).—Habits not recorded in specimens in the national collection.

M. stichothrix (Reitter).—Habits not recorded.

DISTRIBUTION.

The distribution of the species of the family Lyctidæ presents some interesting features, especially in regard to the natural habitat and the temporary and permanent introductions.

The habits of some of the species which infest commercial products make it possible for them to be widely distributed outside of their natural range, but it does not necessarily follow that a species introduced to another country in commercial products will become established in its new environment. Therefore we find many records in literature of localities in which specimens of a species have been collected, some of which evidently represent accidental or temporary introductions. Some other records may be held in doubt as to permanent introduction until they are verified by observations which would indicate that the localities are either within the natural range of the species or that the species has become established.

It would appear that the most reliable guide to the natural distribution of the species is their habit of living in natural growth and under natural conditions of exposure to climatic influences at all seasons of the year.

In a study of the records represented by specimens in the national collection and of the evidently authentic records in literature, it would appear that the distribution of the species of the family Lyctidæ in the western continent is between about the forty-eighth parallel north and the thirtieth parallel south, and in the eastern continent

and Australia, from about the fifty-fifth parallel north to the fortieth parallel south. The genus *Lyctus* has practically the same range as the family; the genus *Lyctoxyton* seems to have its natural distribution in eastern India and Asia between the twentieth and fortieth parallels north; while in the genus *Minthea* one species is from Rodriguez Island and the Philippines, with a record from southern Europe, and the other species is from Bogota, Colombia, South America.

It appears that the center of distribution of the greatest number of species of the family is between the twentieth and fortieth parallels north in both continents.

The available evidence would indicate that the natural distributions of the species studied by the writer are approximately as follows:

THE GENUS LYCTUS

DIVISION I.

SUBDIVISION A.

SECTION a1.

L. impressus Comolli.—Northern Africa, southern Italy, Greece, Spain, and the Caucasus. Probably temporarily introduced into central Europe and southern North America.

SECTION a2.

Subsection b1.

L. punctatus (Le Conte).—Lower California.

Subsection b2.

Series c1.

L. californicus Casey.—Lower California.

L. præustus Erichson.—Peru and Brazil.

Series c2.

L. parallelopipedus (Melsheimer).—Florida, Texas, Louisiana, Georgia, South Carolina, Virginia, West Virginia, District of Columbia, Long Island, N. Y., Ohio, and Missouri. The natural distribution of the species is evidently in the South Atlantic and Gulf States, and in part of the Mississippi and Ohio valleys, from which it has been temporarily introduced into other States.

L. curtulus Casey.—California, Arizona, Texas, and Guatemala. This evidently represents its natural distribution. One record from Montana indicates temporary introduction, and a record from the Sandwich Islands may represent a permanent introduction.

SUBDIVISION B.

L. politus Kraus.—Temporarily introduced into the District of Columbia, probably from northern Spain or Italy, from which the commercial product of licorice is exported.

L. brunneus (Stephens).—Paraguay, Brazil, Cuba, and Mexico. This evidently indicates the natural range of the species, from which it has probably been introduced and become established in Europe, Asia, Africa, and Australia. It has been recorded from South Carolina, from Philadelphia, Pa., and from Chicago, Ill., which probably represent temporary introductions, although it is not at all improbable that it may become permanently established in the Gulf States, especially in Florida and Texas.

L. pubescens Panzer.—Recorded as common in southern and middle Europe, which may be its natural distribution.

SUBDIVISION C.

SECTION a3.

Subsection b1.

L. opaculus Le Conte.—Michigan, Iowa, Nebraska, Ohio, Long Island and Staten Island, N. Y., District of Columbia, and North Carolina. This probably represents the natural distribution, and since the species lives in natural growth it is not likely to be distributed out of its natural range.

Subsection b2.

L. suturalis Faldermann.—Caucasus, southern Russia.

L. cavicollis Le Conte.—California, several localities, with doubtful record from Oregon.

SECTION a4.

L. cinereus Blanchard.—Chile.

L. planicollis Le Conte.—Arizona, Nevada, Texas, and the Gulf and South Atlantic States. This range probably represents the natural distribution of the species, but it is frequently introduced temporarily into the Northern and Middle States and evidently into other countries, since there is a definite record from Capetown, South Africa, in lumber from the southern United States. This species is evidently derived from one or more subtropical forms, of which *L. carbonarius* is a representative.

L. carbonarius Waltl.—Mexico and Florida. This species is evidently distinct from *L. planicollis*, as indicated by a large series not observed by Mr. Kraus, which had been reared by Mr. H. G. Hubbard from winter-killed bamboo in Florida. The specimens from Florida and Mexico are readily distinguished from average specimens of *planicollis* by their more reddish color but otherwise agree

with characters mentioned by Mr. Kraus. It is probable that there is some overlapping of the ranges of these two allied species in Florida and from Texas to California, and that in such localities occasional specimens will be found which occupy an intermediate position.

L. parvulus Casey.—Arizona, California, and Utah. This evidently indicates the natural distribution of the species.

DIVISION II.

SUBDIVISION D.

L. linearis (Goeze).—This species is recorded in literature as extending over Europe, and especially England, France, and Germany, where it lives in natural growth, cordwood, etc. This evidently represents its natural habitat, from which it has been introduced in commercial wood products to many other countries of the world, but it would appear from observations and records in the United States that it becomes permanently established only in those countries with climates similar to that of central and northern Europe. The species appears to be permanently established in the States north of North Carolina, Tennessee, and Arkansas. There are a great many records from this area, including Maine, Massachusetts, New York, Pennsylvania, Virginia, West Virginia, Ohio, Indiana, Michigan, Illinois, Missouri, Iowa, and Minnesota. The specimens in the national collection show but a single record from the South Atlantic and Gulf States, and that is evidently a temporary introduction. Undoubtedly the species is frequently carried into the southern region, but evidently does not survive there.

THE GENUS LYCTOXYLON.

L. japonum Reitter.—Japan, China, and India. This probably represents the natural range of the species, from which it has been introduced into Europe, America, and other countries, possibly becoming established in those with climatic conditions similar to that of its original habitat. The recorded introductions into the United States are from China into California and Massachusetts, and probably from Japan into New Jersey.

THE GENUS MINTHEA.

M. rugicollis (Walker).—Philippine Islands, Siam, China, Ceylon, and the Malay Archipelago. This probably represents the natural habitat, from which it may have been introduced into Europe, the West Indies, and the Hawaiian Islands.

M. stichothrix (Reitter).—Bogota, Colombia, South America.

THE LYCTIDÆ REPRESENTED IN THE COLLECTIONS EXAMINED
BY KRAUS AND HOPKINS.

(Classification according to Kraus.)

Genus **LYCTUS** Fabricius.

Division I.

Subdivision A (*Trogoxylon*).

Section a1.

impressus Comolli.

Section a2.

Subsection b1.

punctatus Le Conte.

Subsection b2.

Series c1.

californicus Casey.

præustus Erichson.

Series c2.

parallelopedus Melsheimer.

curtulus Casey.

Subdivision B (*Xylotrogus*).

politus Kraus.

brunneus Stephens.

pubescens Panzer.

Subdivision C (*Lyctus*).

Section a3.

Subsection b1.

opaculus Le Conte.

Subsection b2.

suturalis Faldermann.

cavicornis Le Conte.

Section a4.

cinereus Blanchard.

planicollis Le Conte.

carbonarius Waltl.

parvulus Casey.

Division II.

Subdivision D.

linearis Goeze.

Genus **LYCTOXYLON** Reitter.

japonum Reitter.

Genus **MINTHEA** Pascoe.

rugicollis Walker.

stichothrix Reitter.

LIST OF DESCRIBED SPECIES, WITH SYNONYMY ACCORDING TO THE LITERATURE AND RECENT STUDIES BY THE AUTHORS.

Genus **LYCTUS** Fabricius.

- æqualis** Wollaston. S. Jago.
africanus Lesne. Africa.
brunneus (Xylotrogus) Stephens. England; Australia; Japan; Paraguay; Brazil; Cuba; Mexico; Philadelphia, Pa.
carolinæ Casey. South Carolina.
colydioides Dejean. France.
glycyrrhizæ Chevrolat.
parasiticus Stephens.
rugulosus Montrouzier. Woodlark Islands (near Australia).
californicus Casey. Lower California.
carbonarius Waltl. Mexico; Florida.
caucasicus Tournier. Caucasus (Russia).
cavicollis Le Conte. California; Missouri; Oregon.
cinereus Blanchard. Chile.
cornifrons Lesne. Obock, Africa (Red Sea).
costatus Blackburn. Australia.
curtulus Casey. Arizona; California; Montana; Texas; Guatemala; Sandwich Islands.
depressicatus White. New Zealand.
discedens Blackburn. Australia.
disputans Walker. Ceylon.
fœricollis Reitter. Santo Domingo, West Indies.
griseus Gorham. Guatemala.
hispidus Kiesenwetter.
serie-hispidus Kiesenwetter. Japan.
impressus Comolli. Cordova, Mex.; Corinth, Greece; Gallia; Meridian, Miss.
 var. *capitalis* Schauf. Algeria, Africa; Mallorca (Mediterranean).
castaneus Perroud. Middle Europe.
*glabiatu*s Villa. Lombardia, Italy.
lærei Galeazzi. Lombardia, Italy.
læripennis Faldermann. Caucasus; Greece.
leococianus Wollaston. Madeira.
linearis Goeze. Canada; District of Columbia; Illinois; Iowa; Indiana; Massachusetts; Maine; Michigan; Minnesota; Missouri; New York; Ohio; Pennsylvania; Texas; West Virginia; Virginia; Middle Europe.
 var. *axellarius* Melsheimer. Pennsylvania.
canaliculatus Fabricius. Lampa, South America (Chile).
duftschmidti Des Grozes.
fuscus Seidlitz.
 var. *fuscus* Melsheimer. Pennsylvania.
linearis Thunberg.
 var. *nitidus* Dahl. Hungaria, Austria.
oblongus (*Dermestes*) Olivier.
pubescens Duftschmid.
striatus Melsheimer. Pennsylvania.
unipunctatus (*Dermestoides*) Herbst. Austria?
longicornis Reitter. Bogota, South America.
nitidicollis Reitter. Bogota, Colombia; Chile.

- obsetus** Wollaston. S. Jago.
- opaculus** Le Conte. District of Columbia; Iowa; Long Island; Michigan; North Carolina; Nebraska; Ohio; Pennsylvania; Texas; West Virginia.
- parallelocollis** Blackburn. Australia
- parallelopipedus** (Xylotrogus) Melsheimer. District of Columbia; Florida; Georgia; Louisiana; Missouri; Ohio; South Carolina; Texas; West Virginia; Virginia; New York.
- parvulus** Casey. Arizona; California; Utah.
- planicollis** Le Conte. Arizona; California; Colorado; District of Columbia; Florida; Georgia; Illinois; Iowa; Mexico; Michigan; Minnesota; Missouri; Nevada; Ohio; Oregon; South Carolina; Tennessee; Texas; Cape Town, Africa.
- politus** Kraus. (Reared at Washington, D. C.)
- præustus** Erichson. Brazil; Peru.
- prostomoides** Gorham. Guatemala; Panama.
- pubescens** Panzer.
bicolor Comolli. Middle Europe.
caucasicus Tournier.
subarmatus Megerle. Austria.
- punctatus** (Trogoxylon) Le Conte. Cape San Lucas and Santa Rosa, Lower California.
- punctipennis** Fauvel. Caen; New Caledonia; Sumatra.
- recticollis** (Trogoxylon) Reitter. La Plata.
- retractus** Walker. Ceylon.
- simplex** Reitter. Colombia.
- suturalis** Faldermann. Caucasus.
deyrollei Tournier. Mingrelia (Russia).
- tomentosus** Reitter. Mexico.

Genus LYCTOXYLON Reitter.

- japonum** Reitter. Hindostan; Europe; China; California; Massachusetts; New Jersey; New York.
- jalnophæ** Wollaston. San Antao.

Genus MINTHEA Pascoe.

- rugicollis** Walker. Philippine Islands.
Lyctopholis færicollis Reitter. Santo Domingo.
Eulachus hispitus Le Conte.
Ditoma rugicollis Walker. Rodrigues Is.; Missouri; Madagascar.
Minthea simulata Pascoe. Styria Marhunaland, near Austria.
- stichothrix** Reitter.
Lyctopholis stichothrix Reitter. Bogota (Colombia); Africa; South Germany; Austria.

TECHNICAL SERIES, No. 20, PART IV.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

TECHNICAL PAPERS ON MISCELLANEOUS
FOREST INSECTS.

IV. STUDIES IN THE SAWFLY GENUS
HOPLOCAMPA.

BY

S. A. ROHWER,
Agent and Expert.

ISSUED MAY 27, 1911.



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TEXT FIGURE.

FIG. 10. Map of the world, showing the distribution of the genus *Hoplocampa*. . . 140

TECHNICAL PAPERS ON MISCELLANEOUS FOREST INSECTS.

IV. STUDIES IN THE SAWFLY GENUS *HOPLOCAMPA*.

By S. A. ROHWER,
Agent and expert.

INTRODUCTORY NOTE.

[By A. D. HOPKINS.]

This second contribution by Mr. Rohwer to technical information on the sawflies, while not treating of species of known economic importance in their relation to forest growth, conforms to our plan of giving in one series of publications the results of the necessary general studies, by a specialist, of the entire group represented by species and genera which are of special economic importance. This not only gives the economic entomologist a comprehensive view of the whole group, but makes available information on species which may prove to be injurious to indigenous or cultivated plants.

INTRÓDUCTION.

In the Canadian Entomologist^a the author has a paper treating the sawfly genus *Hoplocampa* Hartig through the subgenus *Macgillivrayella* Ashmead. The present paper treats the Nearctic species of the subgenus *Hoplocampa*, including also a description of a new species belonging to the subgenus *Macgillivrayella*.

The accompanying map (fig. 10) gives, in general, the distribution of the genus. *Macgillivrayella* apparently does not occur in the Palearctic region. In America the species of the genus will probably be found to occur from the Lower Austral Zone to the lower border of the Boreal Zone.

The species of this genus are small, closely related, and without striking specific characters. The characters used in the following table were found to be reliable, but the saw of the female should be examined when possible. Lacking a large number of males, the male genitalia were not studied, but, judging from the genitalia in other genera of sawflies, they may be expected to possess good specific

^a Can. Ent., vol. 42, pp. 242-244, July, 1910.

characters. The color, in details, is not constant, although a normally black or brownish species was never found to be uniformly pale, or vice versa. The venation, as in many genera, is constant to the typical form. The length of the upper and lower discal cells of the hind wing apparently varies within a species (as in *Hoplocampa marlatti*).

The descriptions were drawn up under a Carl Zeiss binocular with a magnification of 35 diameters, although a Zeiss hand lens, magnifying 27 and 16 diameters, was used for the color description and checking up.

The generic description given in the Canadian Entomologist^a should be corrected and elaborated as follows:

Proepimerum (Epm_1) present.

Mesoprepectus ($Ppct_2$) present.

Pleural suture of metathorax (PS_3) straight from the coxal process (CxP_3) to the wing process (WP_3), not curved as in Nematinae.

Metascutellum (Scl_3) rather large.

Metapostnotum (PN_3) as in Nematinae.

***Hoplocampa* (*Macgillivrayella*) *pallida* n. sp.**

Runs in the table in the Canadian Entomologist^b to *lacteipennis* Rohwer, but may be separated from that species by the large depressions between the ocelli and orbits, higher, narrower occiput, paler color, etc.

Female.—Length 5.5 mm. Head distinctly higher than broad, broadest just above the antennae; labrum rather broadly rounded; clypeus with a deep, obtusely V-shaped emargination, lobes obtusely triangular; supraclypeal area more convex near the clypeus; eyes diverging toward the clypeus; lateral foveae close to the antennae, small, punctiform; antennal furrows not continuous; crest rather well developed; frontal area raised; ocellar basin and middle fovea wanting; postocellar area not defined; vertex depressed on each side of ocelli, so that the occiput is much narrowed; antennae slender, third and fourth joints subequal; shining, practically impunctate, cerci tapering; sheath straight above, gently rounded below; stigma broad, slightly broader basad of middle; transverse radius received in middle of cell, nearly at right angles with the radius; upper discal cell of hind wings slightly exceeding lower on the outer margin. Pallid; legs, antennae, front, and dorsulum pale yellowish; wings strongly milky-hyaline; venation pallid-hyaline, except stigma, which is yellowish.

Type locality.—Michigan. One female from C. F. Baker collection.

Type.—Cat. No. 13469, U. S. National Museum.

***Hoplocampa* (*Hoplocampa*) *orbitalis* n. sp.**

(Plate XXIII, fig. 3; Plate XXIV, fig. 10.)

Female.—Length 4 mm. Labrum broadly rounded apically; clypeus rather deeply emarginate, lobes obtusely triangular; supraclypeal area convex, polished; antennal furrows and postocellar area as in *koebeleri*; middle fovea elongate; ocellar

^a Can. Ent., vol. 42, p. 242, July, 1910. ^b Can. Ent., vol. 42, p. 243, July, 1910.

basin V-shaped, open below; crest poorly defined; head with small, scattered punctures; antennæ rather robust, third and fourth joints equal; stigma broadest at base, tapering to apex; transverse radius normal; sheath and saw as in Plate XXIV, figure 10, and Plate XXIII, figure 3. Black; antennæ brownish; head (except between antennal furrows above antennæ), tegulæ, spot on lower angle of pronotum, apex of venter, sheath, and legs below coxæ reddish-yellow; posterior tibiæ pallid, posterior tarsi dusky; wings hyaline, iridescent; venation pale brown, stigma and costa yellowish.

Type locality.—Montana.

Type.—Cat. No. 13472, U. S. National Museum.

Hoplocampa (Hoplocampa) koebeleri n. sp.

(Plate XXIII, fig. 6; Plate XXIV, fig. 3.)

Female.—Length 3.5 mm. Labrum broad, obtusely triangular; clypeus broadly, triangularly emarginate, lobes broad, sharply triangular; supraclypeal area convex, polished; antennal foveæ not sharply defined; antennal furrows nearly continuous; middle fovea transversely oval; crest poorly defined; ocellar basin reduced to a pit below the ocellus; postocellar area well defined, the furrows punctiform laterally; antennæ wanting; head with small, distinct, separate punctures; stigma gently rounded below, broadest a little basad of middle; transverse radius normal; upper discal cell of hind wings slightly longer than lower; sheath and saw as in Plate XXIV, figure 3, and Plate XXIII, figure 6. Black; head (except inside antennal furrows to postocellar furrow), pronotum, tegulæ, venter, apex of tergum, and legs below trochanters reddish-yellow; posterior tarsi dusky; wings hyaline, iridescent, venation pale brown, stigma pallid.

Type locality.—Oregon. One female collected by Mr. Albert Koëbele.

Type.—Cat. No. 13473, U. S. National Museum.

Hoplocampa (Hoplocampa) alpestris n. sp.

(Plate XXIII, fig. 5; Plate XXIV, fig. 5; Plate XXV, fig. 1.)

Female.—Length 4.5 mm. Labrum obtusely angulate; clypeus with a shallow, narrow, arcuate emargination, lobes broad, obtuse; supraclypeal area convex, polished; antennal foveæ poorly defined; antennal furrows nearly wanting; middle fovea broad, shallow, better defined below; ocellar basin reduced to a circular depression in front of the anterior ocellus; postocellar very poorly defined; head polished, nearly impunctate, punctures very small and scattered; antennæ slender, the third and fourth joints subequal; mesothorax shining, polished; stigma broadest at base, tapering to apex; transverse radius normal; sheath and saw as in Plate XXIV, figure 5, and Plate XXIII, figure 5. Black; orbits (except at upper middle), clypeus, labrum, mandibles, supraclypeal area, tegulæ, a small spot on pronotum, ventral part of tergal segments 6-9, and legs below coxæ reddish-yellow; wings hyaline; venation rather dark brown, stigma and costa yellowish.

Male.—Length 3.5 mm. Structurally not differing in any important characters from the female; hypopygidium broadly rounded to an obtusely angulate middle. Reddish-yellow; antennæ brownish; spot around the ocelli, anterior part of mesoprescutum, metanotum, and most of tergum black; wings as in female.

Type locality.—Veta Pass, Colo. Two females and one male collected June 6, by Mr. E. A. Schwarz.

Type.—Cat. No. 13474, U. S. National Museum.

***Hoplocampa (Hoplocampa) californica* n. sp.**

Allied to *bioculata* Rohwer, but may be separated by the table (p. 147).

Female.—Length 3.5 mm. Clypeus broadly, shallowly, angulately emarginate, lobes broad, obtusely triangular; supraclypeal area convex, finely granular; antennal furrows wanting, antennal foveæ small; middle fovea elongate, shallow, not well defined; ocellar depression small, distinct, not sharply defined; postocellar area well defined on all sides; head and mesoscutum with small, separate, well-defined punctures; antennæ rather slender, third and fourth joints equal; sheath slightly concave above, slender, convex below from apex; cerci short, stout; stigma broadest near base, strongly tapering to apex; transverse radius strongly oblique, in apical third of cell; third cubital cell longer than the first and second combined. Black; clypeus, labrum, mandibles (except piceous apices), orbits, occiput (except postocellar area), tegulæ, anterior legs (except coxæ), intermediate femora, and part of posterior femora reddish-yellow; posterior femora in part, most of four hind tibiæ, and tarsi black or brownish; wings hyaline, iridescent; venation pale brown, stigma in part pallid.

Paratopotypes show that the four hind legs may be mostly black, the posterior orbits pale and the pale spots on the occiput reduced in size.

Male.—Length 3 mm. Clypeus more obtusely emarginate than in female; third joint shorter than fourth; stigma not strongly tapering; hypopygidium narrowly rounded at apex. Black; antennæ, head (except interocellar area), margin of mesoprescutum, latr. pectus, legs, and venter reddish-yellow; wings as in female.

Type locality.—Suisun, Cal., March 10, 1910 (R. W. Braucher); eight females and one male.

Type.—Cat. No. 13471, U. S. National Museum.

***Hoplocampa (Hoplocampa) marlatti* n. sp.**

(Plate XXIV, fig. 7.)

Female.—Length 3 mm. Labrum short, broadly rounded; clypeus shallowly emarginate, lobes broad, obtuse; supraclypeal area shining, convex; middle fovea broad, not sharply defined, spreading over the antennæ; antennal furrows interrupted by the rather well-defined crest; ocellar basin represented by a small fovea in front of the anterior ocellus; postocellar area scarcely narrowing apically; postocellar furrow strongly arcuate; front shining, with separate, well defined, small punctures; antennæ slender, third joint distinctly longer than fourth; venation very like *montanicola* (Plate XXVI, fig. 3); upper discal cell much exceeding the lower on the outer margin; sheath as in Plate XXIV, figure 7; saw concealed. Color reddish-yellow; antennæ brownish; spots on mesoscutum, the metanotum, and the tergum (except apex) black; tarsi dusky; wings hyaline, iridescent; venation pale brown, stigma yellowish pallid.

Male.—Length 2.5 mm. Very like the female. Hypopygidium broadly rounded.

Type locality.—Riley County, Kans. Four specimens collected by Mr. C. L. Marlatt in April.

Paratype locality.—Baldwin, Kans. Two females collected by Mr. J. C. Bridwell.

Type.—Cat. No. 13477, U. S. National Museum.

***Hoplocampa (Hoplocampa) nevadensis* n. sp.**

(Plate XXIII, fig. 10; Plate XXIV, fig. 4; Plate XXV, fig. 4.)

Female.—Length 4.5 mm. Labrum short, broadly rounded apically; clypeus shallowly, arcuately emarginate, lobes short, broad, obtusely rounded apically; supraclypeal area shining, not strongly convex; middle foveæ poorly defined; antennal

furrows not well defined; ocellar basin practically wanting; postocellar area well defined, the postocellar furrow curved; head with small, distinct, rather close punctures; antennæ rather slender, third joint distinctly longer than fourth; venation nearly as in *montanicola* (Plate XXVI, fig. 3); sheath and saw as in Plate XXIV, figure 4, and Plate XXIII, figure 10. Color reddish-yellow; antennæ above, interocellar area with two prongs before, posterior face of mesoscutum, metathorax (except scutellum), and tergum (except apex and sides) black; wings hyaline, iridescent; venation yellowish pallid.

Type locality.—Nevada. One female.

Type.—Cat. No. 13475, U. S. National Museum.

Hoplocampa (*Hoplocampa*) *xantha* n. sp.

(Plate XXIII, fig. 9; Plate XXIV, fig. 1.)

Female.—Length 4 mm. Labrum rather narrow, broadly rounded; clypeus somewhat squarely emarginate, lobes broad, subtruncate; supraclypeal area shining, rather strongly convex; middle fovea deep, well defined, rather small; antennal furrows interrupted by the rather distinct crest; ocellar basin very shallow, practically wanting; postocellar area somewhat convex, narrowing slightly posteriorly; postocellar furrow somewhat arcuate; front shining, with small, separate, well-defined punctures; antennæ rather robust, third and fourth joints equal; venation of fore wing about as in *montanicola* (Plate XXVI, fig. 3), but the stigma is broader, the second and third cubital cells subequal in length; upper discal cell much exceeding the lower on the outer margin; sheath and saw as in Plate XXIV, figure 1, and Plate XXIII, figure 9. Color reddish-yellow; antennæ and basal part of tergum brownish; wings hyaline, iridescent; venation yellowish-pallid.

Paratopotypes indicate that the tergum, except apex and sides, is normally black; venation normally as in *halcyon* (Plate XXVI, fig. 2), with a narrower stigma. The interocellar area may be black; the middle fovea smaller than in type.

Type locality.—Ottawa, Canada. Four females from the Ashmead collection.

Type.—Cat. No. 13478, U. S. National Museum.

Hoplocampa (*Hoplocampa*) *occidentalis* n. sp.

(Plate XXIV, fig. 8; Plate XXV, fig. 5.)

Female.—Length 4 mm. Labrum narrowly rounded apically; clypeus angulately marginate, lobes triangular, narrowly obtuse; supraclypeal area convex dorsally, shining; middle fovea spreading over the antennæ, shallow; antennal furrows interrupted by the broad rounded crest; ocellar basin large, well defined, rectangular in outline; postocellar area scarcely narrowed posteriorly, flat; postocellar furrow nearly straight; front with rather close small punctures; antennæ rather robust, the third and fourth joints equal; venation nearly as in *montanicola* (Pl. XXVI, fig. 3); sheath as in Plate XXIV, figure 8; saw not exerted. Color reddish-yellow; antennæ brownish above; interocellar area, large spot on mesoprescutum, small spots on mesoscutum, the metanotum, and the tergum (except sides and apex) black; wings hyaline, iridescent; venation very pale brown, stigma and costa pallid.

Paratypes show that the mesonotum may be entirely pale, or the mesoscutum may have two spots on each lobe. The black of the interocellar area is wanting in some specimens.

Male.—Length 3 mm. Very like the female. Hypopygidium subtruncate, with an angulate middle. The series shows the color to vary as follows: Mesoprescutum without black, or spotted; mesoscutum spotted or not; interocellar area pale or black. In the Oregon specimens the head and mesonotum are usually entirely pale.

Type locality.—Colorado. Two females and three males from the C. F. Baker collection.

Paratype locality.—Oregon. Males and females collected by Mr. A. Koebele. Also a male from Placer County, Cal., June, which seems to be the same species.

Type.—Cat. 13479, U. S. National Museum.

Hoplocampa (Hoplocampa) montanicola n. sp.

(Plate XXIII, fig. 4; Plate XXIV, fig. 6; Plate XXV, figs 3, 6; Plate XXVI, fig. 3.)

Female.—Length 4 mm. Labrum broadly rounded; clypeus rather deeply, sub-angulately emarginate, lobes triangular, obtusely rounded; supraclypeal area shining, somewhat convex; middle fovea small, well defined; antennal furrows interrupted by the rounded frontal crest; ocellar basin shallow, well defined, rectangular in outline; postocellar area narrowing posteriorly, well defined; postocellar furrow arcuate; front with sparse, small punctures; antennæ rather robust, third and fourth joints subequal; venation as in Plate XXVI, figure 3; upper discal cell exceeding the lower on the outer margin; sheath and saw as in Plate XXIV, figure 6, and Plate XXIII, figure 4. Color reddish yellow; antennæ beyond scape, posterior part of mesoscutum, the mesoscutellum, the metanotum, and the tergum except apex black; wings hyaline, iridescent; venation yellowish pallid.

Paratopotypes show that the scape and interocellar area may be black.

Male.—Length 3.5 mm. Sufficiently like the female to be easily associated with it. In the following color characters it differs from the female: Antennæ reddish yellow, interocellar area black, mesonotum black. Hypopygidium rounded apically to an obtuse angle.

Type locality.—Montana. Four females and two males.

Type.—Cat. No. 13476, U. S. National Museum.

Hoplocampa (Hoplocampa) haleyon (Norton).

(Plate XXIII, fig. 8; Plate XXIV, fig. 9; Plate XXV, fig. 2; Plate XXVI, fig. 2.)

Selandria (Hoplocampa) haleyon Norton, Proc. Boston Soc. Nat. Hist., vol. 8, p. 222, 1861, no. 10, ♂ ♀; Norton, Trans. Amer. Ent. Soc., vol. 1, p. 252, 1867, no. 16, ♂ ♀.

In the collection of the American Entomological Society *Hoplocampa (Hoplocampa) haleyon* (Norton) was confused with *Hoplocampa (Macgillivrayella) lactipennis* Rohwer. That which agreed with Norton's original description, and was from the type locality, has been considered the type. Agreeing with this type, specimens have been seen from the following localities: Ithaca, N. Y. (two females); Canada (one female): McLean, N. Y., May 8, 1891 (male and female); Washington, D. C., April 22, 1885 (one male); Clementon, N. J., April 25, 1909, Harbeck (one male which has the mesoscutum dark brown). Norton records this species from Maine, Massachusetts, Maryland, and Saskatchewan.

Konow^a states that this species feeds on *Amlanchier canadensis*. The only statement which seems to indicate such a habit is by Nor-

^aZeitschr. syst. Hym. Dipt., vol. 1, p, 174, 1901; or Syst. Zusam. Chalastogastra, p. 46, 1901.

ton:^a "Taken in April for successive years in Baltimore, by Mr. Uhler, on *Amelanchier canadensis*." Konow's statement needs verification.

Hoplocampa (Hoplocampa) bioculata Rohwer.

Hoplocampa bioculata Rohwer, Can. Ent., vol. 40, p. 179, 1908, ♀.

In the collection of the U. S. National Museum there are many females of this species from Colorado, two females from Pullman, Wash. (C. V. Piper), and one female from Oregon (Koebele). There are also males from Colorado.

Male.—Length 3.5 mm. Structurally like the female. Hypopygidium truncate apically. Antennæ orange color; head with more reddish-yellow than the female, the postocellar area always black; legs below coxæ, venter, and apical tergite segments orange color; mesoprescutum sometimes margined with pale.

Hoplocampa (Hoplocampa) pallipes MacGillivray.

(Plate XXIII, fig. 7; Plate XXIV, fig. 2.)

Hoplocampa pallipes MacGillivray, Can. Ent., vol. 25, p. 239, 1893.

Two females which have been determined as this species are from Pullman, Wash. (C. V. Piper). MacGillivray's specimens came from Skokomish River, Wash.

Selandria canadensis Provancher.

Selandria canadensis Provancher, Add. Fauna Ent. Canada, pt. 2, p. 7, 1895; l. c., p. 351.

This has been placed in *Hoplocampa*, but does not seem to belong in this genus. Provancher says: "La cellule lancéolée fermée au milieu; ailes inférieures avec une cellule discoïdale." *Hoplocampa* always has two discoidal cells. Nothing in the collection agrees with this. On page 351 (l. c.), after defining *Hoplocampa* on page 349 (l. c.) as follows: "Cellule lancéolée contractée au milieu; ailes inférieures à 2 cellules discoïdales," Provancher places *Selandria canadensis* in *Hoplocampa*.

Selandria flavicornis Provancher.

Selandria flavicornis Provancher, Nat. Can., vol. 10, p. 100, 1878.

Provancher^b placed this as a synonym of *Hoplocampa haleyon* Norton. The original description says: "Cellule lancéolée pétiolée." The types of this and the above species may place these species in different genera.

^a Catalogue of the described Tenthredinidæ and Uroceridæ of North America. <Trans. Amer. Ent. Soc., vol. 1, p. 252, 1867 (catalogue, p. 119).

^b Add. Fauna Ent. Can., pt. 2, p. 351, 1888.

Hoplocampa (?) **atriceps** Kirby.

Hoplocampa (?) *atriceps* Kirby, List Hym. Brit. Mus., vol. 1, p. 168, 1882, no. 19, ♀; pl. 8, fig. 18.

Examination of the type of this species proves that it is the same as *Strongylogaster uncus* Norton.

Hoplocampa lenis (Cresson).**Hoplocampa spissipes** (Cresson).

These two species placed in Cresson's catalogue (1887) in *Hoplocampa* belong to *Lycota* Konow.

Hoplocampa gentilis (Cresson).**Hoplocampa montana** (Cresson).

These two species placed in *Hoplocampa* by Cresson (1887) belong to *Zaschizonyx* Ashmead.

Tenthredo (**Allantus**) **obtusa** Klug.

Tenthredo (*Allantus*) *obtusa* Klug, Mag. ges. Nat. Berlin, vol. 3, p. 55, 1814.

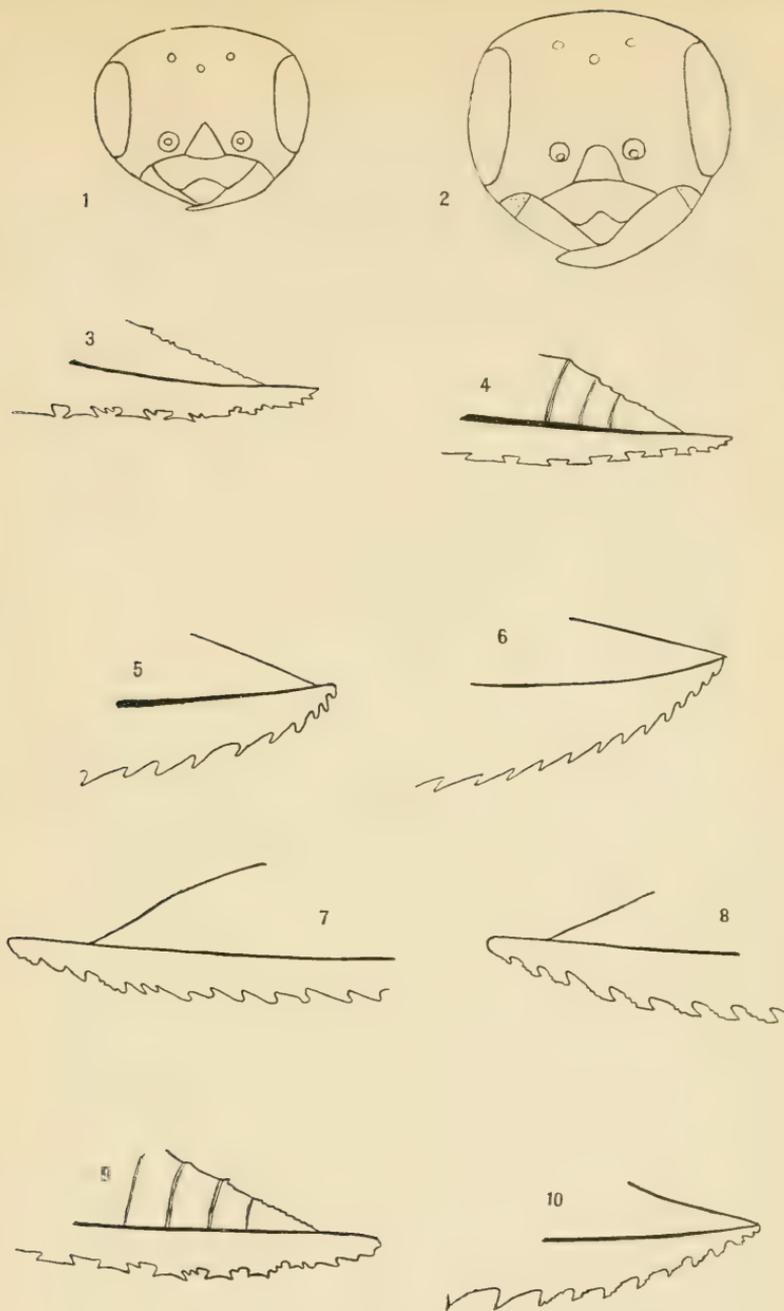
This species has been placed in *Hoplocampa* by Konow (1905). Klug's original description says: "Die zweite Kubitalzelle nimmt zwei zurücklaufende Nerven auf, von welchen der zweite dicht von dem Anfang der dritten Zelle sich einsenkt," which excludes it from *Hoplocampa*.

**SYNOPTIC TABLE TO THE NEARCTIC SPECIES OF THE SUBGENUS
HOPLOCAMPA.**

Males.....	1.
Females.....	7.
1. Hypopygidium not regularly rounded apically, more or less angled at the sides and apical middle.....	2.
Hypopygidium regularly rounded apically ^a	3.
2. Antennæ very slender; mesonotum almost entirely pale; hypopygidium obtusely angled apically.....	<i>occidentalis</i> Rohwer.
Antennæ more robust; mesonotum black; hypopygidium more acutely angled apically.....	<i>montanicola</i> Rohwer.
3. (Clypeus nearly truncate, broadly arcuately emarginate (ocellar basin almost wanting).....	4.
Clypeus deeply emarginate, the emargination subangulate.....	5.
4. Mesopleuræ and pectus black; hypopygidium truncate....	<i>bioculata</i> Rohwer.
Mesopleuræ and pectus pale; hypopygidium rounded....	<i>californica</i> Rohwer.
5. Third antennal joint distinctly longer than the fourth; stigma narrow, broadest basad of middle.....	<i>marlatti</i> Rohwer.
Third antennal joint subequal in length with the fourth.....	6.

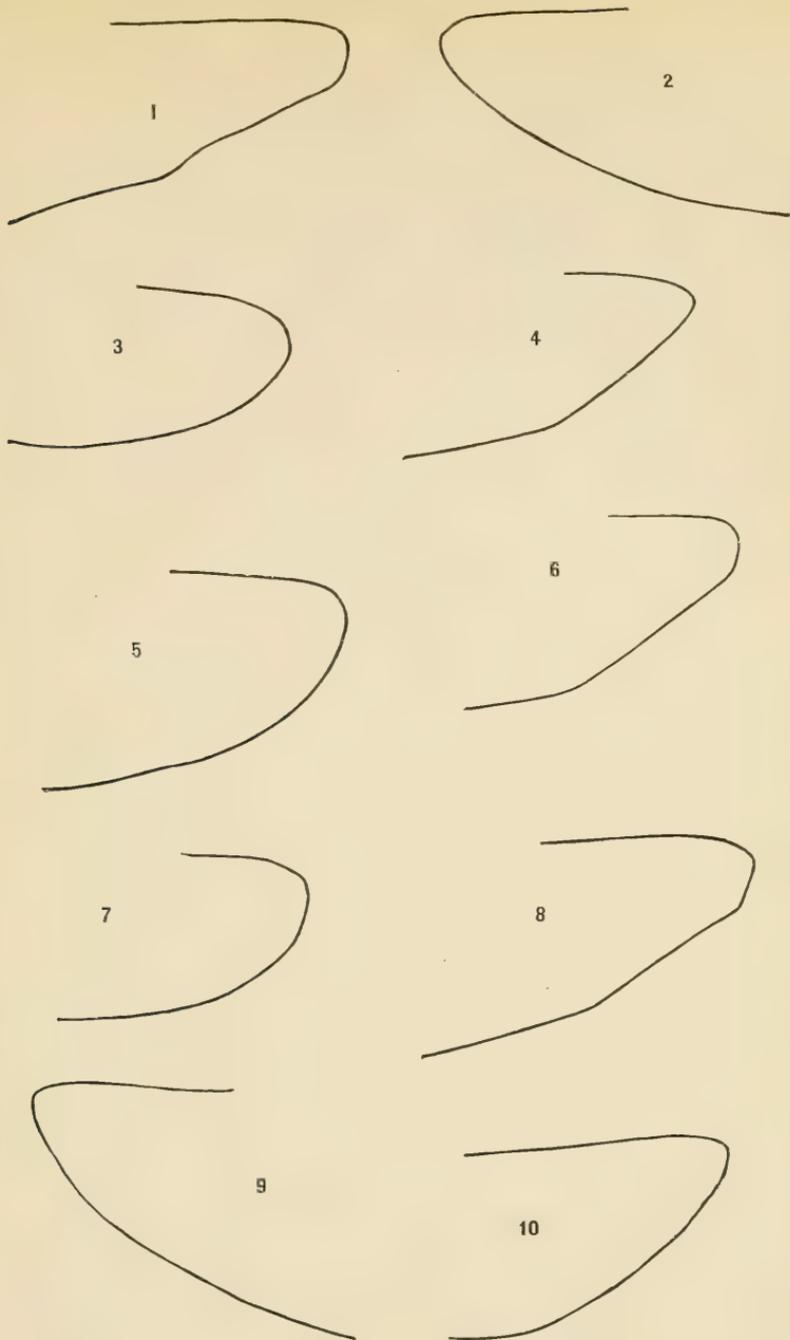
^a To determine this the hypopygidium should be viewed at right angles. When the hypopygidium is not regularly rounded, the sides are subparallel and the apex slopes off obliquely to an angulate middle.

6. Postocellar area well defined, twice as wide as the cephalo-caudal length, flat, stigma narrow; lanceolate cell of the fore-wings narrowly contracted (see figure)..... *alpestris* Rohwer.
 Postocellar area convex, not so sharply defined; stigma broader; contraction of the lanceolate cell distinctly longer than the width of the cell (see figure),
halcyon Norton.
7. Mesopleuræ and pectus black..... 8.
 Mesopleuræ and pectus pale..... 12.
8. Legs entirely fulvo-ferruginous; orbits continuously pale..... 9.
 Legs more or less black or dusky, especially the posterior pair; orbits not continuously pale..... 11.
9. Ocellar basin of the normal type, open below, poorly defined; saw with very long truncate teeth which are narrower at their bases; (clypeus deeply emarginate, lobes narrow)..... *orbitalis* Rohwer.
 Ocellar basin small, punctiform present only just in front of the anterior ocellus; saw with narrow teeth..... 10.
10. Clypeus broadly, angulately emarginate, lobes sharply triangular; head distinctly punctured; stigma gently rounded below..... *koebelci* Rohwer.
 Clypeus arcuately emarginate, lobes broad, obtusely rounded; head shining, very sparsely punctured; stigma strongly tapering..... *alpestris* Rohwer.
11. Supraclypeal area shiny, flattened, or but slightly convex; stigma rounded on the lower margin; clypeus very shallowly emarginate..... *bioculata* Rohwer.
 Supraclypeal area roughened, strongly convex; stigma strongly tapering; clypeus rather deeply, angulately emarginate..... *californica* Rohwer.
12. Third antennal joint distinctly longer than the fourth..... 13.
 Third and fourth antennal joints subequal..... 14.
13. A small circular fovea in front of the anterior ocellus; mesoscutum with black spots laterally..... *marlatti* Rohwer.
 No small fovea in front of the anterior ocellus; mesoscutum immaculate,
nevadensis Rohwer.
14. Ocellar basin practically wanting..... 15.
 Ocellar basin large, distinct..... 16.
15. Middle fovea wanting; sheath narrowly rounded apically... *pallipes* MacGillivray.
 Middle fovea represented by a large shallow depression; sheath narrowly truncate apically..... *xantha* Rohwer.
16. Sheath narrowly rounded apically; stigma broadest at base, tapering to apex,
halcyon Norton.
 Sheath obtusely rounded or subtruncate apically; stigma narrower, gently rounded below..... 17.
17. Scape black; sheath subtruncate apically; front of head closely punctured,
occidentalis Rohwer.
 Scape pale; sheath obtusely rounded apically; front of head with separate, small, distinct punctures..... *montanicola* Rohwer.



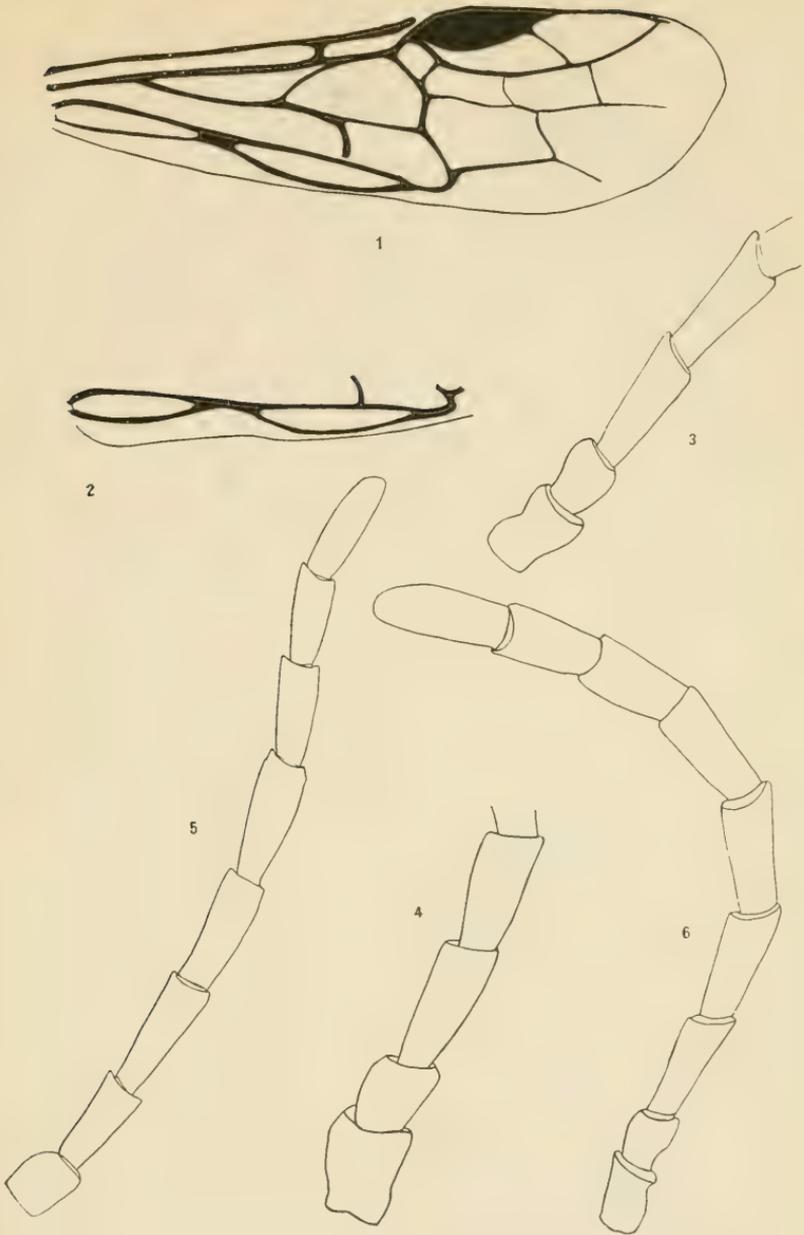
THE SAWFLY GENUS HOPLOCAMPA.

Fig. 1.—*Hoplocampa (Macgillivrayella) oregonensis*: Front view of head. Fig. 2.—*Hoplocampa (Hoplocampa) flava*: Front view of head. Fig. 3.—*Hoplocampa (Hoplocampa) orbitalis*: Saw. Fig. 4.—*Hoplocampa (Hoplocampa) montanicola*: Saw. Fig. 5.—*Hoplocampa (Hoplocampa) alpestris*: Saw. Fig. 6.—*Hoplocampa (Hoplocampa) kobchei*: Saw. Fig. 7.—*Hoplocampa (Hoplocampa) pallipes*: Saw. Fig. 8.—*Hoplocampa (Hoplocampa) halecyon*: Saw. Fig. 9.—*Hoplocampa (Hoplocampa) xantha*: Saw. Fig. 10.—*Hoplocampa (Hoplocampa) nevadensis*: Saw. (Original.)



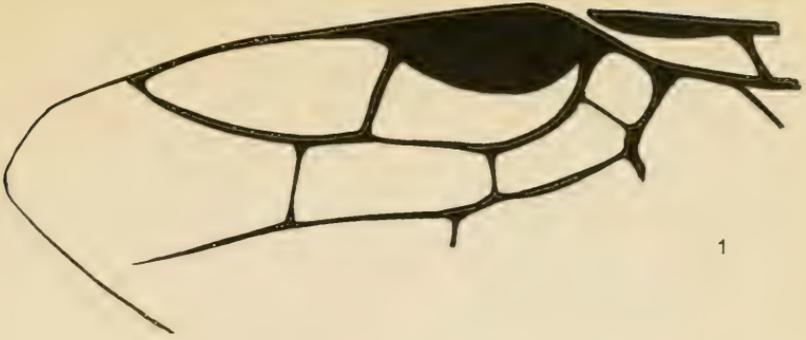
THE SAWFLY GENUS HOPLOCAMPA.

Fig. 1.—*Hoplocampa* (*Hoplocampa*) *xantha*: Sheath. Fig. 2.—*Hoplocampa* (*Hoplocampa*) *pallipes*: Sheath. Fig. 3.—*Hoplocampa* (*Hoplocampa*) *kocbelei*: Sheath. Fig. 4.—*Hoplocampa* (*Hoplocampa*) *nevadensis*: Sheath. Fig. 5.—*Hoplocampa* (*Hoplocampa*) *alpestris*: Sheath. Fig. 6.—*Hoplocampa* (*Hoplocampa*) *montanicola*: Sheath. Fig. 7.—*Hoplocampa* (*Hoplocampa*) *marlatti*: Sheath. Fig. 8.—*Hoplocampa* (*Hoplocampa*) *occidentalis*: Sheath. Fig. 9.—*Hoplocampa* (*Hoplocampa*) *halyon*: Sheath. Fig. 10.—*Hoplocampa* (*Hoplocampa*) *orbitalis*: Sheath. (Original.)

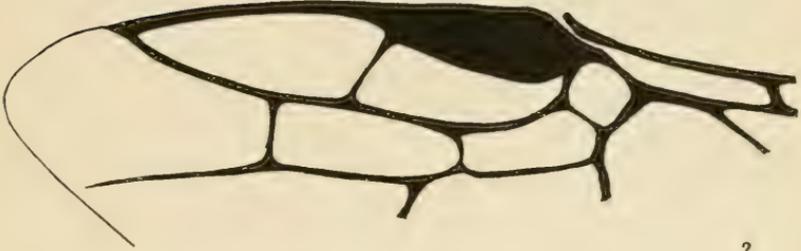


THE SAWFLY GENUS HOPLOCAMPA.

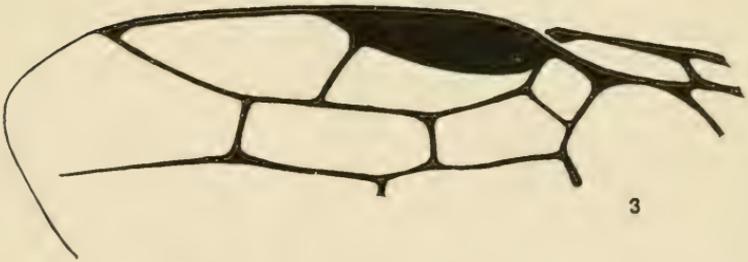
Fig. 1.—*Hoplocampa (Hoplocampa) alpestris*: Male, anterior wing. Fig. 2.—*Hoplocampa (Hoplocampa) halcyon*: Male, anal cell of fore wing. Fig. 3.—*Hoplocampa (Hoplocampa) montanicola*: Female, four basal antennal joints. Fig. 4.—*Hoplocampa (Hoplocampa) nevadensis*: Female, four basal antennal joints. Fig. 5.—*Hoplocampa (Hoplocampa) occidentalis*: Male antenna. Fig. 6.—*Hoplocampa (Hoplocampa) montanicola*: Male antenna. (Original.)



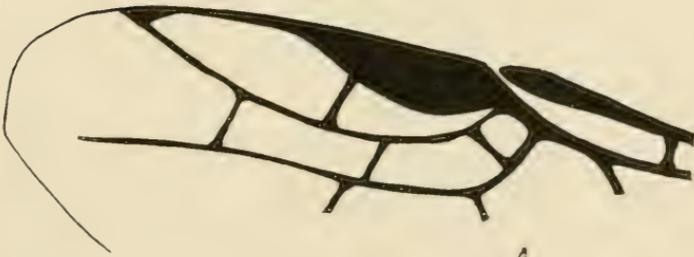
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THE SAWFLY GENUS HOPLOCAMPA.

Fig. 1.—*Hoplocampa* (*Hoplocampa*) *glava*: Female, radial area in fore wing. Fig. 2.—*Hoplocampa* (*Hoplocampa*) *halcyon*: Female, radial area in fore wing. Fig. 3.—*Hoplocampa* (*Hoplocampa*) *montanicola*: Female, radial area in fore wing. Fig. 4.—*Hoplocampa* (*Megyllivora*) *gellaytaeipennis*: Female, radial area in fore wing. (Original.)

TECHNICAL SERIES, No. 20, PART V.

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L. O. HOWARD, Entomologist and Chief of Bureau.

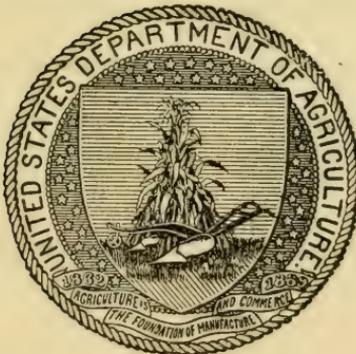
TECHNICAL PAPERS ON MISCELLANEOUS
FOREST INSECTS.

V. A PRELIMINARY SYNOPSIS OF
CERAMBYCID LARVÆ.

BY

J. L. WEBB,
Entomological Assistant.

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¹ Transferred to Southern Field Crop Insect Investigations.

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V. A PRELIMINARY SYNOPSIS OF CERAMBYCOID LARVÆ.

By J. L. WEBB,
Entomological Assistant.

INTRODUCTION.

In this study of cerambycoid larvæ the writer has adopted the primary groups defined by Schiødte,¹ but has given them family rank under a superfamily. Schiødte's primary groups, namely, Prionini, Asemini, Cerambycini, Lepturini, and Lamiini, are easily recognized, and up to the present time no other author has given a better division of the family into primary groups. The writer proposes the raising of these groups to family rank under the superfamily Cerambycoidea, designating the families as Lamiidæ, Cerambycidæ, Lepturidæ, Prionidæ, and Asemidæ. Schiødte gives most excellent plates showing the characteristics of these different groups. He fails, however, to give any tables of genera or to subdivide his primary groups. He does give a morphological conspectus of the genera known to him, but it is not in the form of a table by which the identity of any of the genera treated can be definitely determined. And, so far as the writer has been able to determine, no author has ever attempted such a table for the entire superfamily as here recognized, and for a very good reason, namely, the great difficulty experienced in finding suitable characters upon which to base a table of genera. Perris alone gives a table separating the genera *Spondylis*, *Tetropium*, *Criocephalus*, and *Aseum*, but further than this he does not go, although he divides the entire family into groups, subgroups, etc., without indicating the characters by which his divisions are made. Specific descriptions innumerable are given by different authors, but these are practically worthless when it comes to identifying isolated larvæ.

The need for such a table is all too apparent. The larvæ of the Cerambycoidea are much more commonly met with in an economic way than are the adults. Thus larvæ of a given species may be found

¹ De Metamorphosi Eleutheratorum Observationes: Bidrag til Insekternes Udviklingshistorie ved J. C. Schiødte.

within their host perhaps during the greater part of the year, while the adults are to be found in the host only within a very short period of the year, namely, just before they leave the host. A tree or piece of wood may be found to be badly infested and damaged by Cerambycoid larvæ, and no adults present to give a clue to the identity of the species. In fact, there may be several species present. The question immediately arises, "Which is the destructive species and what is it? What are the known habits of the species? And what relation to the damage done, and to the primary enemy, do the other species bear?" Without knowing the identity of the destructive species one is at sea as to its known habits and the methods which may have been used to combat it. This necessitates the working out of life history and habits in each case. It can thus be seen that much time and labor would be saved if the larvæ could be readily identified.

As indicated above, the making of a table by which the genera of cerambycoid larvæ can be recognized is extremely difficult. The first requisite is, of course, the possession of authentically identified specimens of the different genera. To gather together such a collection is in itself a stupendous task. Cerambycoid larvæ are to be found in abundance, and in many cases in situations which seem to indicate the identity of the species. But right here is where extreme care must be exercised to avoid making serious mistakes. The fact that a certain larva is taken from a piece of wood or bark, and that later a certain adult Cerambycoid is reared from the same host, is by no means proof that the larva and adult are the same species. In fact, adults of two or three species are often reared from the same piece of wood. The most conclusive proof of the identity of a given larva is obtained by rearing it to the adult stage in a vial or other receptacle, where it is kept entirely to itself until the adult stage is reached. In order to do this the larva must be taken from its host only after it has practically completed its growth. If the collector cuts out a half-grown larva there is practically no chance of rearing it to the adult stage. It can not complete its growth and go through its metamorphoses outside of its natural environment. However, the building up of a collection of larvæ identified by this method is such a slow process that for practical purposes the writer has accepted as authentic, identifications made in other ways. Thus, where several larvæ, exactly similar morphologically, have been found together with pupæ and adults, all of which are the same species, he has considered the larvæ to be the same species as the adults.

In all, the writer has studied the larvæ of 46 genera of Cerambycoidea; 15 in the family Lamiidæ, 18 in the family Cerambycidæ, 5 in the family Lepturidæ, 5 in the family Prionidæ, and 3 in the family Asemidæ. Henshaw lists 175 genera of Cerambycidæ for America north of Mexico. Therefore it is readily seen that the present effort

is a bare beginning of the work. The material studied has for the most part been collected by the members of the Branch of Forest Insect Investigations of the Bureau of Entomology, United States Department of Agriculture.

The 46 genera referred to above are as follows: In the family Lamiidæ: *Ptychodes*, *Monohammus*, *Leptostylus*, *Dorcaschema*, *Acanthoderes*, *Liopus*, *Hyperplatys*, *Oncideres*, *Goes*, *Lepturges*, *Plectrura*, *Synaphæta*, *Saperda*, *Graphisurus*, and *Acanthocinus*. In the family Cerambycidæ: *Chion*, *Æme*, *Tylonotus*, *Phymatodes*, *Euderces*, *Opsimus*, *Clytanthus*, *Cyrtophorus*, *Hylotrupes*, *Smodicum*, *Elaphidion*, *Callidium*, *Romaleum*, *Physocnemum*, *Cyllene*, *Neoclytus*, *Xylotrechus*, and *Notorhina*. In the family Lepturidæ: *Desmocerus*, *Bellamira*, *Leptura*, *Rhagium*, and *Ulochætes*. In the family Prionidæ: *Tragosoma*, *Prionus*, *Ergates*, *Orthosoma*, and *Malloodon*. In the family Asemidæ: *Asemum*, *Tetropium*, and *Atimia*.

The following table is based upon these genera and beyond the family characters may not be found applicable to the entire superfamily. (See also Plate XXVII.)

Superfamily CERAMBYCOIDEA.

Head much longer than broad, deeply invaginated into the prothorax....Division I.
Head as broad as long, or broader than long, not deeply invaginated into the prothorax.....Division II.

DIVISION I.

Labrum large; clypeus large, filling frontal margin.....Family Lamiidæ.

DIVISION II.

Labrum small; clypeus small, not filling frontal margin.....Subdivision A.

Labrum large; clypeus large, filling frontal margin.....Subdivision B.

SUBDIVISION A.

Without spines or tubercles on anal and ninth abdominal segments.

Family Cerambycidæ.

SUBDIVISION B.

Head somewhat flattened; sides of head behind epistoma separated, angulate. Legs quite long.....Family Lepturidæ.

Head not flattened; sides of head not separated immediately behind epistoma. Legs moderate.....Section a1.

Section a1.

Sides of head behind epistoma fused for some distance, later separating, angulate.

Head invaginated into prothorax almost to base of maxillæ. Usually larvæ of very large size.....Family Prionidæ.

Sides of head behind epistoma fused almost to apex, farther back each one rounded.

Head not invaginated into prothorax to base of maxillæ. Larvæ of medium size. Family Asemidæ.

Family LAMIIDÆ.

- Abdominal segments bearing fleshy tubercles.....Division I.
 Abdominal segments without fleshy tubercles.....Division II.

DIVISION I.

- Dorsal aspect of ninth abdominal segment smooth.....Subdivision A.
 Dorsal aspect of ninth abdominal segment bearing one or more spines or chitinous tubercles.....Subdivision B.

SUBDIVISION A.

- Sternum of prothorax not separated from sternellum by well-defined, deep suture. Section a1.
 Sternum of prothorax separated from sternellum by well-defined, deep suture. Section a2.

Section a1.

- Pleural folds present on at least seven abdominal segments.....Subsection b1.
 Pleural folds not present on more than three abdominal segments....Subsection b2.

Subsection b1.

- Anal segment bearing a group of small spines on ventral aspect.....*Ptychodes*.
 Anal segment without spines.....*Monohammus*.

Subsection b2.

- Gular suture or sutures present.....Series c1.
 Gular suture or sutures lacking.....Series c2.

Series c1.

- Posterior half of protergum alutaceous.....*Leptostylus*.
 Posterior half of protergum smooth and shining.....*Dorcaschema*.
 Posterior half of protergum rugose and shining.....*Acanthoderes*.

Series c2.

- Epipleural sutures of prothorax deep at posterior end and extending almost entire length of segment. Anterior half of protergum sparsely but evenly clothed with long erect hairs.....*Liopus*.
 Epipleural sutures of prothorax extending only about half the length of segment. Anterior half of protergum with only a few straggling hairs.....*Hyperplatys*.

Section a2.

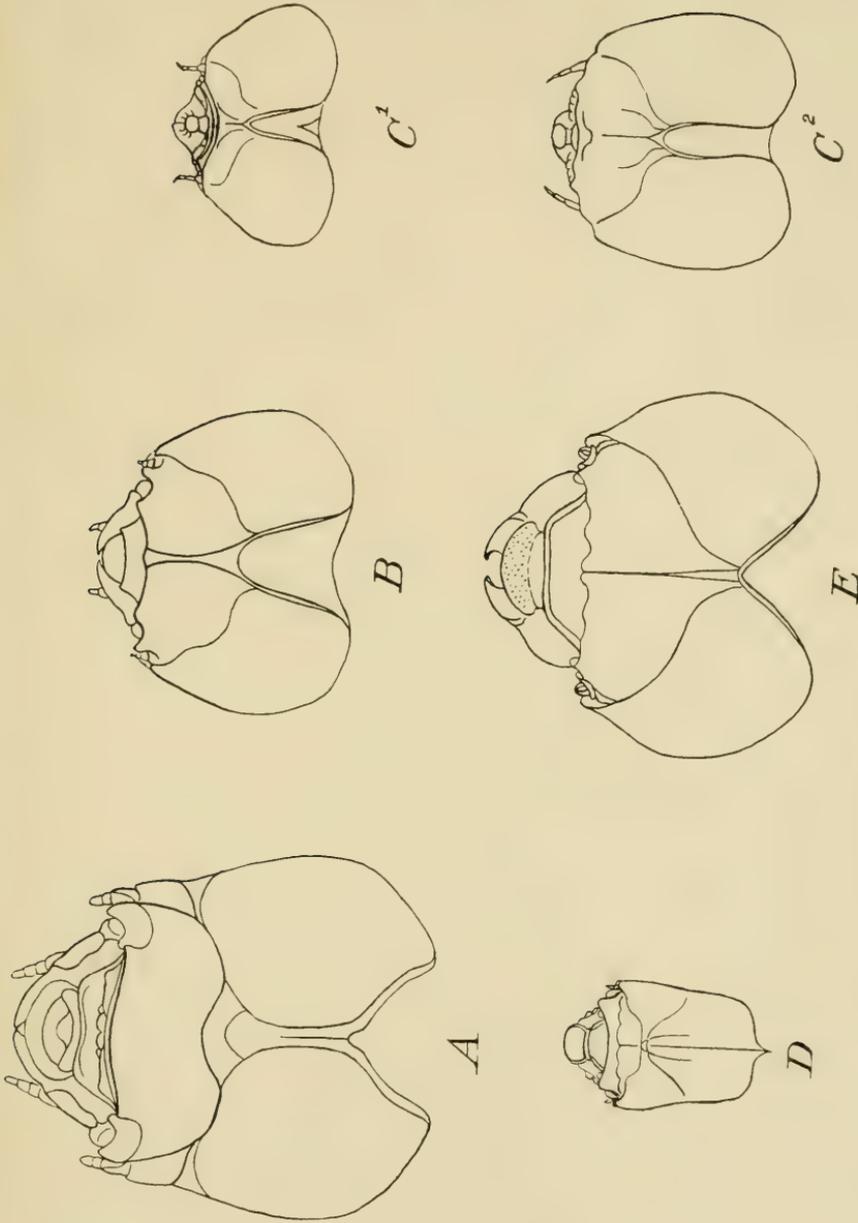
- Epistoma with many parallel longitudinal carinae.....*Oncideres*.
 Epistoma without parallel longitudinal carinae.....*Goes*.

SUBDIVISION B.

- Ninth abdominal segment bearing a single, slender, strongly chitinized spine pointing dorsally.....*Lepturges*.
 Ninth abdominal segment bearing a more or less fleshy spine pointing posteriorly. *Plectrura*.
 Ninth abdominal segment bearing two very small, closely placed, chitinized points sometimes apparently merged into one.....*Synaphæta*

DIVISION II.

- All abdominal segments bearing pleural folds.....*Saperda*.
 Pleural folds borne only on posterior three abdominal segments.....Subdivision C.



CERAMBYCID LARVÆ.

Dorsal aspect of heads of representative larvae of each family of Cerambycoidea: *A*, *Prionus*, Family Prionidae; *B*, *Tetropium*, Family Asemidae; *C*¹, *Cyrtomerus*, Family Cerambycidae; *C*², *Phaniscus*, Family Cerambycidae; *D*, *Liopus*, Family Lamidae; *E*, *Rhagium*, Family Lepturidae. (After Schiødt.)

SUBDIVISION C.

- Ninth abdominal segment with blunt chitinized tubercle on posterior dorsal margin. *Graphisurus.*
 Ninth abdominal segment without chitinized tubercle..... *Acanthocinus.*

Family CERAMBYCIDÆ.

- Epipleural lines on protergum distinct for entire length of prothorax..... Division I.
 Epipleural lines on protergum indistinct, or faintly impressed on anterior part of protergum..... Division II.

DIVISION I.

- Legs present..... Subdivision A.
 Legs lacking..... Subdivision B.

SUBDIVISION A.

- Legs long..... Section a1.
 Legs short..... Section a2.

Section a1.

- Long hairs on anterior part of protergum dense. Median line of protergum showing for entire length of segment..... *Chion.*

Section a2.

- Head bearing long, dense hairs near base of antennæ..... *Æme.*
 Head not bearing long, dense hairs near base of antennæ..... Subsection b1.

Subsection b1.

- Median line on protergum distinct only on anterior portion of segment. . . . *Tylonotus.*
 Median line on protergum distinct on posterior portion of segment. Series c1.

Series c1.

- Head with an ocellus near base of each antenna..... *Phymatodes.*
 Head without ocelli..... *Euderces.*

SUBDIVISION B.

- Median line of protergum indistinct..... *Opsimus.*
 Median line of protergum distinct..... Section a3.

Section a3.

- Median line of protergum deeply impressed on anterior half of segment. . . . *Clytanthus.*
 Median line of protergum not deeply impressed on anterior half of segment.

Cyrtophorus.

DIVISION II.

- Sternum and sternellum of prothorax differentiated..... Subdivision C.
 Sternum and sternellum of prothorax not differentiated..... Subdivision D.

SUBDIVISION C.

- Body robust. Abdominal segments 3, 4, 5, and 6 not constricted near middle. *Hylotrupes bajulus.*
 Body slender. Abdominal segments 3, 4, 5, and 6 constricted near middle. *Smodicum.*

SUBDIVISION D.

Legs long.....	Section a4.
Legs short.....	Section a5.
Legs lacking.....	Section a6.

Section a4.

Body very slender.....	<i>Elaphidion.</i>
Body robust.....	Subsection b2.

Subsection b2.

Anterior part of protergum with scarcely any hairs.....	<i>Callidium antennatum.</i>
Anterior part of protergum sparsely clothed with long hairs.....	Series c2.

Series c2.

Scutum, scutellum, and postscutellum of both mesotergum and metatergum plainly differentiated.....	<i>Romaleum.</i>
Scutum, scutellum, and postscutellum of mesotergum and metatergum not differentiated.....	Subseries d1.

Subseries d1.

Head with an ocellus near base of each antenna.....	<i>Physocnemum.</i>
Head without ocelli.	

Sides of thoracic and abdominal segments bearing long, dense, yellowish hairs.
Callidium areum.

Sides of thoracic and abdominal segments not bearing long, dense, yellowish hairs.
Hylotrupes (ligneus and amethystinus).

Section a5.

Head with 3 ocelli at each side.....	<i>Cyllene (robinia, crinicornis and antennatus).</i>
Head with not more than one ocellus at each side.....	<i>Noclytus.</i>

Section a6.

Xylotrechus, Notorhina, and Cyllene caryæ, impossible of separation by the author.

Family LEPTURIDÆ.

Abdominal segments bearing fleshy tubercles.....	Division I.
Abdominal segments without fleshy tubercles.....	Division II.

DIVISION I.

Mandibles very finely sulcate on middle third. Long hairs on eighth and ninth abdominal segments arising from small tubercles.....	<i>Desmocerus.</i>
Mandibles not finely sulcate on middle third.....	Subdivision A.

SUBDIVISION A.

Tubercles on first seven segments not closely placed, but separated from each other and spherical.....	<i>Bellamira.</i>
Tubercles closely grouped.....	<i>Leptura (with the exception of L. nitens).</i>

DIVISION II.

Head very much flattened. Mandibles tridentate.....	<i>Rhagium.</i>
Head not extremely flattened. Mandibles bidentate.....	Subdivision B.

TECHNICAL SERIES No. 20, PART VI.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

TECHNICAL PAPERS ON MISCELLANEOUS
FOREST INSECTS.

VI. CHALCIDIDS INJURIOUS TO
FOREST-TREE SEEDS.

BY

S. A. ROHWER,
Entomological Assistant.

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II

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TECHNICAL PAPERS ON MISCELLANEOUS FOREST INSECTS.

VI. CHALCIDIDS INJURIOUS TO FOREST-TREE SEEDS.¹

By S. A. ROHWER,
Entomological Assistant.

INTRODUCTION.

For a long time entomologists were loath to give up the theory that all chalcidids were parasitic, and most of the species which attacked the seeds of forest trees were originally described as being parasitic on some other insect which either lived within the seeds of the trees or lived within the cones, but in 1893 Wachtl recorded definitely that *Megastigmus spermotrophus* lives within the seeds of Douglas fir and is phytophagous. Even after this statement entomologists were loath to believe that any chalcidids are not parasitic, and many of the foremost authorities on these insects believed up to the time of their death that some day it would be proven that all chalcidids, with the exception of certain few belonging to the genus *Isosoma* and its allies, are parasitic. Of late years, however, most entomologists have come to believe that the phytophagous habit in many of the chalcidids is not uncommon. We know at present phytophagous species of the family Collimanidæ (*olim* Torymidæ), of the subfamilies Collimaninæ and Megastigminæ, and of the family Eurytomidæ, the phytophagous species being in the tribes Isosomini and Eurytomini. To these also may be added certain genera which have been assigned to the family Perilampidæ.

The species that attack seeds of forest trees are confined to the Collimanidæ, and most of them belong to the subfamily Megastigminæ. Summing up the literature on phytophagous Chalcidoidea belonging to this family, it is possible to outline the life history of every species which may live within the seeds of forest trees. This would be as follows: The egg is laid in the early summer or late spring.

¹ Although certain hymenopterous insects belonging to the superfamily Chalcidoidea have been shown to be very injurious to the seeds of certain forest trees, very little work has been done on these insects in America. The present paper is a résumé of the literature which deals with these insects, with a bibliography of the literature. It is prepared to facilitate the work of field men and to call the attention of entomologists in general to the damage done by these insects.

the larva feeding within the seed until it reaches maturity, passing the winter within the seed as a prepupal larva, transforming into a pupa early in the spring, and emerging as an adult in time to oviposit in the rather young seeds of the trees. The egg-laying habit of some of the chalcidids which attack the seeds of shrubs or vines differs in a measure from that of those attacking the seeds of trees; for instance, the grape-seed chalcidid (*Evoxyssoma vitis* Saund.) oviposits in the seeds that are quite hard, and the only way that the female is able to deposit eggs within the seed of the grape is by finding a soft portion of the shell which is known as the chalaza. This is also the case with the seed chalcidid of Virginia creeper (*Prodecatoma phytophaga* Crosby). The oviposition of species of *Megastigmus* which live within the seeds of coniferous trees has never been observed, but owing to the heavy, leathery texture of the cones it is possible that oviposition occurs when the cones are very small.

Species of chalcidids feeding within the seeds of various plants have proven in some cases to be of much economic importance. A few examples will suffice to show this. Forty pounds of apple seed planted at Budapest failed to give even a good standing of apple seedlings, the seeds having been destroyed by the apple-seed chalcidid (*Syntomaspis druparum*). The seeds of the Douglas fir usually gathered in Aberdeenshire, Scotland, and amounting to over 300 bushels were, according to a letter from Mr. John Crosier published by MacDougall in 1906, not worth gathering, owing to the attack of the Douglas fir seed chalcidid (*Megastigmus spermotrophus*). According to a letter published by Riley in 1893, the seeds of the silver fir (*Abies pectinata*) in the forests of Denmark were so completely destroyed during the years 1886 and 1888 by species of the genus *Megastigmus* that not a single healthy seed could be found. As a great many of the species of *Megastigmus* which are troublesome in Europe come from the seed of the American conifers it is very likely that difficulty will be found in North America on account of the attacks of these insects. No parasite of the species of the genus *Megastigmus* is as yet known.

SYNTOMASPIS DRUPARUM (Boheman).

This species, which normally attacks the apple but is known to attack the seeds of mountain ash (*Sorbus scandica*, and probably *Sorbus latifolia*) and hawthorn (*Crataegus*), is very elaborately treated by Crosby in his paper entitled "Certain seed-infesting chalcid flies," where an account is given of practically the entire life history of this insect. The egg is deposited by the female within the seed of an apple when the apple is about three-fourths of an inch in diameter. The young larva feeds within the seed and develops until it hibernates as a larva within the seed, pupating early in the spring and emerging as an adult in June. As this species is not of any economic importance

so far as forest trees are concerned, no more details concerning it need be given, but any one wishing to obtain information regarding this insect may consult the above-mentioned paper by Crosby.

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MEGASTIGMUS SP.

A species of *Megastigmus* is recorded by Riley through rearings conducted by Borries, from the Japanese *Abies mariesii*. Nothing more is known about this species.

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MEGASTIGMUS BREVICAUDIS Ratzeburg.

This insect is considered by its original describer as probably a parasite of a gall fly inhabiting the fruit of mountain ash (*Sorbus scandica*), but Crosby has proven the species as entirely phytophagous in habit, and has reared it from seeds of *Sorbus aucuparia*. Crosby describes the larva as white, smaller than the larva of *Syntomaspis druparum*, from which it may be distinguished by the mandibles having four teeth on their inner margin and by the absence of brown tubercules on the face. The oviposition habit and the egg of this species are unknown, but it may be presumed that they are similar to those of the foregoing species.

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MEGASTIGMUS STROBILOBIUS Ratzburg.

The original describer of this insect considered it to be parasitic on *Tortrix strobilotina*, but since then it has been shown by Judeich and Nitsche that this species lives, as do other species of *Megastigmus*, within the seeds of plants, this species choosing the amabilis fir (*Abies*

amabilis). They also state that this species is distinct from *Megastigmus spermotrophus*, and that the larva is about 4 millimeters long, whitish in color, and that the mandibles have three inner teeth. Crosby records this species in *Abies pectinata*. Riley records it from Hooker hemlock (*Tsuga mertensiana hookeriana*) and from *Abies excelsa*.

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- Megastigmus pictus* (Foerster) Mayr, 1874, p. 138.
 Cameron, 1879, p. 138.
 Dalla Torre (in part), 1898, p. 287.

MEGASTIGMUS PINUS Parfitt.

This species was considered by its original describer to be a parasite on some species of *Cynips* which infested the seeds of the bristle-cone fir (*Abies venusta*) (according to the original describer this was considered as *Picca bracteata*), of a new species of *Tsuga*, and of the noble fir (*Abies nobilis*). In the original account "etc." is added after the foregoing list, which implies that other coniferous seeds are attacked by this insect. Riley, in referring to material reared by Mr. Borries, of Copenhagen, Denmark, adds that this species has been reared from the seeds of Shasta fir (*Abies magnifica*), from the white fir (*Abies concolor*), from the grand fir (*Abies grandis*), and from the amabilis fir (*Abies amabilis*), but as Riley allows great variation within this species it may be that some of these rearings actually contained some of the other species of *Megastigmus*. Other than the above mentioned list of food plants nothing is published concerning the biology of this species.

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 Dalla Torre, 1898, p. 287.
 Riley, 1893, p. 360.
 Crosby, 1909, p. 368.

MEGASTIGMUS SPERMOTROPHUS Wachtl.

This insect was originally described in 1893 by Wachtl, and at that time Wachtl stated with assurance that this species of *Megastigmus* was phytophagous and lived within the seeds of the Douglas fir (*Pseudotsuga taxifolia*). Since then two papers have treated this insect in some detail. The first of these was by MacDougall in 1906. MacDougall knew the larva and felt reasonably sure that this species was phytophagous. Some of his statements as to emergence are not without interest; he states that from a lot of seeds harvested in October, 1904, he found larvæ in May, June, July, August, September, Octo-

ber, and November, 1905, and seemed to be of the opinion that the great variation in the dates of emergence of this insect was due to the irregularity of the hatching of the eggs and the coming to maturity of the larvæ. It may be, however, that the females which had emerged in the receptacle containing the seeds oviposited within the seeds, thus accounting for the larvæ found in the months of July, August, September, October, and November, 1905, when the larvæ which would be adults in the spring of 1906 should be feeding within the seeds. MacDougall does not give sufficient information to make his statement concerning variation in emergence conclusive, while rearings by Crosby, Crosier, and Wachtl confirm this last supposition.

The egg has been obtained by Crosby by dissection of a female and is described by him as "white, smooth, and spindle-shaped with a very long pedicel at the anterior end and the vestige of one at the opposite end. Length of body of egg, .36 mm.; tail-like process, .9 to 1.2 mm." The larva described by Crosby is as follows: "The full-grown larva is yellowish white with brownish mouth parts; its length varies from 2.5 to 3.5 millimeters. The surface is smooth without apparent sculpture, and the hairs are very sparse and microscopic in size. The inner margin of the mandibles is provided with three sharp teeth." The pupa is described by Crosby as follows: "The pupa is yellowish white and in the female has the ovipositor curved over the back and reaching to about the middle of the thorax. Length of female pupa, 3 mm.; of male, 2.5 mm."

The oviposition of this species is unknown, and the shape of the egg after having been deposited is not known. Neither has this insect been recorded as having been reared from the seeds of any Douglas fir raised in the United States. All seeds from which it has been reared were collected in Aberdeenshire, Scotland, on the estate of Mr. John Crosier. In this statement we must except the seeds from which the species was reared by Wachtl, as it is presumed that these were collected somewhere in the northwestern United States. Crosby also records the larvæ within the seeds of Douglas fir in Colorado, but these seeds came from a nursery firm and definite locality could not be secured.

Up to the present time this is the most injurious chalcidid on forest trees which has received the attention of any entomologist. The attention which this insect has received in America, with the exception of the work done by Crosby, has been nil. MacDougall recommends as protection from this species that the cones be gathered as soon as ripe, and that, as soon as they will permit, the seed be thrashed from them, and that this be fumigated without delay with bisulphid of carbon. No experiments have been published concerning the results of such fumigation, but except for killing the larvæ within the seed and preventing another generation of adults this method can not be considered as valuable.

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SUMMARY.

Up to the present time there are seven species of chalcidid flies which are known to attack the seeds of the following forest trees:

Mountain ash.....	{ <i>Sorbus scandica</i> . <i>Sorbus aucuparia</i> . <i>Sorbus latifolia</i> ?
Amabilis fir.....	<i>Abies amabilis</i> .
White fir.....	<i>Abies concolor</i> .
Great silver fir.....	<i>Abies grandis</i> .
Shasta fir.....	<i>Abies magnifica</i> .
Bristlecone fir.....	<i>Abies venusta</i> .
Noble fir.....	<i>Abies nobilis</i> .
Three exotic firs.....	{ <i>Abies excelsa</i> . <i>Abies pectinata</i> . <i>Abies mariesii</i> .
Hooker hemlock.....	<i>Tsuga mertensiana hookeriana</i> .
Unknown Tsuga.....	<i>Tsuga</i> sp. (?)
Douglas fir.....	<i>Pseudotsuga taxifolia</i> .

Of these seven species the eggs of two are known, the larvæ of four, the pupæ of two, the oviposition habit of one, and the emergence dates of three. The only species of which the life history has been completely traced is that of the apple-seed chalcidid (*Syntomaspis druparum*) which is also known to attack the seeds of mountain ash.

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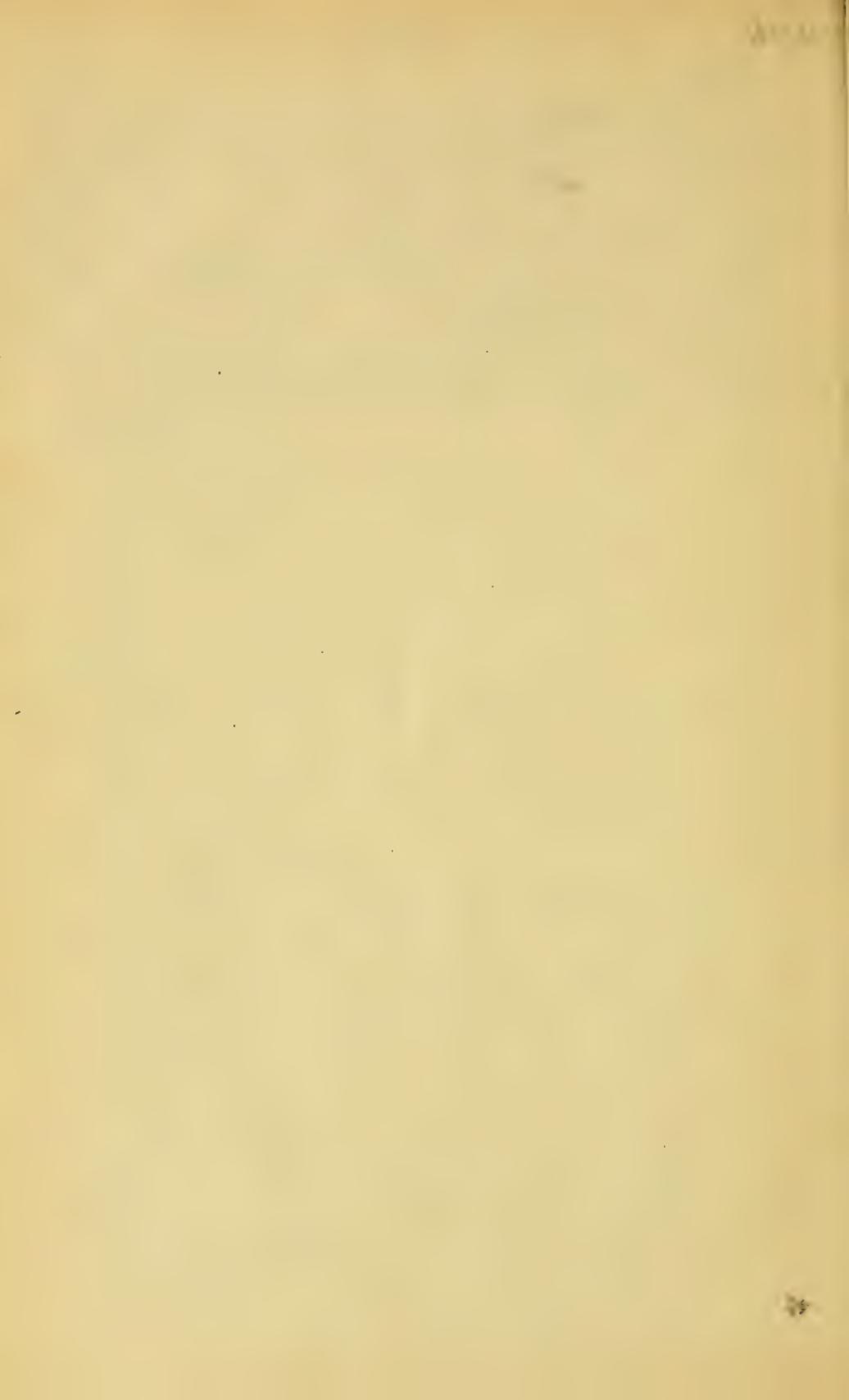
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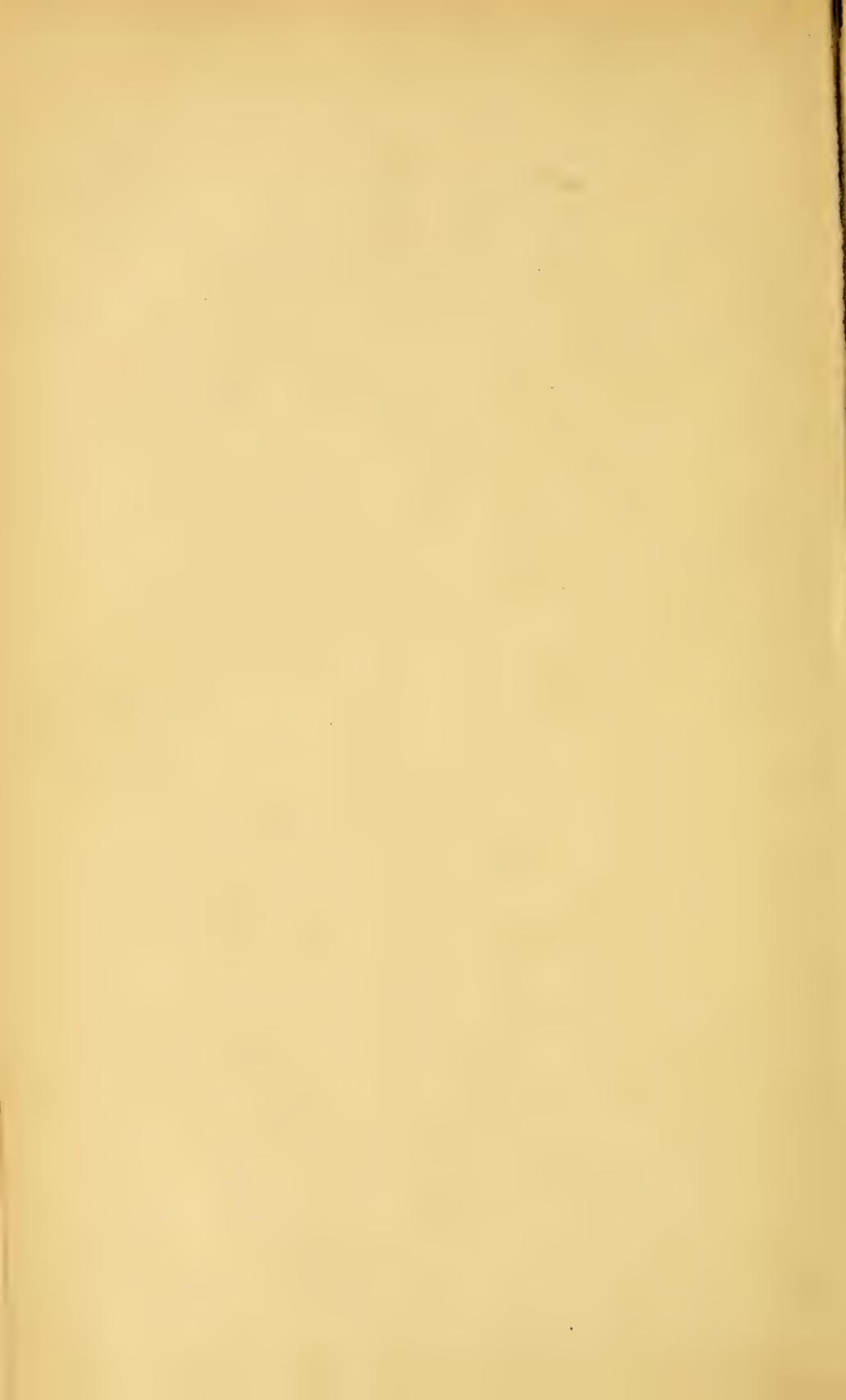
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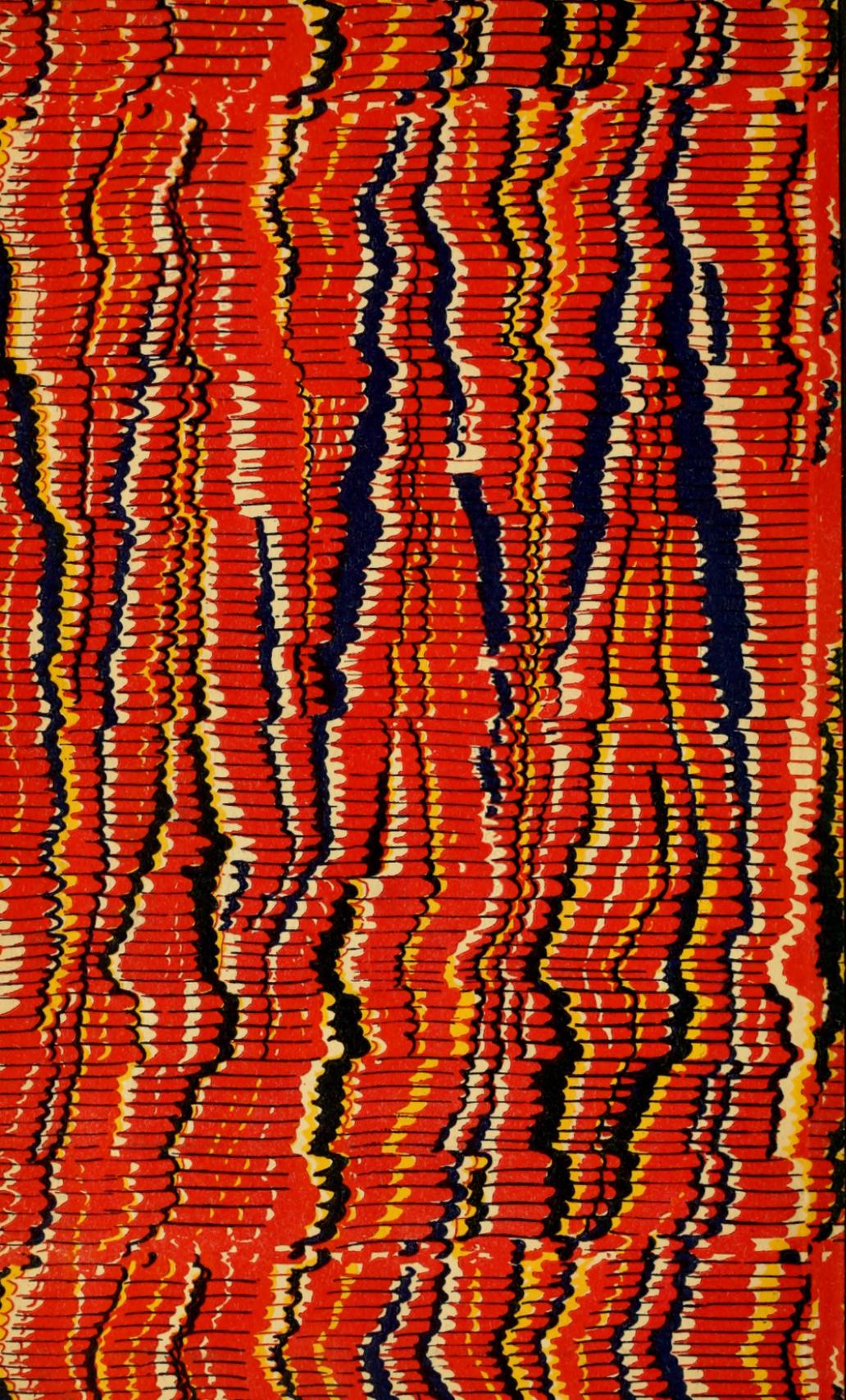














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