

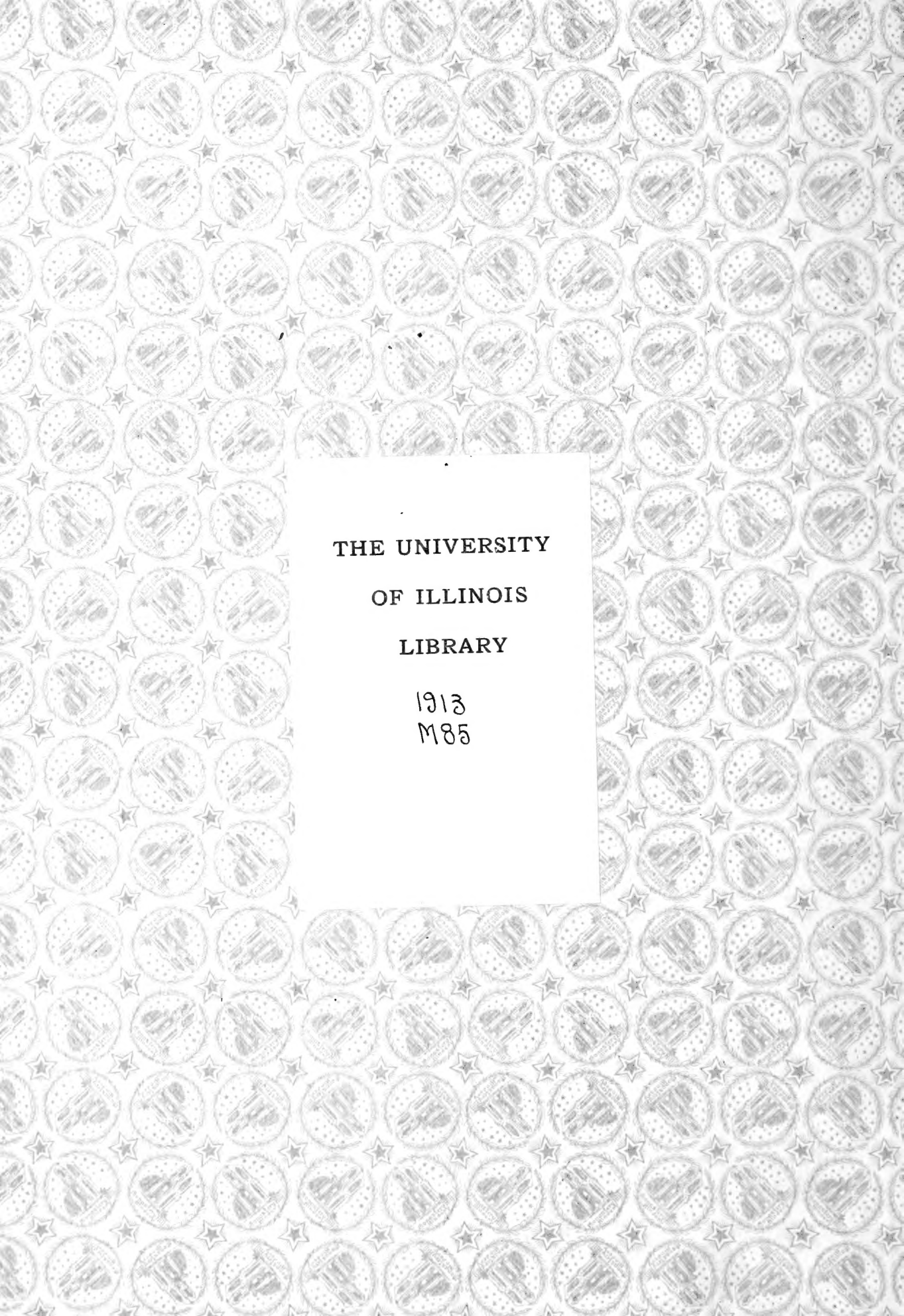
MOSHER

The Pupae of the Lepidoptera

Entomology

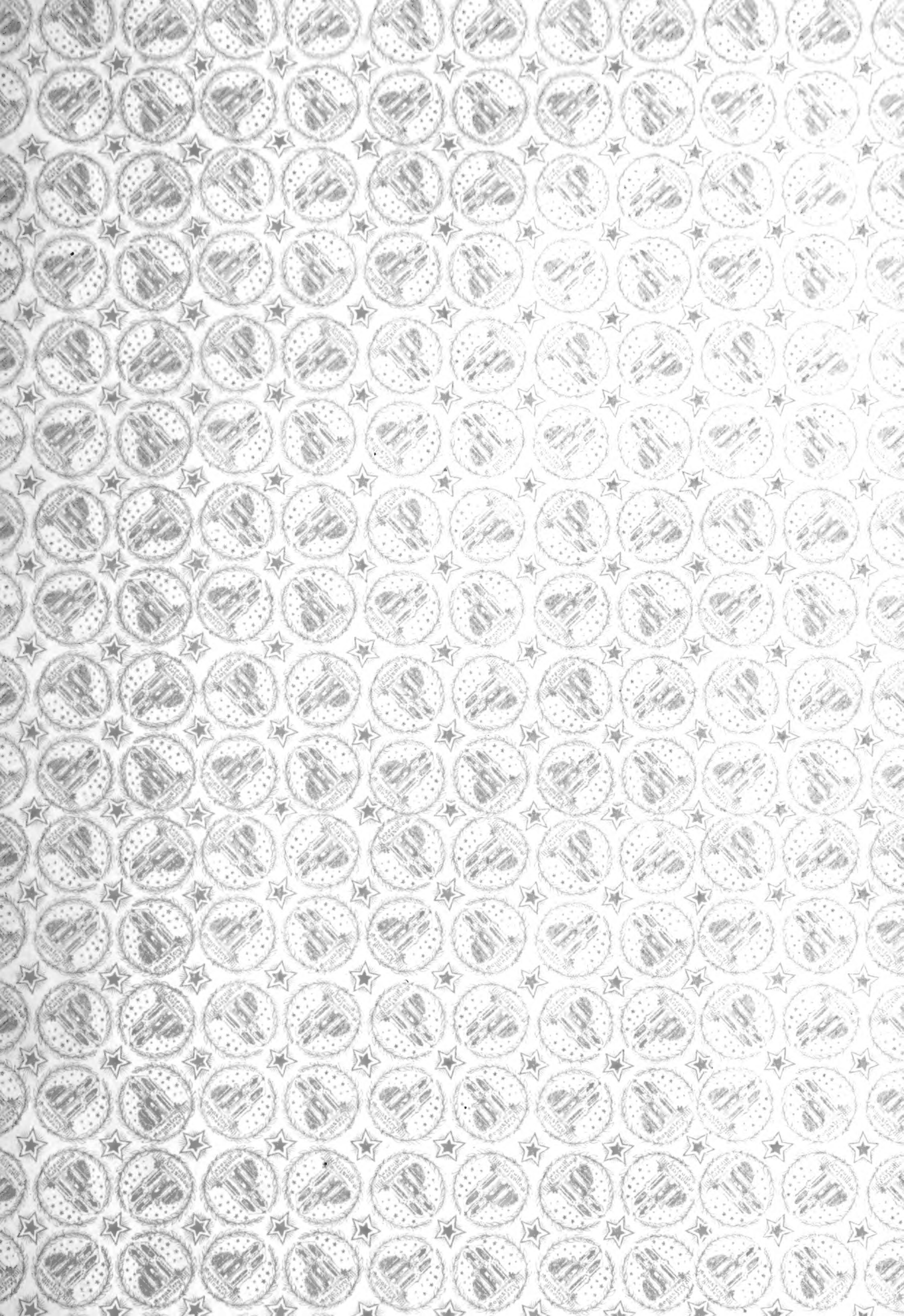
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THE PUPAE OF THE LEPIDOPTERA

BY

EDNA MOSHER

B. S. A. Cornell University, 1908

THESIS

Submitted in Partial Fulfillment of the Requirements for the

Degree of

MASTER OF SCIENCE

IN ENTOMOLOGY

IN

THE GRADUATE SCHOOL

OF THE

UNIVERSITY OF ILLINOIS

1913

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Edna Mosher, B. S. A.

ENTITLED The Pupae of the Lepidoptera.

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Master of Science.

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Committee
on
Final Examination

1913
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I. INTRODUCTION

A very important paper by Dr. Thomas Algernon Chapman, "On some neglected points in the structure of the pupae of Heterocerous Lepidoptera and their probable value in classification", was published in the Transactions of the Entomological Society of London for 1893. This paper was the first attempt to use pupal characters in working out the phylogeny of the Lepidoptera.

Dr. Chapman called attention to the fact that in descriptions of pupae, which were often minute in some particulars, there was a surprising lack of information as to the characters which were of sufficient importance to be used as a basis for classification.

The first of these characters was the number of segments in the pupa retaining freedom of motion, and he accordingly divided pupae into two great classes, the first class included those in which movement exists between the fourth and fifth, between the fifth and sixth and between the sixth and seventh abdominal segments in both sexes, spoken of as having the fifth and sixth abdominal segments free; the second class, which in addition to the segments mentioned above, have the seventh abdominal segment free in the male and fixed in the female.

The first group he considered remarkably uniform, not only in the number of free segments, but in correlated characters throughout; the second group presenting considerable

variation in various directions, especially in the number of free segments cephalad of the fifth abdominal segment.

To the first group he gave the name "obtectated" because when the last larval skin is cast, the appendages fall into their places and lie together so as to form a smooth exterior, which becomes very hard through deposits of chitin, while the inner hidden surfaces remain very thin and delicate and are represented by a few flimsy shreds when the pupa emerges.

The second group, which he designated "incomplete", usually has a less solid surface than the obtectated pupae and the pupal skin of the inner surfaces is much stronger, so that it is not broken by the emergence of the pupa and the nature of each portion is generally easy to determine, the appendage cases readily separating from each other. A peculiarity of this latter group is that the head coverings separate from the rest of the pupa in dehiscence, while in obtectated pupae the head parts only remain together while they are attached to the rest of the body covering, but never do when separated from the rest of the pupal case. Another peculiarity of dehiscence is that in obtectated pupae the cast pupal skin shows plainly that the fifth and sixth segments were free and no others, while the incomplete pupa leaves one in doubt as to which segments were free, because at many places where there was no movement allowed in the pupa, movement takes place in dehiscence.

A character which Dr. Chapman thought would prove to be



of value in classification was the presence or absence of the "eye-collar", a structure which he noticed in many incomplete pupae and which proved to be the case of the maxillary palpus. This structure is not known to exist among obtected pupae.

The manner of dehiscence of the glazed eye-piece proved to be another character of importance. In the case of incomplete pupae, instead of remaining attached to the face-piece, it remains attached to the dorsal head piece which extends ventrad under the antennae.

In many incomplete pupae there is a strong tendency to form a "waist" by a sinking in dorsally of the first abdominal segment. This is practically unknown among obtected pupae.

When the incomplete pupae have long antennae projecting beyond the other appendages, each remains separate and free to its distal end, while in obtected pupae they are carried around the margin of the wing.

Another character distinguishing incomplete pupae is the fact that most of them leave the cocoon or other place of pupation for the emergence of the moth, while no obtected pupa does; also the incomplete pupae usually hibernate as larvae in their cocoons, changing to pupae in the spring, while the obtected pupae hibernate as such, spending a much longer time in the pupal state.

These characters Dr. Chapman thought sufficient to clearly separate the two great groups, but he was unable to complete the subdivision of these groups owing to lack of material and

his inability to find pupal characters which he could use as a basis for this classification. He called attention to the fact that some *Tineina* had not very distinct or decided characters and needed further study before deciding to which class they belonged; whether they were a connecting group, or a division of equal importance with the others. He also attempted to show how these characters could be used in studying the phylogeny of the group. In the key which was given at the close of his paper for the separation of the major groups he used larval and imaginal characters in addition to the pupal characters which he had observed.

In a paper published in 1896 he referred to another pupal piece which he had observed as occurring chiefly in the lower incomplete pupae. This is often a separate piece between the face-piece proper and the dorsal head-piece and which he thinks is the dorsal plate belonging to the antennal section of the head. He also noticed that certain incomplete pupae are characterized by a very narrow prothoracic piece and a very large head plate.

In the Memoirs of the National Academy of Sciences for 1895, Dr. A. S. Packard published a "Monograph of the Bombycine Moths of North America" and included a section "On the Phylogeny or Classification of the Lepidoptera", in which he reviewed the work of Dr. Chapman. In the introduction to this paper he referred to the use made of pupal characters in classifying other orders of insects.

He considered those pupae in which the appendages were free or pupae liberae, such as *Micropteryx*, the most generalized because they are more like the pupae liberae of Trichoptera and Neuroptera. The pupae incompletae of Chapman he placed next in order, as they retained visible maxillary palpi, labial palpi and the so-called paraclypeal pieces of the pupae liberae; where these characters have been lost as in the obtected pupae of Chapman we find the highest development among the Heterocerous Lepidoptera.

Dr. Packard divided the Lepidoptera into two suborders, the first, the Lepidoptera laciniata or those with maxillae of the same type as the biting or mandibulate insects, of which *Eriocephala* is a typical genus; the second, the Lepidoptera haustellata, with the maxillae modified to form a tube. The latter suborder was divided into two series of superfamilies and families, the Paleolepidoptera and the Neolepidoptera; the former comprising the pupae liberae, having the characters of *Micropteryx* and the latter both the pupae incompletae and the pupae obtectae of Chapman. The pupae incompletae he called Tineoids; the pupae obtectae, Macrolepidoptera or Platylepidoptera.

He used Chapman's characters for separating these two groups and then worked over the material used by Chapman, with additional material obtained from America and Australia. He listed pupal characters for many of the families, mostly among the Tineoids of which Chapman had failed to establish the re-

relationship with other pupae. Dr. Packard made no attempt to formulate a key for the identification of pupae but tabulated his results in the form of a genealogical tree of the Lepidoptera.

In the following paper an attempt has been made to use pupal characters for the classification of the pupae of American species of Lepidoptera, and later to work out the phylogeny of the group following the suggestions of Dr. Chapman and Dr. Packard.

Since Dr. Chapman described European forms and published few figures his excellent papers furnish little help in studying American forms. Dr. Packard's studies seem to have been made largely from cast pupal skins, and this perhaps made it impossible for him to accurately determine the homology of the various parts, since in many cases dissection has shown his homologies to be incorrect. In looking over the literature regarding pupae there have been found no figures showing pupae with the outer or pupal skin removed, giving the relation of the appendages beneath or within the pupal cases, and, with the exception of Dr. Chapman's work, there is no evidence that pupae have been dissected so as to show the true homology or relationship of their parts. It is necessary to learn the names of the parts and their homologies before making any attempt at classification, and for this reason considerable time has been given to a study of the pupal parts and structure with this end in view.

II. PUPAL MORPHOLOGY

There are many pupal characters and structures which deserve a great deal of careful study and, in order to understand them thoroughly, many of them need to be compared with the same or similar characters and structures in other pupae and also with the same structures in the larva and imago of the same species. The time allotted for the preparation of this paper was not sufficient to study many of these structures thoroughly and some of them have only been cursorily examined. For purposes of classification the mouthparts and appendages proved most important and were considered first. In order to identify without doubt the pupal cases, a number of pupae in their adult stages were dissected carefully and the contents of each case noted. When all the pupal case had been removed, a drawing was made of the pupa, or preimago as it may better be called, as in this stage all the adult parts are fully formed.

The pupae of three families were studied in this way, *Sthenopis thule*, an hepialid; *Archips argyrospila*, a tortricid, and *Lymantria leucostigma*, a liparid.

Sthenopisthule:- In studying the external parts of pupae it is always possible to identify without doubt the antennae and wings. The antennae in *Sthenopis thule* as shown in a ventral view (Fig. 1) are very short and attached to the head capsule at the lateral margin of the clypeus, with a distinct suture between and extending laterad and caudad slightly beyond the bases of the first pair of wings. The clypeus is in-

determinately ridged and bears two prominent protuberances near the cephalic margin, curved ventrad and a third on the meson near the caudal margin. The invaginations for the anterior arms of the tentorium are not very distinct and located along the caudal margin of the clypeus. Caudad of the clypeus is a somewhat shield shaped labrum bearing four long setae. Laterad of the labrum and caudo-laterad of the clypeus there is, on each side, a five-sided piece, extending cephalad to the antenna, a part of the head covering or face-piece, which in reality covers most of the eye. Laterad of each face-piece and between it and the antenna is another piece which is longer than the face-piece, separated from it by a slight furrow and broadly rounded at its caudo-lateral end. This is the eye-piece which is divided into two parts, a narrow, smooth, polished portion at the cephalo-mesal end, called the glazed eye-piece, and a much larger, lateral portion sculptured like the rest of the face parts. Laterad of the distal portion of the labrum and lying between it and the face-piece on each side is a diamond-shaped mandibular case bearing a single seta. Caudad of the labrum and lying on the meson is the case for the labial palpi, which broadens out and is slightly bi-lobed at the distal end. Near the middle of this case on the meson is a prominent pointed tubercle. Laterad of the case for the labial palpi and between it and the eye-pieces on each side are the large triangular cases for the maxillary palpi. Caudad of the cases for the maxillary and labial palpi are the leg cases, which are

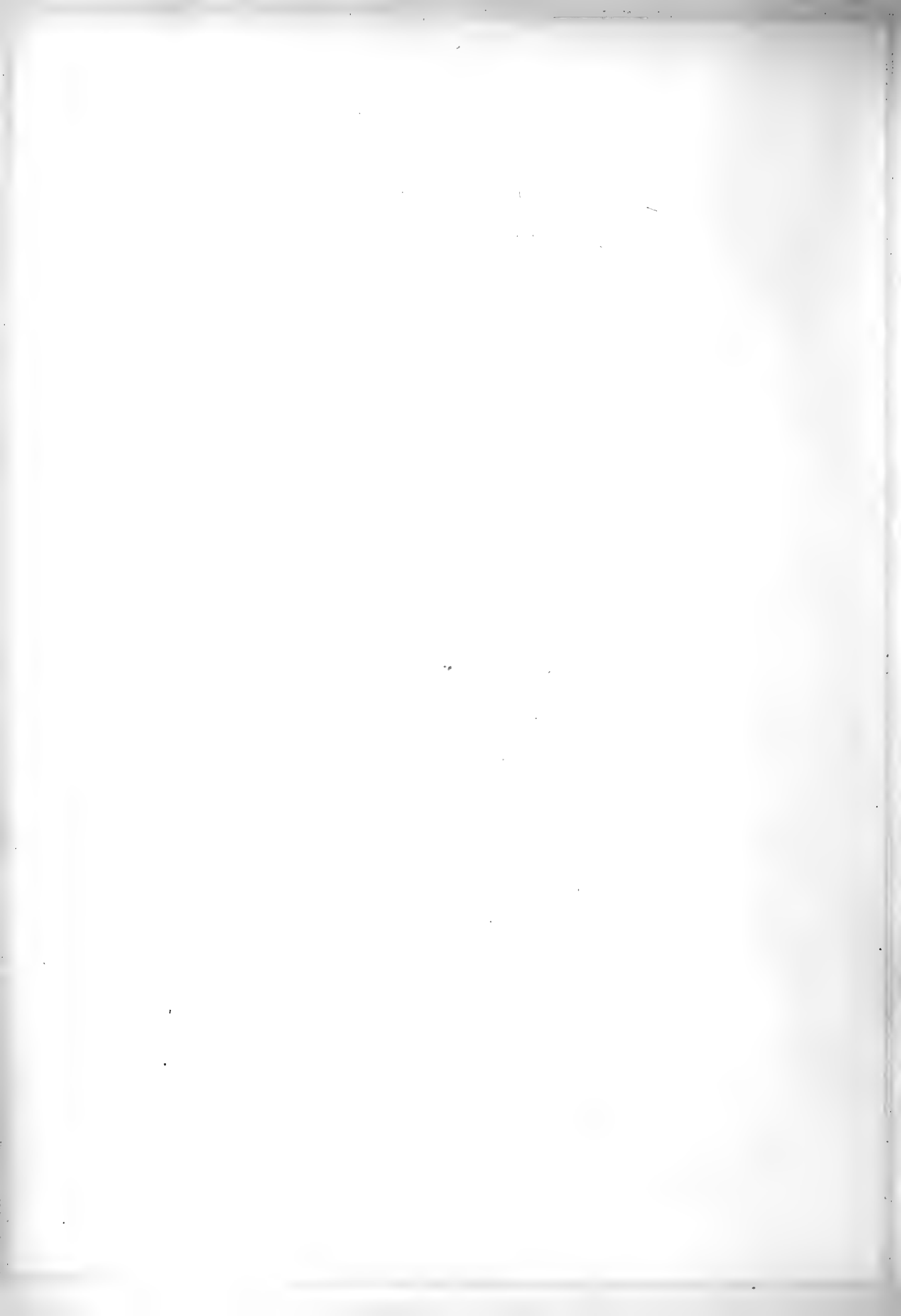


often very hard to homologize as their arrangement varies more in the generalized forms than any other structure. These appendages being encased in the pupal skin and then folded, makes it possible for any one leg to be so arranged as to look like three separate cases, the coxa being in one, the femur in another and the tibia and tarsus in a third. In *Sthenopis*, the triangular coxal cases for the first pair of legs lie adjacent on the meson just caudad of the case for the labial palpi. These cases have what seems to be a distinct suture, for about the proximal half of their length near the lateral margin. This may indicate the division between the trochantin and the coxa, the former being present in *Sthenopis*. More material would be necessary to determine this. Laterad of the coxal cases are the cases for the tibial and tarsi of the first pair of legs which are folded over the femur cases so that the latter are not exposed. The cases for the tibiae and tarsi of the first pair of legs extend from the antennae to the meson of the ventral aspect where they lie adjacent for a short distance. Laterad of these cases are similar ones for the tibiae and tarsi of the second pair of legs which come to lie adjacent on the meson for a short distance caudad of the first pair of legs. Laterad of these leg cases are the wing cases. The cases for the first pair of wings lie over the cases for the second pair. The latter lie adjacent on the meson for a short distance caudad of the second pair of legs and are seen below the caudal margins of the first pair of wings. The tips of



the third pair of legs show adjacent on the meson between and caudad of the wing cases. The wing cases only reach to the caudal margin of the second abdominal segment (Fig. 2) or slightly over the cephalic margin of the third segment (Fig. 1). The scars of the abdominal prolegs of the larva may be seen on abdominal segments 3-6. The ninth segment bears the opening of the reproductive organs in the male, which is located on the meson between two small rounded tubercles. The anal opening is on the meson near the caudal margin of the tenth segment.

A lateral view (Fig. 2) shows the epicranial area dorsad of the clypeus, and bearing a prominent protuberance on each side the meson. The prothorax is a short segment, the mesothorax long and the metathorax also very long in comparison with the first abdominal segment. The prothoracic spiracle is slit-like, indicated on the exterior by a slight elevation along its cephalic margin. The abdominal spiracles are found on segments 2-8 but only the first six are functional, the spiracle on the eighth segment being a "blind" or "closed" spiracle. In a dorsal view (Fig. 3) the movable abdominal segments are shown to be 3-7 in the male. Both cephalic and caudal margins of the movable abdominal segments are produced into thin flange-like plates, longitudinally ridged and slightly toothed. The caudal plate extends around the entire segment, but the cephalic plate is dorsal and ends at the spiracular line. There are also some short, stout spines on abdominal segments 8-10 and these, with the plates, assist the pupa in



working its way to the surface, as it spends its pupal life in a tunnel bored into a tree by the larva. The setae are conspicuous, and arranged in the same order on each abdominal segment as they were in the larva, so far as the parts are exposed.

The ventral view of the preimago (Fig. 4) should be compared with a ventral view of the pupa (Fig. 1) and the relationship of the parts noted. In the preimago the legs are slightly spread to show how they were folded in the pupa.

Archips argyrospila:- A more specialized form, *Archips argyrospila*, (Fig. 5) shows fewer distinct areas belonging to the head, altho the preimago has all the parts found in *Sthenopis thule*, a fact of particular interest in that there is indicated clearly here a specialization of the pupal case which has not reached to the preimago. As in *Sthenopis* the wings and antennae are easily located. The wings do not meet on the meson, and the antennae are very long, reaching nearly to the tips of the wings. The sutures between the antennae and the epicranial area are distinct but there is no distinct suture between the clypeus and epicranial piece, or between the clypeus and labrum altho these sutures show plainly in the preimago. The clypeus may be located by the setae, of which there are two on each lateral margin near the caudal part of the clypeus. These setae are slightly caudad and mesad of the invaginations for the anterior arms of the tentorium, which are very large and distinct. Laterad of the clypeus on each side is a more or less oblong face-piece with a quadrangular area just



caudad of the clypeal area and adjoining the labrum. This quadrangular area is slightly elevated and is a mandibular case altho it has no distinct suture separating it from the face-piece. Between the antennae and adjoining the face-pieces there is on each side a triangular eye-piece. Each eye-piece probably consists of the two parts found in *Sthenopis* but as the pupal case is thin and almost transparent these can not be differentiated. Just caudad of the clypeus and lying adjacent on the meson are the cases for the labial palpi, while the cases for the maxillae lie laterad of these and extend farther caudad, so that they come to lie adjacent on the meson for a greater distance than the labial palpi. Caudad of the eye-pieces and extending band-like below them are the distal ends of the cases for the maxillary palpi, which show two distinct segments. Dr. Chapman called these pieces the "eye-collar" when he first discovered them and later proved them to be the cases for the maxillary palpi, which project laterad from each maxilla, pass backward in the angle between the head and prothorax until they are situated deeply beneath the antennae and only reach the exterior by emerging from beneath the antennae and turning forward, exposing the tips of the cases caudad of the eyes and mesad of the antennae. Laterad of the maxillae are the femur cases of the first pair of legs and next to these the cases for the tibiae and tarsi of the first pair of legs. Caudad of the maxillae and femur cases of the first pair of legs and between the tarsi of the first pair, lying adjacent on the meson, are the

coxal cases of the second pair of legs. Laterad of the cases for the tibiae and tarsi of the first pair of legs and extending caudad of the coxal cases of the second pair so that they lie adjacent on the meson are cases each of which contains the femur, tibia and tarsus of the second pair of legs. Caudad of these, lying adjacent on the meson are the tarsal cases of the third pair of legs. The setae on the body of Archips are quite conspicuous and arranged in the same order on each abdominal segment as they were in the larva, so far as the parts are exposed.

The cremaster, which is a prolongation at the caudal end of the body, is not present in Sthenopsis. Those who have given it careful study declare it to be the homologue of the suranal plate of the larva. The curved spines at the end serve to anchor the insect during its pupal life.

In the preimago (Fig. 6) the parts are shown just as they were when the pupal skin was removed excepting that the legs have been slightly separated. This should be compared with the pupa (Fig. 5) and the relation of the parts noted.

Lymantria leucostigma:- A still higher degree of specialization is shown in the pupa of Lymantria leucostigma (Fig. 7). The coverings for the parts of the head and the mouth parts are arranged as in Archips, but there is a distinct suture between clypeus and labrum. The antennae are very short and lie on top of the leg cases at their distal end, an unusual arrangement in pupae. The leg cases in Lymantria are more compactly folded and consequently fewer parts are exposed than in the forms de-

scribed previously. Caudad of the maxillae and lying adjacent on the meson are the coxal cases of the first pair of legs. Laterad of these are the cases for the tibiae and tarsi of the first pair of legs, and next to these are the cases for the tibiae and tarsi of the second pair of legs. The tips of the cases for the tarsi of the third pair of legs lie adjacent on the meson between the cases for the first pair of wings. The wing cases in the female extend down on the fourth abdominal segment, but the wings never fill the cases, as in the adult females the wings are wanting. The setae show the characteristic arrangement of the larva on the exposed portions of the abdomen. The preimago (Fig. 8) should be compared with the pupa (Fig. 7) and a careful comparison made of the parts shown in each.

III. HOMOLOGY OF THE MOUTH PARTS OF THE PREIMAGO

Sthenopsis thule:- A study was first made of the mouth parts of three forms selected from widely differing families. The first, *Sthenopsis thule*, an hepialid, belongs to a very generalized family of Lepidoptera, where it would be expected that all of the parts represented in any family of the order would be present. Altho the adult mouth parts are functionless, the parts are all present in the preimago and the clypeus, labrum, mandibles, maxillary lobes which are doubtless the homologues of the maxillae of other members of the order, maxillary palpi and labial palpi are easily identified. In a cephalic view of

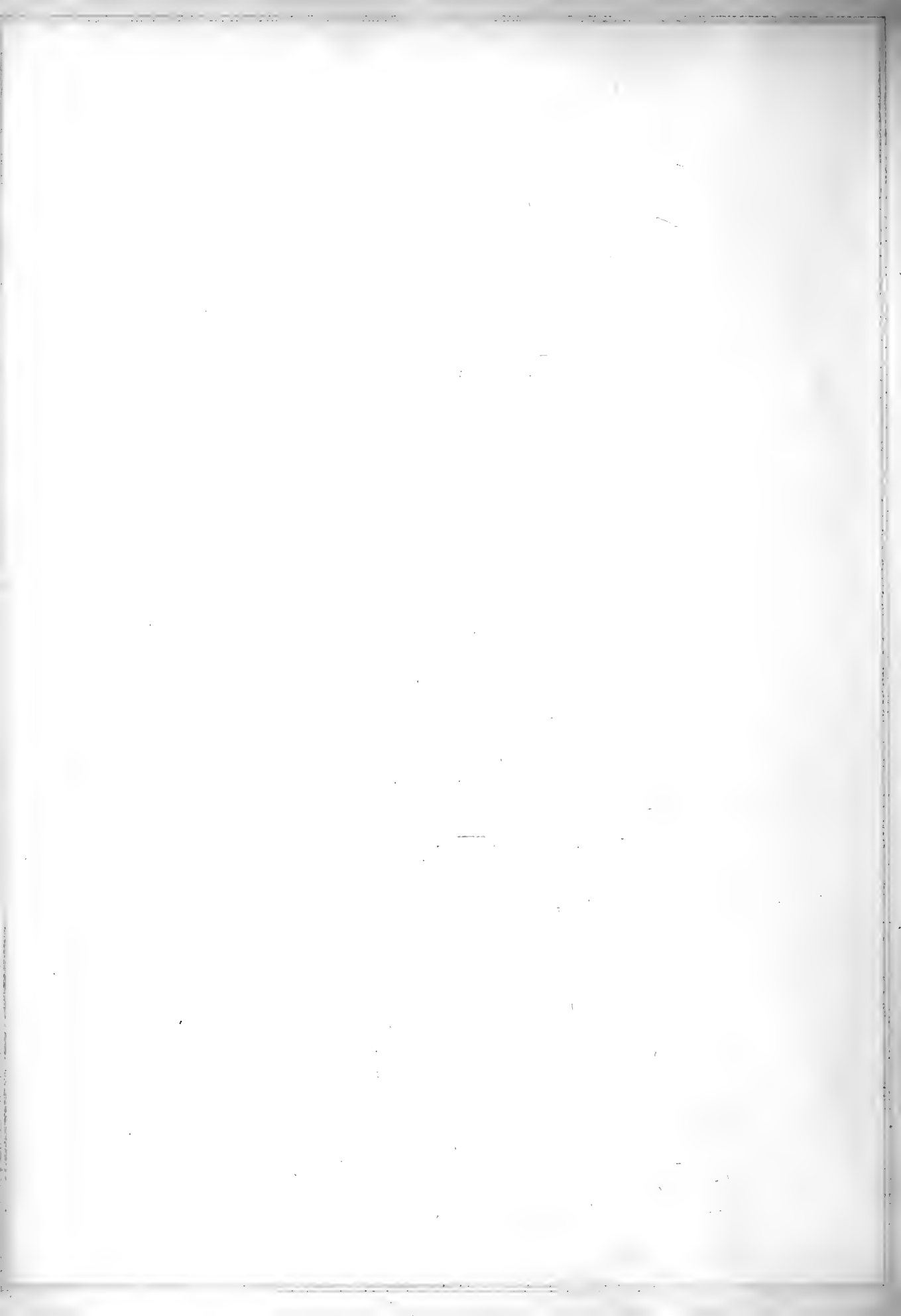
Sthenopsis thule (Fig. 9) the clypeus is shown occupying the central portion of the head, strongly concave on the margin adjoining the labrum, with the caudo-lateral angles produced, and rounded, the invaginations for the anterior arms of the tentorium being located between these angles and the labrum. There is a distinct oval tubercle near the caudal margin of the clypeus and it is more strongly chitinized than the labrum. The clypeo-labral suture is distinct, the labrum slightly convex on its distal margin, the length and breadth approximately equal. Laterad of the labrum and apparently articulating with the caudo-lateral angles of the clypeus are functionless mandibles, the suture between these and the genae being very distinct. Caudad of the mouth cavity is the mentum, bearing a pair of two-segmented labial palpi covered with setae and laterad of its proximal margin on each side is a maxillary lobe. Each of these lobes consists of three segments, a long proximal segment and two shorter distal ones. A ventral view of the head (Fig. 10) shows a distinct suture between the submentum and mentum and on the lateral margin, near the proximal end of each maxillary lobe is a short maxillary palpus.

Archips argyrospila:- Later, *Archips argyrospila*, a tortricid, whose mouth parts are functional in the adult was considered and the same parts found to be present. The clypeus is well defined (Fig. 11), the clypeo-labral suture distinct and the margin slightly convex adjoining the labrum. The invaginations for the anterior arms of the tentorium are very

distinct and located along the lateral margins of the clypeus. The labrum is well developed, much wider than long, with distinct pillifers at each disto-lateral angle, bearing long setae along their mesal margins. The distal margin of the labrum has a distinct tooth at the meson and below it may be seen the epipharynx, projecting tongue-like from beneath the labrum. In order to be sure of the homology of this part, a preparation was made of the clypeus and labrum of *Phlegethontius carolina*, which shows a similar projection from beneath the labrum. The ental surface of the cephalic aspect of the head (Fig. 13) shows the distal margin of the labrum indicated by a dotted line. The projecting part of the epipharynx is shown to be continuous with that lining the ental surface of the clypeus and labrum. Just proximad of the line indicating the distal margin of the labrum is a more or less triangular, slightly chitinized area. Laterad of this slightly chitinized area on each side is a group of sensory pits. At the left is shown the anterior arm of the tentorium. The fulcrum is seen as a narrow, chitinized T-shaped rod on each side fastened at base to the anterior arm of the tentorium. Proximad of the T-shaped fulcrum there is, on each side, a thinly chitinized quadrangular area which narrows to a point mesad of the fulcrum. The dotted lines at the proximal end indicate the end of the pharynx. The arrangement of these parts is very similar to such mandibulate insects as the cockroach and grasshopper. Laterad of the labrum (Fig. 11) at each proximo-lateral angle be-

tween the clypeus and labrum is a thin, colorless appendage, undoubtedly a mandible. The maxillae are well developed, more than twice the length of the head, the two parts lying closely approximated so that they can be fitted together to form a tube. The distal half of each maxilla has a number of fine short setae along the lateral margin. Beneath the maxillae may be seen the labial palpi, which are slightly wider than the maxillae, about half their length and densely covered with fine setae. In a ventral view (Fig. 12) there may be seen, attached to the lateral margin at the base of the maxilla, on the side from which the labial palpus has been removed, a slender four-segmented maxillary palpus. Each maxillary palpus extends laterad towards the antenna, then is directed cephalad until it reaches the ventral surface where it bends mesad and lies closely appressed to the caudal margin of the eye and is seldom seen in cephalic view.

Lymantria leucostigma:- The next form considered was Lymantria leucostigma, a liparid. In this form the adult mouth parts are functionless, but in the preimago the parts found in the previous forms were all present, the mandibles (Fig. 14) being much more distinct and mandible-like than in either Sthenopsis or Archips and leaving no doubt as to their identity. The clypeo-labral suture is obsolete and the invaginations for the anterior arms of the tentorium are larger and more prominent than in the forms previously considered and located along the lateral margin of the clypeus. The mandibles are four-



toothed and heavily chitinized. Mesad of these are the maxillae which are shorter than the head, rather broad at base, with a distinct projection on each lateral margin but showing no traces of maxillary palpi. The labial palpi show on each side the meson between the two halves of the maxillae, the proximal segments larger than the distal ones, which are globular in the pupa, but ovoid in the preimago.

Following these a study was made of the mouth parts of six genera of the superfamily Saturnioidea. These showed little variation and were very similar to the mouth parts of *Sthenopis thule* and *Lymantria leucostigma* for, like these species, the mouth parts are functionless in the adult. It was noticed in all these forms that the appendages were much more distinct in pupae than in the preimagos. The mandibles, which in the adult seem but projections from the genae, are plainly appendages in the pupa with the proximal suture distinct and also the articulation with the clypeus. The latter can not be seen in the preimago, but the proximal suture is usually distinct, the mandible being more heavily chitinized and more plate-like in this stage. The maxillae show much difference in the stages of their development, being larger at first and usually more closely approximated in the younger stages, gradually becoming contracted and farther apart in the preimago. The maxillae show varying degrees of development in the different genera. Maxillary palpi were not found in all the genera studied, but lack of material prevented a study of

the earlier stages of some forms and it may be that further study would show them to be always present. In every case there is a projection at the base of each maxilla, where the palpi are located when present.

The labial palpi are always present and show about the same degree of development, altho the number of segments varies in different species.

The mouth parts of the six genera of Saturnioidea studied are as follows: *Citheronia regalis*, *Dryocampa rubicunda*, *Automeris io*, *Telea polyphemus*, *Callosamia promethea* and *Samia cecropia*.

Citheronia regalis:- (Figs. 15 and 16) shows a decided, transverse projection on the clypeus, probably about the place where it is joined to the labrum, altho the clypeo-labral suture is indistinct. The invaginations for the anterior arms of the tentorium are small and located at either end of the transverse ridge. The labrum is slightly convex at the proximal margin, concave at the distal margin and its width is less than twice the length. The mandibles could not be clearly distinguished in the specimen at hand, but as it had emerged from the cocoon they were doubtless so fused with the genae as to be indistinguishable. The maxillae are not as long as the head and are slender with each half the maxilla tube-like, tapering to a point at the distal end, where they are strongly recurved. The labial palpi are large and prominent, two-segmented, the distal segment porrect, and the whole appendage

densely covered with setae.

Dryocampa rubicunda:- (Figs. 17, 18, 19) has a distinct suture between the clypeus and labrum, with the invaginations for the anterior arms of the tentorium located at each end. The portion of the clypeus adjoining the labrum is elevated into a prominent transverse ridge similar to that in *Citheronia regalis*. The labrum is convex along its proximal margin, concave on its distal margin, considerably elevated above the surface of the clypeus and much wider than long. Laterad of the labrum are structures which have every appearance of being functionless mandibles. They have a distinct suture at the proximal end and are quite heavily chitinized along the distal margin, but not toothed. The maxillae are very small and lie adjacent on the meson, the distal ends pointed and projecting slightly cephalad. The labial palpi, ^{are} slightly longer than each half the maxillae, clavate and covered with long setae, more numerous on the lateral margin.

Automeris io:- (Figs. 20, 21, 22) has the distal margin of the clypeus elevated into a prominent transverse ridge which projects much farther cephalad than similar ridges in *Citheronia regalis* and *Dryocampa rubicunda*. The clypeo-labral suture is obsolete. The invaginations for the anterior arms of the tentorium are large and prominent and located along the lateral margins of the labrum. The labrum is quadrangular in outline, much wider than long, the caudo-lateral angles slightly produced and rounded. Laterad of the labrum are the functionless

mandibles, the proximal suture distinct and the distal margins heavily chitinized. The maxillae are small, somewhat oblong in outline and meet on the meson. They bear a few long setae on the lateral margin, which extend the whole length of the appendage. The labial palpi are very large and prominent, three-segmented and thickly covered with setae.

Telea polyphemus:- In *Telea polyphemus* (Figs. 23, 24, 25) the mouth parts are very distinct and leave no doubt as to their homology. The clypeus is heavily chitinized, strongly concave with the labrum fitting into the concavity, with the corners of the clypeus produced into a rounded angle on each side of it. The labrum is narrow, much wider than long with its distal margin irregularly corrugated. The invaginations for the anterior arms of the tentorium are very prominent and located along the lateral margins of the clypeus. Laterad of the clypeus and labrum on each side is a well developed mandible, each strongly chitinized and slightly toothed on the distal margin and projecting slightly cephalad. The maxillae are fairly well developed, slightly longer than the head. Each half has a prominent lateral projection near the base, but no trace of a maxillary palpus could be found. They are slightly separated at the proximal end but lie adjacent on the meson for about three-fourths their length, tapering gradually to a point at the distal end. The labial palpi are more than half as long as the maxillae, cylindrical in outline, broadly rounded at the distal end and covered with setae which are longer along

the mesal margins.

Callosamia promethea:- (Figs. 26, 27, 28) This form has a strongly chitinized clypeus, with the invaginations for the anterior arms of the tentorium very prominent, and located at its ventro-lateral angles. The clypeo-labral suture is distinct, the labrum slightly concave along its distal margin and its width much greater than the length. Laterad of the labrum on each side are functionless mandibles, heavily chitinized along their mesal and caudal margins, the mesal margin irregular, but not distinctly toothed, the proximal articulation having been lost. Caudad of the mandibles there is a pair of maxillae, separated by a distance equal to the width of the labrum. The proximal part of each maxilla is conical and bears a short but well defined two-segmented maxillary palpus which is more heavily chitinized than the basal part of the maxilla. The distal portion of the maxilla is triangular in outline and is directed cephalad, the margin chitinized and distinctly serrate. Caudad of the maxillae and slightly nearer the median line are a pair of clavate labial palpi, the proximal part chitinized at point of attachment; the distal portion covered with setae, as long or longer than the appendage itself. The mentum and submentum are fused, strongly chitinized, and bear two short setae on each side the meson near the proximal margin. At the base of each maxilla is located an invagination for the posterior arms of the tentorium.

Samia cecropia:- (Figs. 29,30) has the clypeus strongly

chitinized especially along the margin adjoining the labrum. The invaginations for the anterior arms of the tentorium are very large, oval in outline, and located along the lateral margin of the clypeus. The clypeo-labral suture is distinct and the labrum less heavily chitinized than the clypeus. The labrum is slightly concave on its distal margin, much wider than long, and bears on each side the meson, near the cephalic margin, a number of prominent setae, whose number appears to vary from 2--6 according to the age of the pupa. Laterad of the labrum on each side are the mandibles, which were not heavily chitinized in the pupae first examined, but the margin was irregular and the proximal articulation was distinctly seen. Later stages showed the mandibles more heavily chitinized and the mesal margin more distinctly toothed, but the proximal articulation much less distinct. Caudad of the labrum, and separated by a distance equal to one-third of the labrum is a pair of well developed maxillae. They are elongate, the length more than twice the width, with a prominent projection on the lateral margin bearing a small maxillary palpus having a group of long setae. In older pupae the maxillae were much shorter and somewhat broader, so they are more or less rounded, and closely approximate each other on the median line. Caudad of the maxillae are the labial palpi, which are globular or ellipsoid and very little longer than broad. The labial palpi are covered with setae considerably longer than the appendage and are slightly chitinized at the base and distal end. The

mentum and submentum are distinct in this species, the latter being heavily chitinized. At the base of each maxilla may be seen an invagination for the posterior arms of the tentorium.

IV. PUPAL HOMOLOGY AND TERMINOLOGY

In studying the superfamily, Saturnioidea, certain structures are found present which are lacking in the pupae previously described. These structures are described in the following pages and a study of the types (Figs. 33-36) will assist in identifying the parts of Saturnian pupae.

Types of Saturnian Pupae:- The pupae of this group belong, in the main, to either of two types. There are, of course, many individual modifications of these types, but all forms available for study were easily identified as being either of the cecropia type or of the io type.

Cecropia type:- Pupae of this type (Figs. 33-35) have the face parts, antennae and legs elevated and convex; the wings prominently elevated above the level of the body dorsally; the caudal portion of the mesonotum and metanotum always depressed adjacent to the wings; the mesal portion of the mesothorax strongly elevated and rounded; the free abdominal segments with their lateral margins approximately parallel, so that these segments appear of equal size and are capable of being telescoped so that only the caudal margins of the segments are visible; abdominal segments 8-10 with the lateral margins straight lines, strongly convergent or tapering rapidly to

form a cone; no cremaster present.

Io type:- Pupae of this type (Fig. 36) have the face parts, antennae and all appendages on a level or nearly so, never prominently convex; the wings are never elevated above the surface of the body dorsally; the dorsal surface of thorax, abdomen and wings forming a smooth surface with no prominent elevations; the free abdominal segments with their lateral margins distinctly tapering caudad and each segment distinctly smaller than the segment cephalad of it, and never capable of being telescoped; abdominal segments 8-10 with the lateral margins never straight lines, but broadly rounded or distinctly convex; cremaster always present.

Special Structures:- The following descriptions are of structures which are mostly peculiar to pupae.

Epicranial Area:- The epicranial area is that portion of the head covering on the ventral surface bounded on its cephalic margin by the suture between the head and prothorax, on its lateral margin by the proximal ends of the antennae and on its caudal margin by the line drawn between the caudo-lateral angles of the proximal end of each antenna.

Face Parts:- The face parts include that portion of the ventral surface of the head extending cephalad to the epicranial area, laterad to the antennae, and caudad to the proximal ends of the maxillae and leg cases. It includes the eye-pieces, when present, the clypeal area, the face pieces and the labrum.

Eye-pieces:- The eye-pieces consist of two portions, the

mesal, glazed eye-piece and the lateral sculptured portion. These pieces do not entirely cover the eyes, which lie partially under the face pieces and their exact homology has never been determined. Dr. Scudder thought the glazed portion marked the line of the larval ocelli, but from the manner of dehiscence in generalized pupae it would seem that another name might better be given to this structure.

Clypeus:- The clypeus is not well defined in the superfamily Saturnioidea, the clypeo-labral suture is the only one ever present and even this is often lacking.

The antennae and wings are as easily identified as in generalized forms and occupy the same positions.

Cremaster:- The cremaster is a structure at the caudal end of the body, which is said to be the homologue of the suranal plate of the larva. In this paper the cremaster is said to be absent when there is no noticeable prolongation of the tenth segment. The cremaster in all cases has been measured from the caudal margin of the convexity on the ventral surface on which is located the anal opening.

Alar Area:- The alar area is a narrow strip on each side the mesothorax adjacent to the proximal end of each wing, wider at the caudal portion of the segment, the mesal margin usually indicated by a smooth line. It is usually a depression or a difference in sculpturing.

Mesothoracic Tubercles:- Mesothoracic tubercles are found in many genera of pupae but are especially prominent in

the case of *Tropaea luna* and *Telea polyphemus*, where at the proximal ends of the wings they differed so much in shape and size from any others noticed in the study of pupae, that they were investigated and each found to contain a prominent spine. This spine is used to cut the cocoon to allow the imago to escape and was found in the imagos of all genera of Saturniidae studied, but especially well developed in the genera previously mentioned. A study of the preimago showed that this spine was an outgrowth from one of the wing sclerites, the third axillary of Snodgrass. In *Telea polyphemus* (Fig. 32) there is also a smaller spine cephalad of the large one.

Cephalic Margin:- The cephalic margin of an abdominal segment (Fig. 33) is that part of the segment covered by the transverse conjunctiva of the preceding segment when the body is in its normal position. It is usually different in sculpturing from the remainder of the segment and its caudal boundary frequently indicated by a slightly raised line or produced to form a flange-like plate or ridge.

Transverse Conjunctiva:- The transverse conjunctiva (Fig. 33) is the membrane connecting the segments, and is very distinct on abdominal segments 4-6 where its length is usually equal to that of the part of the segment between the cephalic margin and the transverse conjunctiva.

Leg Cases:- The leg cases for the first and second pairs of legs are those commonly present in the Saturnians, only in rare instances are the tips of the cases for the third pair

of legs exposed. By "tips of the legs" is meant the distal portion of the legs, the length not to exceed the combined width of the two legs at the distal end.

Proleg Scars:- The proleg scars indicate the position of these structures in the larva and are usually clearly distinguished on the venter a short distance from the meson on the fifth and sixth abdominal segments, and less clearly distinguished on the tenth, where they are located on each side the anal opening.

Genital Openings:- The genital opening of the male is located between two small rounded tubercles, one on each side the meson of the ninth segment. In the female the opening is on the meson of both eighth and ninth segments, and there are seldom any indications of tubercles adjacent to the opening. The cephalic margins of segments 9-10 on the female are prominently convex, and never more than slightly convex in the male. The openings of the genital organs furnish the only reliable method of sex determination in pupae.

V. SUPERFAMILY SATURNIOIDEA

The members of this superfamily may be recognized easily

by the following characteristics: Fifth and sixth abdominal segments free in both sexes; body surface hard and firm, always with setae, but these rarely long enough to be observed with the unaided eye; face-parts never distinctly segmented; antennal suture obsolete; labial palpi or maxillary palpi never visible; distinct cases for the mandibles never present, these structures often represented by an elevation or a distinct tubercle adjoining the caudo-lateral angles of the labrum; antennae usually showing distinct pectinations, the width at least one-fifth the length and usually much wider, the stem of the flagellum distinctly raised above the level of the pectinations, or if the stem of the flagellum is not distinct, then the body of io type with the cephalic margins of the movable segments produced into distinct flange-like plates; maxillae, measured on the meson, seldom more than one-sixth the length of the wings, if longer, then the body surface without visible setae; third pair of legs very seldom visible; pupae usually more than an inch in length.

The pupae of this superfamily are found either in thick silken cocoons, or thin "papery" ones; or in the ground. More than twenty genera are found in North America; of these, the pupae of only sixteen genera were available for study.

The classification used in the following pages is, in the main, that of Dyar's "List of North American Lepidoptera", with slight changes made in accordance with the classification followed in Comstock's "Manual for the Study of Insects". The

superfamily may be divided into three subfamilies as follows:

A. Pupae with a distinctly bifurcate cremaster; body usually roughened with spines on the exposed surface of the thorax and abdomen; metathorax with prominent oblong tubercles on each side the meson extending one-third or more of the distance between the meson and the margin of the first pair of wings; pupae always found in the ground.

Ceratocampidae

AA. Pupae without a distinctly bifurcate cremaster; body never roughened with spines on the exposed surface of the thorax and abdomen; metathorax never with prominent oblong tubercles; pupae found either in cocoons or in the ground.

B. Pupae with a deep suture between the seventh and eighth abdominal segments, the margins of the suture with distinct crenulations; pupae found in the ground.

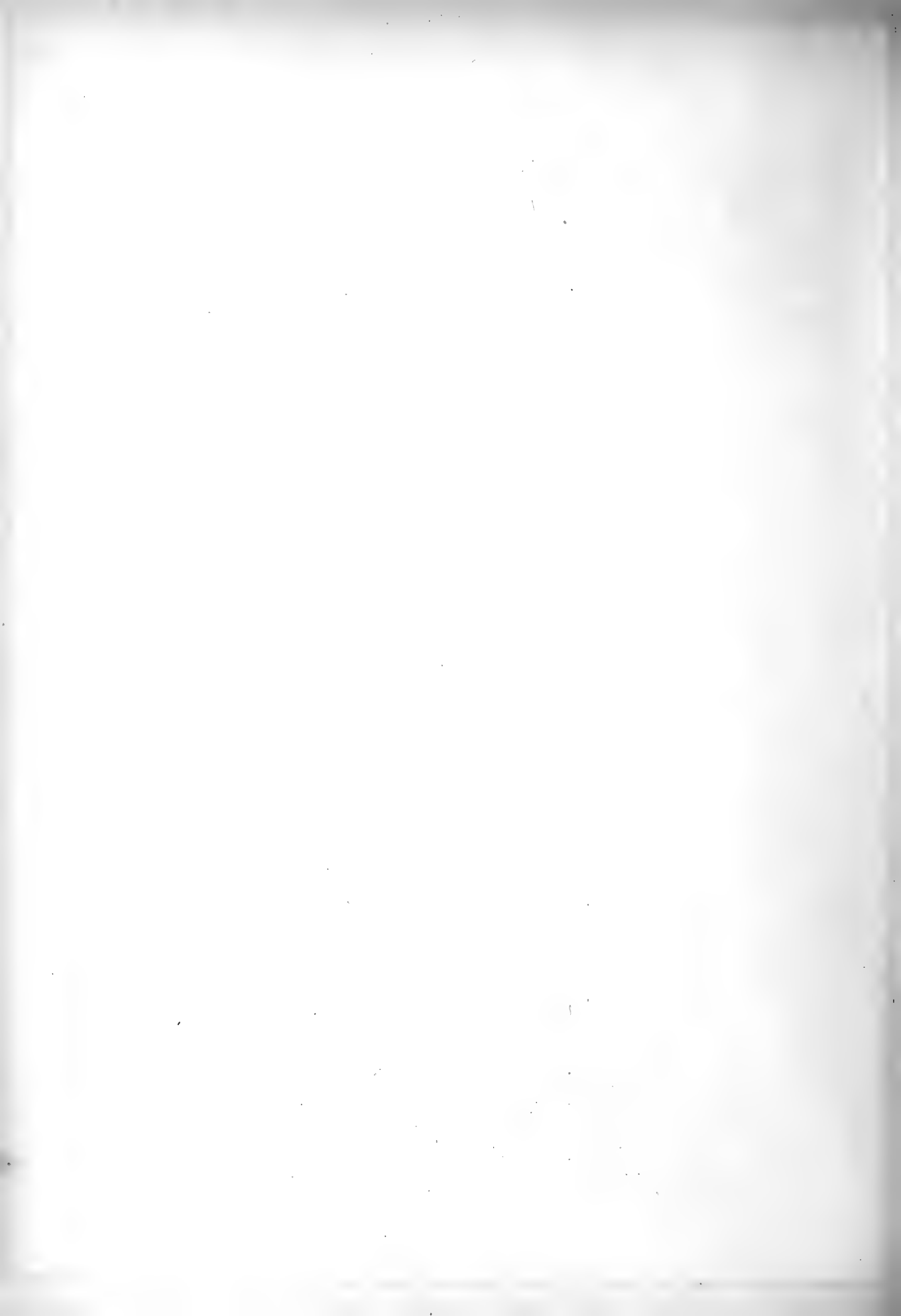
Hemileucidae

BB. Pupae never with a deep suture between the seventh and eighth abdominal segments, the suture in most cases indistinct on the dorsum, the margins never with distinct crenulations; pupae found in cocoons.

Saturniidae

VI. FAMILY CERATOCAMPIDAE

Body of io type, the free segments never capable of being telescoped, the margins of the free abdominal segments usually with a row of spines, and the exposed surface of the thorax and abdomen usually roughened with spines; antennae never



broadly pectinate throughout, but broadly pectinate and almost parallel for about one-half the length, then narrowed rapidly to about half the greatest width tapering gradually to a pointed tip, the stem of the flagellum never distinct, the surface convex and the central axis of the antenna bearing one or two rows of small spines; maxillae, measured on the meson, never less than one-fourth the length of the wings; tips of the tarsi of the second pair of legs meeting obliquely on the meson, never lying adjacent on the meson; proleg scars very prominent on abdominal segments five and six, the scars for the anal prolegs often very conspicuous; first pair of wings with the anal angles broadly rounded usually at the cephalic margin of the fourth abdominal segment and never reaching the caudal margin of the fourth segment ventrally; second pair of wings never produced below anal angle of first wing and never visible in ventral view; metathorax with distinct tubercles more or less oblong in outline on each side the meson and extending more than one-third the distance from the meson to the margin of the wing; the suture between the seventh and eighth segments never deep with distinct crenulations on its margins; cremaster always present, usually long and bifurcate at tip. Five genera of this family have been described. One genus, *Syssphinx*, consisting of three species, was not available for study. The remaining genera of Ceratocampidae can be separated by the following table:

- A. Surface of pupa never spinose; cremaster broader

than long, broadly and shallowly bifurcate, never over 2 mm. in length.

Citheronia

AA. Surface of pupa spinose; cremaster at least twice as long as broad, bifurcate at tip, always more than 2 mm. in length.

B. Thorax rugose with short isolated spines, abdominal segments not spinose, but bearing a row of spines along both cephalic and caudal margins of segments 1-7, the spines along the caudal margins of segments 5-7 much longer than the spines of the cephalic rows.

Basilona

BB. Thorax and abdominal segments densely spinose; abdominal segments 1-7 with a row of spines along both cephalic and caudal margins, the spines in the cephalic rows on abdominal segments 5-7 always much longer than the spines in the caudal rows.

C. With prominent scattered spines on the thoracic segments, at least four times as long as those covering the segments; antennae with the central axis bearing a row of prominent spines curved caudad.

D. Eighth abdominal segment never with a prominent transverse ridge in the middle of the segment bearing a row of spines; central axis of antennae with two rows of spines, the mesal row very small.

Adelocephala



DD. Eighth abdominal segment always with a prominent transverse ridge in the middle of the segment bearing a row of spines; central axis of antenna with but a single row of spines.

Dryocampa

CC. Without prominent scattered spines on the thoracic segments, the longest never four times the length of those covering the segments; antennae with the central axis never bearing prominent spines, the spines never curving caudad.

Anisota

Genus *Citheronia*

Body of io type; face parts and appendages not at all elevated; body surface not roughened with spines; eye-pieces both present; invaginations for the anterior arms of the tentorium small but distinct; clypeo-lateral suture present; labrum a little wider than long; maxillae, measured on the meson, about two-fifths the length of the wings, but little longer than the greatest width, triangular in outline; tips of the tarsi of the first and second pair of legs meet obliquely on the meson; median line distinct on all thoracic segments; mesothorax with a few minute tubercles at the bases of the wings; metathorax with a prominent oblong tubercle or plate, irregularly sculptured at the sides, on each side the meson extending more than half the width of the segment and nearly its whole length; cephalic margins of abdominal seg-

ments 5-7 produced into thin plate-like ridges; spiracular line curved slightly ventrad; cremaster short and bifurcate at tip.

This genus is found principally east of the Mississippi and consists of two species, *C. regalis* and *C. sepulchralis*. Specimens of the latter were not available for study. The pupae of *C. regalis* have a peculiar odor somewhat resembling laudanum.

Citheronia regalis:- Color dark brown, almost black; body surface usually polished, occasionally roughened with indeterminate transverse striations; antennae in both sexes with the length more than four times the greatest width and reaching about half way along the exposed portion of the second pair of legs; face parts with a slightly raised line on each lateral margin of the clypeus extending cephalad from the proximo-lateral margins of the labrum to the proximal ends of the antennae; labrum variable, five-sided, pointed at the distal end; maxillae much longer than broad, the proximal margin sinuate; prothoracic spiracle with elevated margins, the cephalic margin forming a prominent rounded ridge, each spiracle extending about one-third the distance along caudal margin of prothorax to meson; mesothorax with a small tubercle on each side the meson on the caudal half of the segment, a tubercle scar laterad of each tubercle and in line with it, and a smaller tubercle near the caudal margin of the alar area on each side; abdominal segments 2-7 with a row of punctures

near the cephalic margin, in the movable segments, at the caudal margin of the ridge and extending all around the segment; segmentation in abdominal segments 8-10 hard to determine; the eighth segment usually polished, its dorsal cephalic margin roughened and plate-like, with a row of punctures along the cephalic margin of the plate and opening cephalad; abdominal segments with two dorsal rows of tubercle scars and one ventral row; cremaster short, never exceeding two millimeters in length, broader than long and broadly and shallowly bifurcate at tip. Length $1\frac{3}{4}$ "-- $2\frac{1}{2}$ "; girth about equal to length.

Genus *Basilona*

Body of *io* type; face parts slightly elevated above the level of the appendages; body surface roughened with spines; eye-pieces both present; invaginations for the anterior arms of the tentorium small and indistinct; clypeo-labral suture present; labrum with the length and breadth approximately equal; maxilla, measured on the meson, with the length twice the greatest width and one-half the length of the wings, triangular in outline; tips of the tarsi of the first pair of legs usually meeting on the meson, but sometimes falling short so that the tips of the maxillae lie between them; tips of the second pair of legs always meeting obliquely on the meson; median line distinct on prothorax and mesothorax and sometimes showing on the cephalic half of the metathorax; metathorax with a prominent oblong roughened tubercle with fluted edges on each side the meson, extending half the distance between the

meson and the margin of the first pair of wings; cephalic margins of abdominal segments 5-7 never with any indications of a plate or ridge; spiracular line curved slightly ventrad; cremaster long, bifurcate at tip.

This genus includes a single species, *Basilona imperialis*, found in the states east of the Mississippi.

Basilona imperialis:- Color dark brown; body surface with indeterminate sculpturing and roughened with spines; antennae with the length four times the greatest width, the central axis set with a row of short spines directed caudad; face parts roughened with spines irregularly arranged, with the exception of a row extending cephalad from each proximo-lateral angle of the labrum to the proximal end of the antenna, sometimes confused with the general sculpturing; labrum variable, usually five-sided, pointed at the distal end; maxillae with the length twice the breadth, each half quadrilateral; prothorax slightly wrinkled, with a row of spines around entire margin except in the region of the spiracles; prothoracic spiracles lens-shaped, each spiracle extending less than one-third the distance across caudal margin of prothorax to meson; mesothorax with fine indeterminate transverse striations and very small spines, a spinose area extending from the meson to the alar area, a few small spines at the base of the wings; wings with the venation outlined with short spines; abdominal segments 1-8 with an interrupted row of very small spines along the cephalic margin dorsally, and with many large semicircular

to ovate punctures caudad of the spines, distributed over the cephalic third of the segment and the spiracular region, the remainder of the segment sparsely covered with smaller circular punctures; caudal margins of all abdominal segments with a row of small curved spines directed caudad, the spines larger than those on the cephalic rows, the largest on segments 8-10; lateral cephalic margins of abdominal segments 5-7 cephalad of the spiracles with three prominent transverse ridges with distinct furrows between; cremaster from 5-7 millimeters in length, a smooth dorsal concavity at the cephalic end, then strongly rugose to the bifurcate tip. Length 1-3/4"--2"; girth about equal to length.

Genus *Adelocephala*

Body of *io* type; face parts very slightly raised above the level of the appendages; body surface roughened with spines; antennae strongly convex with two rows of spines, the outer row large, prominent and curved caudad, the mesal row minute; eye-pieces both present; invaginations for the anterior arms of the tentorium small but distinct; clypeo-labral suture present; labrum broader than long; maxillae, measured on the meson, one-fourth the length of the wings, triangular in outline; distal two-thirds of the tarsi of the first pair of legs adjacent on the meson, the tips of the tarsi of the second pair of legs meeting obliquely on the meson; median thoracic line distinct on prothorax and mesothorax; mesothorax with minute tubercles and spines at bases of wings; metathorax with an oblong tuber-

cule on each side the meson, not prominently elevated but slightly rugose and polished; cephalic margins of abdominal segments 5-7 produced into prominent flange-like ridges directed cephalad and set with spines; cremaster long, bifurcate at tip.

This genus consists of a single species, *Adelocephala bicolor*, found in the Mississippi Valley and the Southern Atlantic states.

Adelocephala bicolor:— Color dark reddish brown; head, thorax and appendages finely spinose; abdominal segments both punctate and finely spinose; antennae with the length four times the greatest width; face parts with an elevated spiny ridge on each side extending cephalad from the proximo-lateral angles of the labrum to the proximal end of each antenna, bearing a prominent spine near the cephalic end and a smaller one half-way between this and the labrum; epicranial area with two prominent spines on each side the meson at the proximal end of each antenna; glazed eye-piece often lighter in color than the rest of the face parts, the sculptured portion with a prominent spiny tubercule; labrum usually six-sided, broader than long, maxillae with length and greatest width equal, each half quadrilateral; first and second pair of legs elevated and convex; cephalic portion of prothorax prominently elevated on meson sloping gradually to lateral margins, the larger spines on the elevation pointing dorsad, a slight elevation with larger spines near the meson at caudal margin on each side the meson;



prothoracic spiracles with cephalic margins arcuate, each spiracle extending one-fourth the distance along caudal margin of prothorax to meson; mesothorax with a slightly elevated ridge each side the meson with at least two bifid spines, a prominent spine at the base of each wing and another half-way between these spines and the meson; abdominal segments 1-4 with rows of minute spines along the cephalic and caudal margins of the exposed portion; abdominal segments 5-7 having the cephalic margins dorsally between the spiracles with sharp transverse ridges and distinct furrows between, ventrally with large circular punctures, the margins produced into flange-like ridges set with broad, flat, erect spines, many of them bifid; the caudal margins of abdominal segments 5-7 with similar but very much smaller spines, the spines of both cephalic and caudal rows much smaller on the venter; abdominal segments 8-10 thickly punctate, the eighth segment with a distinct lateral protuberance on each side and a prominent tubercle on the meson; ninth and tenth segments with some larger spines on the lateral margins; cremaster with a smooth V-shaped area on the proximal end at dorsum, with the point of the V prolonged down the middle of the cremaster, the remainder of the surface irregularly rugose and bifurcate at tip for about one-fourth the length, the tips divergent. Length about 1-1/4", cremaster one-seventh of total length; girth slightly less than length.

Genus *Dryocampa*

Body of *io* type; face parts elevated above the level of the



appendages; body roughened with spines; antennae with a row of prominent spines curving caudad on each central axis; eye-pieces both present; invaginations for the anterior arms of the tentorium small but distinct; clypeo-labral suture present; labrum a little wider than long; maxillae, measured on meson, one-fourth the length of the wings, triangular in outline; about half the exposed portion of the first pair of legs lying adjacent on the meson; tips of the tarsi of the second pair of legs meeting obliquely on the meson; median line elevated on prothorax and distinct on mesothorax, represented on the cephalic two-thirds of the metathorax by a clear elevated area; metathorax with a prominently elevated, oblong, polished tubercle on each side the median elevation, slightly rugose and extending at least one-third the distance from the meson to the margin of the first pair of wings; cephalic margins of abdominal segments 5-7 produced into prominent flange-like ridges directed cephalad and set with spines; abdominal segments 9-10 with prominent lateral spines; cremaster long, over one-seventh the total length of the body, bifurcate at tip.

This genus consists of a single species, *Dryocampa rubicunda*, found east of the Mississippi.

Dryocampa rubicunda: - Color dark brown to black; exposed surface of head, thorax and appendages finely spinose, the abdominal segments both punctate and spinose; face parts with an elevated spiny ridge on each side extending cephalad from the proximo-lateral angles of the labrum to the proximal end of



each antenna bearing two or three prominent spines; epicranial area with a prominent laciniate spine on each side the meson at the proximal end of each antenna directed cephalo-laterad and giving the pupa a horned appearance; glazed eye-piece usually one-third or more the entire width, the sculptured portion bearing at least one prominent spine; labrum six-sided, usually slightly sunken, pointed at distal end; maxillae with the greatest width and length approximately equal, each half triangular; prothorax with a few slightly larger spines on each side the median line; prothoracic spiracles with the cephalic margins arcuate, each spiracle extending one-fourth the distance across caudal margin of prothorax to meson; mesothorax with two prominent spines along cephalic margin near the meson a large scattered group at base of wing and half way between these two groups on each side the largest thoracic spine; abdominal segments 1-4 with a row of minute spines along both cephalic and caudal margins; abdominal segments 5-7 with the margins punctate, produced into flange-like ridges directed cephalad and bearing a row of large sharp spines occasionally bifid or trifid and about one-third the length of the segment, the caudal part of these segments with a distinct furrow near the caudal margin separating the cephalic spinose portion from a narrow smooth portion, with a row of small spines between it and the transverse conjunctiva; eighth abdominal segment with a row of large spines dorsally on the summit of a median transverse ridge, extending laterad and becoming indistinct on the ventral aspect; abdominal segments 9-10 with prominent lateral

spines curving caudad; cremaster irregularly, longitudinally rugose, bifurcate at tip with the points widely divergent. Length $7/8$ "--1"; girth less than length.

Genus *Anisota*

Body of *io* type, with the cephalic margins of abdominal segments 5-7 produced into flange-like ridges directed cephalad, and set with spines; exposed surface of head and thorax spinose, the abdominal segments both spinose and punctate; both eye-pieces present, the sculptured portion spinose; invaginations for the anterior arms of the tentorium small but distinct; clypeo-labral suture present; labrum variable, small, never twice as broad as long; maxillae, measured on the meson, always one-fourth the length of the wings, triangular in outline; tarsi of the first pair of legs adjacent on the meson, tips of the tarsi of the second pair meeting obliquely on the meson; metathorax with a prominent oblong tubercle on each side the meson, extending more than one-third the distance between the meson and the margin of the first pair of wings; cremaster always long and bifurcate at tip.

This genus includes at least five species commonly found in the United States, one of these, *A. skinneri*, is reported from Arizona, the other four from the states east of the Mississippi.

These five species can be separated by means of the following table:

A. Cremaster one-eighth or more of the total length of the body; spines on the epicranial area at the proximal end

of each antenna large and prominent, extending beyond the margin of the body in ventral view and giving the pupa a horned appearance.

B. Cremaster more than one-eighth the total length of body and bifurcate for less than one-fourth its length; small species, less than one inch in length.

A. virginiensis

BB. Cremaster about one-eighth the total length of the body and bifurcate for one-fourth its length; species one inch or more in length.

C. Face parts prominently elevated above the level of the appendages; mesothorax with at least one lacinate spine on each side the meson near the cephalic margin.

A. stigma

CC. Face parts not elevated above the level of the appendages; never with a lacinate spine on each side the meson near the cephalic margin.

A. senatoria

AA. Cremaster less than one-eighth the total length of the pupa; spines of the epicranial area at the proximal end of each antenna never extending beyond the margin of the body in ventral view, so that the pupa does not present a horned appearance.

B. Each metathoracic tubercle very prominently elevated, its length more than half the length of the seg-

ment and extending at least half the distance from the meson to the margin of the first pair of wings; color black.

A. skinneri

BB. Each metathoracic tubercule somewhat diamond shaped, never very prominently elevated, its length never as much as half the length of the segment, and never extending half the distance between the meson and the margin of the first pair of wings; color bright reddish brown.

A. consularis

Anisota virginiensis: - Color dark brown to black; abdominal segments 1-4 and 8-10 with few spines and more large circular punctures as compared with the remainder of the surface; each antenna with two rows of minute spines on the central axis, the length three times the greatest width; face parts prominently elevated above the level of the appendages, an elevated densely spinose ridge extending cephalad from the proximo-lateral angles of the labrum to the proximal end of each antenna with a large spine at its cephalic end; epicranial area with one large spine and several smaller ones on each side the meson near the proximal end of each antenna; labrum variable, ususally six-sided, with two small tubercules or spines, the width greater than the length, pointed at distal end; maxillae with the length and breadth approximately equal, each half quadrilateral; median thoracic line distinct on all segments; prothorax with the median line slightly elevated; each



prothoracic spiracle extending about one-third the distance across caudal margin of prothorax to meson; mesothorax without prominent spines, usually with two tubercle scars on each side the meson, sometimes spine-like, seldom all prominent; metathoracic tubercles wedge-shaped, irregularly impressed, black and polished, each extending less than half the distance from the meson to the margin of the first pair of wings; abdominal segments 1-3 with an indistinct row of minute spines along both cephalic and caudal margins of the segment; abdominal segments 5-7 with the cephalic margins punctate and produced into flange-like ridges projecting cephalad and set with stout spines less than one-sixth the length of the segment; caudal margins of segments 4-7 with a slight depression, the elevation adjacent to the transverse conjunctiva set with two rows of minute spines; eighth segment with a transverse ridge in the middle of the segment set with spines, with slightly larger spines on the lateral margins of the segment; ninth abdominal segment with prominent lateral spines and the tenth with a prominent hooked spine on each side the base of the cremaster; cremaster longitudinally rugose, bifurcate for less than one-fourth its length, the tips divergent. Length $7/8$ "; cremaster about one-seventh the total length; girth less than length.

Anisota stigma:- Color dark reddish brown; antennae in both sexes with the length about three times the greatest width, central axis bearing a row of minute spines; face parts prom-

inently elevated above the level of the appendages, an elevated ridge extending cephalad from each proximo-lateral angle of the labrum to the proximal end of each antenna, bearing a large lacinate spine near its cephalic end; epicranial area with a stout curved spine on each side the meson near the proximal end of the antenna; labrum variable, usually hexagonal, with two small tubercles or spines and pointed at the distal end; prothorax with the median line generally elevated, more densely spinose on each side adjacent to the meson than on the remainder of the segment; prothoracic spiracles convex on the cephalic margin, each spiracle extending slightly less than one-third of the distance along the caudal margin of prothorax to meson; mesothorax with one and sometimes two lacinate spines on each side the meson near the cephalic margin with sometimes one or two smaller spines, a scattering group of spines at the base of each wing and one spine on each side, half-way between the base of the wing and the meson which is larger than those covering the segment; metathoracic tubercles rugose, somewhat diamond-shaped, each extending about half the distance from the meson to the margin of the first pair of wings, subadjacent on the meson; abdominal segments 1-3 with a row of minute spines along both cephalic and caudal margins of the segment; cephalic margins of abdominal segments 5-7 punctate and produced into flange-like ridges directed cephalad, bearing a row of prominent, erect, triangular spines, less than one-fourth the length of the segment; caudal margins of ab-

dominal segments 4-7 with a furrow near the caudal margin of the segment and a row of spines on the elevation at the junction of the segment and the transverse conjunctiva, these spines about one-third the size of the spines in the cephalic rows; abdominal segments 8-10 with fewer spines and more punctures on the surface; the eighth abdominal segment with a prominent transverse ridge in the middle of the segment, with a slight protuberance on each lateral margin, the transverse ridge set with spines similar to those along the caudal margins of segments 4-7, a smaller row along the caudal margin of the segment; ninth abdominal segment with two rows of spines near the caudal margin with two or three prominent ones along each lateral margin; tenth segment with two or three prominent spines along each lateral margin at the proximal end of cremaster; cremaster with a smoother, triangular depressed area dorsally at proximal end, the remainder of the surface rugose with wavy longitudinal ridges, the caudal end bifurcate for less than one-fourth of the length, the tips divergent. Length 1"--1-1/8"; cremaster about one-ninth the total length; girth equal to length.

Anisota senatoria:- Color dark brown to black; antennae scarcely convex, each central axis with two rows of minute spines, length about three times the greatest width; face parts slightly elevated above the level of the appendages; no prominent ridge extending cephalad from each proximo-lateral angle of the labrum, but a prominent curved spine on each side

the cephalic part of clypeal area adjacent to the proximal end of each antenna; epicranial area with a prominent curved spine at the proximal end of each antenna and usually one or two smaller ones; labrum usually six-sided, broader than long, usually with two small tubercles, slightly pointed at the distal end; maxillae with the length slightly greater than the greatest width, each half quadrilateral; prothorax with a dense row of slightly larger spines on each side the median line, prothoracic spiracles slit-like, each spiracle extending one-third of the distance along caudal margin of prothorax to meson; mesothorax with a tubercle scar on each side the meson indicated by a small polished area; mesothorax without prominent spines; metathorax with the tubercles oblong, slightly rugose, black and polished, each extending less than half the distance from the meson to the margin of the first pair of wings; abdominal segments 1-3 with a row of minute spines along the cephalic and caudal margins of each segment; cephalic margins of abdominal segments 5-7 with one distinct furrow dorsally and punctate around entire segment, produced into flange-like ridges bearing stout spines about one-fourth the length of the segment; abdominal segments 4-7 with a distinct depression near the caudal margin of the segment and with a caudal row of small spines between the segment and the transverse conjunctiva, with an interrupted row of smaller spines just cephalad; eighth abdominal segment with a distinct median transverse ridge bearing spines similar to those on the ceph-

alic margins of segments 5-7, a row of small spines along the cephalic margin of the ninth abdominal segment with two rows of spines near the caudal margin of the segment and several prominent lateral spines; tenth abdominal segment with one or two prominent lateral spines at the proximal end of the cremaster, smaller than those on the ninth segment; cremaster with a slightly depressed heart-shaped area at the proximal end with fine longitudinal ridges, about three-fifths of the remaining length finely rugose, the distal end smooth, bifurcate for about one-fourth its length, the tips slightly divergent. Length 1-1/8"--1-1/4"; cremaster about one-ninth the total length; girth less than length.

Anisota skinneri:- Color dark brown to black; antennae with the length three times the greatest breadth, a row of minute spines on the central axis of each antenna; face parts slightly raised above the level of the appendages, the ridge extending cephalad from each proximo-lateral angle of the labrum scarcely indicated, a medium sized lacinate spine on the face parts near the proximal end of each antenna; epicranial area with a long lacinate prominence or ridge, which is never horn-like, with a small spinose tubercule caudad of it on each side the meson near the proximal end of each antenna; labrum variable, usually five-sided, broadly rounded or slightly pointed at the distal end; maxillae with the length and breadth approximately equal, each half quadrilateral; prothorax more densely spinose on each side adjacent to the med-

ian line, each spiracle with its margins convex, the caudal margin only slightly so, and extending less than one-third the distance along caudal margin of prothorax to meson; mesothorax without any especially prominent spines; metathoracic tubercle strongly elevated, ovate, irregularly impressed, almost adjacent on the meson, and extending half the distance from the meson to the margin of the first pair of wings; abdominal segments 1-4 with a row of minute, closely set spines along both cephalic and caudal margins of the segment; cephalic margins of abdominal segments 5-7 dorsally with sharp transverse ridges with distinct furrows between and punctate around entire segment, produced into flange-like ridges set with spines only about one-eighth the length of the segment; abdominal segments 4-7 with a distinct furrow near the caudal margin of the segment and two distinct rows of minute spines between the segment and the transverse conjunctiva; eighth abdominal segment with a slightly elevated transverse ridge in the middle of the segment set with small spines and another row at the caudal margin of the segment; ninth abdominal segment with two rows of spines at the caudal margin of the segment, some spines slightly more prominent at each lateral margin; tenth abdominal segment with a small lateral spine on each side the cremaster; cremaster with a small, triangular, slightly depressed area at the proximal end of cremaster dorsally, but rugose much like the remainder of the surface, bifurcate at tip for less than one fourth the length, the tips

not divergent. Length $1\frac{3}{8}$ "-- $1\frac{5}{8}$ "; cremaster about one-tenth total length; girth exceeding length.

Anisota consularis:- Color bright reddish brown; antennae with the length about four times the greatest width; face parts slightly raised above the level of the appendages, an elevated ridge extending cephalad from each proximo-lateral angle of the labrum to the proximal end of each antenna and bearing several prominent spines; epicranial area with a large spine on each side the meson near the proximal end of each antenna; labrum variable, usually five-sided, broader than long and bearing two minute tubercles or spines, slightly pointed at the distal end; maxillae with the length greater than the breadth, each half quadrilateral- prothorax with a larger spine on each side the median line near the middle of the segment; each prothoracic spiracle with its cephalic margin slightly convex and extending one-fourth the distance along the caudal margin of prothorax to the meson; mesothorax without any especially prominent spines, a few longer ones at the base of each wing; metathoracic tubercles irregular, somewhat diamond-shaped, black and polished, irregularly impressed or punctate, each tubercle extending less than half the distance from the meson to the margin of the first pair of wings; abdominal segments 1-4 with a row of very minute spines on each cephalic and caudal margin; abdominal segments 5-7 with the cephalic margins punctate and produced into flange-like ridges directed cephalad and set with spines less than one-sixth the

length of the segment, a smooth band at the caudal margin of the segments and a row of small spines along the segment adjacent to the transverse conjunctiva almost wanting on the seventh segment; eighth segment with a row of spines on a slight transverse ridge in the middle of the segment, becoming indistinct in ventral view, the caudal row of spines indistinct dorsally but very distinct laterally and ventrally; ninth abdominal segment with a caudal row of spines, a prominence on the lateral margin set with longer spines; the tenth segment with two prominent lateral spines on each side of the cremaster; cremaster with a small, triangular depressed area, much smoother than the remainder of the surface, which is longitudinally rugose, bifurcate for about one-fourth the length, the tips divergent. Length $1-1/8''$ -- $1-3/8''$; cremaster less than one-eighth the total length; girth equal to length.

VII. FAMILY HEMILEUCIDAE

Body io type; the margins of the free segments never with a row of spines; the body surface never roughened with spines; antennae with the stem of the flagellum never distinct, the central axis never set with spines, the antennae tapering gradually from the part with the greatest width; maxillae measured on the meson never more than one-sixth the length of the wings; proleg scars never prominent on abdominal segments five and six and rarely with the anal proleg scars visible; first pair of wings with the anal angles broadly rounded usually at the cep-

alic margin of fourth abdominal segment, and usually reaching the caudal margin of the fourth abdominal segment ventrally; second pair of wings never produced below the anal angles of the first pair of wings and never visible in ventral view; metathorax never with prominent tubercles; abdominal segments 5-7 with their cephalic margins produced into thick oblique flange-like plates directed cephalad, never with transverse ridges; suture between the seventh and eighth segments deep with distinct crenulations along both margins; cremaster short never bifurcate at tip.

The description of this family is of necessity very incomplete owing to lack of material. According to the available knowledge of the subject the two genera described may be separated as follows:

A. Cremaster bearing setae arranged in a transverse row, and spreading out fanlike.

Pseudohazis

AA. Cremaster never with setae, either with curved spines or without spines or setae of any kind.

Hemileuca

Genus *Hemileuca*

Body of io type; face parts slightly elevated above the surface of the body; antennae with the stem of the flagellum indistinguishable from remainder of surface, entire surface flat to uniformly convex, tapering gradually to a point at the distal end; invaginations for the anterior arms of the tentorium distinct; eye-pieces both present; clypeo-labral su-

ture generally distinct; maxillae, measured on meson, never more than one-sixth the length of the wings, each half quadrilateral; less than half the exposed tibiae and the tarsi of the first pair of legs with the tips of the second pair of legs adjacent on the meson; second leg visible for almost entire tibial and tarsal length; median thoracic line always distinct on prothorax and mesothorax, seldom on metathorax; first pair of wings with the anal angles broadly rounded near cephalic margin of fourth abdominal segment; second pair of wings visible along entire dorsal margin of first wing, its margin entire, but never produced beyond anal angle of first pair of wings and never visible on the ventral surface; spiracular line almost straight; cephalic margins of abdominal segments 5-7 produced into thick, oblique flange-like plates; suture between the seventh and eighth abdominal segments deep, both margins strongly crenulate, the crenulations of the two sides fitting together like a set of teeth; cremaster short, pointed, never exceeding two millimeters in length.

This genus includes at least nine species found in the United States, only three of which are described here. The most common species is *H. maia*, which is found from the Atlantic states westward to the Rocky Mountains. The others are reported from the western states. These moths spend their pupal life in the ground. The species described can be separated by the following key:

A. Cremaster without recurved spines.

B. Clypeal region strongly convex; labrum strongly elevated; maxillae short, inconspicuous, each half triangular in outline and length on meson less than a millimeter; mesothorax with a tubercle on each side the meson outlined by a depressed ring.

H. barnsii

BB. Clypeal region not strongly convex; labrum not elevated; maxillae conspicuous, each half quadrangular in outline and meeting on meson for at least a millimeter; mesothorax without tubercles on each side the meson.

H. maia.

AA. Cremaster with a group of strongly recurved spines.

H. hualapai, var oliviae

Hemileuca maia:- Color dark brown; face-parts and appendages with fine transverse striations, remainder of surface shagreened, excepting abdominal segments 8-10; face-parts without a prominent convexity in clypeal region; antennae in male with length four times the width, the sides parallel for at least the proximal two-thirds of their length and then tapering rapidly to a point, reaching just below the tips of the first pair of legs; clypeo-labral suture sometimes indistinct; labrum about twice as broad as long, quadrate and broadly truncate at distal end; maxillae, measured on meson, one-sixth the length of wings, its median length less than its greatest breadth; prothoracic spiracle when closed almost invisible; first pair of wings with their anal angles at the cephalic^{margin} of fourth abdominal segment; abdominal segments 1-4 and 7-8 with

distinct furrows between, their margins wavy, more apparent on the cephalic margins of the segments; abdominal segments 5-7 with their cephalic margins produced into thick flange-like plates covered with fine longitudinal striations and a distinct smooth furrow at the caudal margin of the segment, adjoining the transverse conjunctiva; cremaster nearly two millimeters in length, indefinitely rugose, triangular in outline, pointed at distal end and without hooks. Length, abdomen retracted, about 1", firth about 1-1/4". Described from male specimens only.

Hemileuca barnsii:- Color dark brown; face parts and appendages with fine, transverse striations, the remainder of the body surface shagreened; face parts with a prominent convexity in the clypeal region; antennae of male with length three times the width, tapering from the region of greatest width to form a long, pointed tip at distal end, ending opposite the tips of the first pair of legs; clypeo-labral suture distinct, labrum elevated, somewhat shield-shaped, rounded at distal end; maxillae very short, scarcely visible, each half of maxilla triangular, much broader than long; prothoracic spiracles with strongly elevated margins, each spiracle measuring about two-fifths of the distance across caudal margin of prothorax to meson; mesothorax with a prominent tubercle on each side the meson, outlined by a depressed ring; first pair of wings with their anal angles nearly opposite the caudal margin of the fourth abdominal segment; sutures between abdom-

inal segments 1-4 distinct, margins of adjoining segments crenulate, suture between segments 7-8 very prominent, the dorsal cephalic margin of the suture with longitudinally corrugate ridges, the caudal margin crenulate; abdominal segments 5-7 with their cephalic margins produced into a prominent, flange-like plate, with longitudinal striations, never more than indications of a furrow at caudal margins of segments, an elevated roughened line between the caudal margin of the segment and the transverse conjunctiva; cremaster short, not more than a millimeter in length, triangular, rugose, ending in a blunt tip at distal end, without spines. Length about 7/8"; girth about 1".

Described from one male specimen, for which we are indebted to Dr. Wm. Barnes, of Decatur, Illinois.

Hemileuca hualapai var. olivae:- Color dark brown; surface of body with interrupted transverse striations or impressions; face-parts slightly elevated, but without a prominent convexity in clypeal region; antennae in male with length a little more than three times the width, the sides parallel for at least two-thirds of the distance and then tapering to form a blunt rounded tip, ending opposite tips of second pair of legs; clypeo-labral suture distinct; labrum with length and breadth approximately equal, five-sided, with a sharp point at distal end; maxillae, measured on meson, about one-seventh the length of the wings, each half the maxilla quadrilateral, distance between the parallel sides about equal to the length on meson; each prothoracic spiracle with a slightly raised

roughened margin, extending about one-third the distance along caudal margin of prothorax to meson; first pair of wings with their anal angles nearly opposite the caudal margin of the fourth abdominal segment; suture between abdominal segments 1-3 distinct, cephalic margin of suture approximately smooth, caudal margin of suture irregularly corrugated and on the fourth segment depressed, between segments 7-8 slight, the caudal margin of the seventh segment slightly raised above the eighth segment; abdominal segments 5-7 produced into thin flange-like plates, the margins slightly undulate, a distinct furrow at the caudal margin adjoining the transverse conjunctiva; cremaster triangular, the distal end covered with sharply recurved spines. Length $7/8$ "--1"; girth about 1-1/4".

Described from one male specimen, for which we are indebted to Dr. Wm. Barnes, of Decatur, Illinois.

Genus *Pseudohazis*

Body of *io* type; median thoracic line distinct on the prothorax and mesothorax, faint on the metathorax; first pair of wings with the anal angles broadly rounded, near the cephalic margin of the fourth abdominal segment; second pair of wings visible along entire dorsal margin of first wing, its margin entire, but never produced beyond the anal angle of first pair of wings and never visible in ventral view; spiracular line straight; cephalic margins of abdominal segments 5-7 produced into thick, oblique, flange-like plates directed caudad; suture between the seventh and eighth abdominal segments deep, the cephalic margin with distinct crenulations

along both margins, the cephalic margin with quadrangular depressions, the caudal margin with deep longitudinal furrows; cremaster short, bearing a fan-shaped group of long straight setae.

This genus and species have been described from a single specimen kindly loaned by the American Museum of Natural History through the kindness of Mr. J. A. Grosbeck. Unfortunately the specimen had lost its prothorax, face parts, and all appendages except the wings. These descriptions are included, however, to show the relationship of this genus to the genus *Hemileuca*. Little is known of its life history, but owing to its close relationship to *Hemileuca* it probably spends its pupal life in the ground. There are three species named in Dyar's "List of North American Lepidoptera", all from the western part of the United States.

Pseudohazis eglanterina:— Color dark reddish brown; exposed surface of thorax, wings and abdomen coarsely shagreened; abdominal segments 5-7 with their flange-like plates shagreened like the remainder of the segment, except for a few faint longitudinal striations near the margin; abdominal segments 4-8 with a raised transverse line near the caudal margin of the segment; cremaster about one millimeter in length, indefinitely rugose, conical, bearing a fan-shaped group of coarse, straight setae. Length, abdomen expanded, about 1-1/8"; girth 1-1/2".

Body of two distinct types, either the cecropia type with abdominal segments 5-7 capable of being telescoped, or of io type with the cephalic margins of the segments produced into distinct flange-like plates, but the exposed surface of the thorax and abdomen never roughened with spines; antennae broadly pectinate throughout, or nearly so, the stem of the flagellum usually distinct and raised above the level of the pectinations; maxillae, measured on the meson, never more than one-third the length of the wings; the exposed portion of the tibiae and tarsi of the first pair of legs, and the tips of the second pair of legs with their lateral margins adjacent on the meson, never with the distal ends of the tarsi of the first and second pairs of legs meeting obliquely on the meson; first pair of wings with the anal angles broadly rounded and always reaching the caudal margin of the fourth abdominal segment on the ventral surface; second pair of wings produced around the anal angles of the first pair of wings and usually forming prominent angles on the fourth abdominal segment, always extending at least a short distance along the ventral margin of the first pair of wings; metathorax without distinct oblong tubercles one-third or more the width of the segment; suture between the seventh and eighth abdominal segments never deep with distinct crenulations on its margins; cremaster, if present, very short and never bifurcate at tip.

Of the family Saturniidae, the pupae of nine genera have been described in the following pages. They may be separated



by the following key:

A. Body never of typical cecropia shape, but modified in some way, or of io type; caudal end of body usually with stout, curved spines.

B. Body of io type; cremaster always present.

Automeris

BB. Body of modified cecropia type; cremaster absent.

C. Tenth segment never flattened into a transverse plate, with the caudo-lateral angles produced into short lobes.

D. Caudal end of body without spines; body surface with slightly wavy, transverse ridges, with distinct furrows between; mesothorax never with a prominent tubercule at the base of each wing.

Copaxa

DD. Caudal end of body with stout, curved spines; body surface never with slightly wavy, transverse ridges with distinct furrows between; mesothorax with a prominent tubercule at the base of each wing.

E. Lateral aspects of the cephalic margins of abdominal segments 5-7 never with sharp, slightly wavy, transverse ridges with distinct furrows between; caudal end of body with an oval area set with

slightly curved spines, usually arranged in two groups and nearly all pointing outwards.

Telea

EE. Lateral aspects of the cephalic margins of abdominal segments 5-7 covered with sharp, slightly wavy, transverse ridges with distinct furrows between; caudal end of body deeply rugose, with a slight concavity containing a circular group of strongly recurved spines.

Tropaea

CC. Tenth segment, viewed dorsally, a transverse plate, concave on the caudal margin, the caudolateral angles produced into lobes, the segment strongly concave in ventral view, with five short, curved spines inserted close together in the caudolateral margin of each lobe.

Agapema

AA. Body of typical cecropia shape, without a cremaster; the caudal end of the body never with stout curved spines.

B. Maxillae, measured on the meson, always one-fourth or less the length of the wings, the proximal two-thirds of their margins never strongly concave; first pair of wings with their anal angles on the cephalic margin of the fourth abdominal segment or caudad of that portion of the segment.

C. Maxillae, measured on the meson, less than

one-fifth the length of the wings; antennae of males with the sides tapering gradually to a pointed tip.

D. Both eye-pieces never visible in either sex; glazed eye-piece seldom visible in females, never in the males; if glazed eye-piece is visible, then the caudal end of the abdomen with a few very short, straight spines; caudal end of abdomen never with a band of coarse setae.

Callosamia

DD. Both eye-pieces visible in either sex; caudal end of abdomen with a transverse band of coarse setae.

Rothschildia

CC. Maxillae, measured on the meson, never less than one-fifth the length of the wings; antennae of males with the sides approximately parallel for the greater part of their length, tapering rapidly to a blunt rounded tip; a small portion of glazed eye-piece always visible in the females.

Samia

BB. Maxillae, measured on the meson, always more than one-fourth the length of the wings; the proximal two-thirds of the lateral margins of the maxillae concave; first pair of wings with their anal angles on the third abdominal segment, opposite the second pair of abdominal spiracles.

Philosamia



Genus Automeris

Body of io type; face parts not noticeably elevated above the body surface; antennae pectinate throughout, tapering gradually to a point at the distal end, the stem of the flagellum never noticeably raised above the level of the pectinations; sexual differences, if any, very slight; invaginations for the anterior arms of the tentorium obscure; eye-pieces both present; clypeo-labral suture usually distinct; maxillae, measured on meson, never more than one-sixth the length of the wings, triangular in outline; less than half the exposed tibiae and the tarsi of the first pair of legs and tips of the second pair adjacent on the meson; second leg visible for almost entire tibial and tarsal length; median thoracic line faint, and seldom found on all segments; first wing with anal angle broadly rounded, near the cephalic margin of fourth abdominal segment; second wing visible around the entire dorsal margin of first wing, its margin entire and produced around anal angle of first wing to form a prominent angle on the fourth abdominal segment, scarcely visible in ventral view; spiracular line slightly curved ventrad; cephalic margins of abdominal segments 5-7 with sharp, transverse ridges having distinct furrows between, and produced into an oblique flange-like plate, generally hidden when segments are retracted; abdominal segments 8-10 taper gradually to caudal end; cremaster always distinct and set with hooked spines.

This genus includes perhaps more than a dozen species in

North America of which four species are described here. These all spin cocoons. Our common species, *A. io*, which is found all over the Eastern United States and Mexico, spins a thin brown "papery" cocoon much like *Tropaea luna* but thinner and more shapeless. They are found on the ground usually with a projecting leaf attached and are thin enough so that the pupa may usually be seen through the cocoon. *A. pamina* is described from Arizona and Mexico. Its cocoon is much like that of *A. io* with many small leaves securely fastened to it. The cocoon of *A. incarnata* of Mexico is very similar to the preceding forms but thicker and covered with leaves. The cocoon of *A. leucana* is shaped much like that of *Samia cecropia* and covered with small pieces of bark. It is also a Mexican species. These four species can be separated by using the following table:

A. *Cremaster triangular*, at least two millimeters long, with a transverse row of hooked spines curving dorsad; cephalic margins of abdominal segments 5-7 produced into an oblique, flange-like plate with an undulate margin produced into prominent curves dorsad of the spiracular line.

A. leucana

AA. *Cremaster* never triangular, usually only a button-like constriction with a thickly set group of strongly recurved spines, the tips curving outward in all directions; cephalic margins of abdominal segments 5-7 produced into an oblique flange-like plate with its margin entire, never produced into curves dorsad of the spiracular line.

B. Mesothorax with fine indeterminate transverse

striations; body setae conspicuous.

Automeris io

BB. Mesothorax never with fine indeterminate transverse striations; body setae inconspicuous.

C. Mesothorax rugose; a small tubercule each side the meson on the metathorax and first three abdominal segments.

A. pamina

CC. Mesothorax tuberculate with blunt conical projections; never with small tubercules each side of the meson on the mesothorax and first three abdominal segments.

A. incarnata

Automeris pamina: - Color dark brown; body setae inconspicuous, light brown, few in number; face parts and appendages with fine, indeterminate transverse striations; exposed surface of thorax rugose, remainder of surface finely shagreened; length of antennae in both sexes more than four times the breadth and ending in line with the tips of the first pair of legs; labrum variable, length and breadth approximately equal, usually six-sided and pointed at distal end; maxillae, measured on meson, about one-sixth the length of the wings, triangular in outline, median length greater than the greatest width; each prothoracic spiracle measures about one-third the distance across caudal margin of prothorax to meson; cephalic margins of abdominal segments 5-7 with fine ridges, becoming indistinct on the meson of both dorsal and ventral surfaces,

the margin produced into a flange-like plate with its margin entire, never produced into prominent curves; dorsal surface of abdominal segments 4-7 with a smooth, elevated line just cephalad of the junction of segment and transverse conjunctiva, extending laterad and ending beyond the spiracles on ventral surface; dorsal and lateral surfaces of tenth abdominal segment rugose with irregular, longitudinal depressions at the base of cremaster. Cremaster short, constricted slightly at base and forming a rounded protuberance with a closely set group of strongly recurved spines, the tips turning outward in all directions. Length, abdomen expanded, from 1-1/8"--1-1/4"; girth about 1-3/4".

Automeris io:- Color dark brown; body setae conspicuous, light brown, sparsely distributed over entire surface excepting appendages, most numerous on thorax; body often noticeably depressed; face parts, appendages except the wings, and exposed surface of thorax with fine, indeterminate, transverse striations, remainder of surface shagreened, with the projections in transverse rows; antennae in both sexes with length three times the width and quite reaching the tips of the first pair of legs; labrum variable, broader than long, usually five-sided and pointed at the distal end; maxillae, measured on meson, about one-sixth the length of wings, median length always less than the greatest width, each half the maxilla quadrilateral, sometimes modified so that entire maxilla appears heart-shaped; median thoracic line narrow, usually visible on

all segments; each prothoracic spiracle extending less than one-third the distance along caudal margin of prothorax to meson; abdominal segments 5-7 with the cephalic margins covered with sharp transverse ridges, with distinct furrows between, the furrows becoming shallower at the meson on the ventral surface, the flange-like plate with its edges entire; abdominal segments 4-7 with a distinct furrow of varying width between the segment and the transverse conjunctiva, which becomes indistinct in the region of the proleg scars on the ventral surface, its cephalic margin being indicated by a raised line; abdominal segments 8-10 with segmentation distinct; dorsal surface of tenth abdominal segment with deep, longitudinal ridges at base of cremaster; tip of cremaster with a small group of closely set, sharply recurved spines, the hooks turning outward in all directions. Length, abdomen retracted, $7/8''$ -- $1-1/4''$, expanded $1''$ -- $1-3/8''$; girth $1-3/4''$ -- $2''$.

Automeris leucana:- Color dark brown; body setae light brown, inconspicuous; face parts and appendages with indeterminate, transverse striations, exposed surface of thorax rugose, with interrupted transverse ridges; remainder of surface coarsely shagreened; antennae in both sexes with the length more than four times the breadth, not extending as far caudad as the tips of first pair of legs; labrum variable, length and breadth approximately equal, pointed at tip, usually five-sided; maxillae, measured on meson, about one-seventh the length of wings, the greatest width about one and one-half

times the median length, each half the maxilla quadrilateral; median thoracic line very narrow, only distinct on the mesothorax; each prothoracic spiracle measures about one-third the distance along caudal margin of prothorax to meson; abdominal segments 5-7 with the cephalic margin ridged, produced into an oblique flange-like plate with an undulate margin having prominent curves dorsad of the spiracular line, the median line of cephalic margin indicated by oblique ridges, a slightly raised, smooth line cephalad of the junction of the segment and the transverse conjunctiva; tenth abdominal segment having the dorsal and lateral margins of the cremaster with semi-longitudinal ridges at base of cremaster; cremaster at least two millimeters in length, triangular in outline, tapering rapidly to a pointed tip with a transverse row of sharply recurved spines, the tips curving dorsad. Length, abdomen expanded, 1-1/4"--1-5/8"; girth about 1-3/4".

Automeris incarnata:- Color dark brown to blackish, transverse conjunctiva lighter; body setae light brown, inconspicuous; face parts and appendages with wavy, indeterminate transverse striations, exposed surface of thorax tuberculate with blunt, conical projections; antennae in both sexes with length about four times the width and ending opposite the tips of the first pair of legs; labrum variable, broader than long, usually five-sided, pointed at distal end; maxillae, measured on meson, about one-sixth the length of the wings, median length less than greatest width, each half quadrilateral, lateral mar-

gins concave, basal half sculptured and roughened; median thoracic line wanting except on metathorax; each prothoracic spiracle small, less than one-third the distance across the caudal margin of prothorax to meson; dorsal and lateral projections of cephalic margins of abdominal segments 5-7 with fine, sharp, transverse ridges becoming indistinct in the region of the proleg scars, the cephalic margin narrower in this region and produced all around segment into a very narrow, flange-like plate with a distinct longitudinal impression at meson; abdominal segments 4-7 with a raised line cephalad of the line between the segment and the transverse conjunctiva; tenth abdominal segment rugose at base of cremaster; the cremaster short, rounded, constricted at base and set with a small group of closely set, sharply recurved spines, the tips turning outward in all directions. Length, abdomen contracted, about 1", expanded about 1-1/8"; girth about 1-1/2".

Genus Copaxa

Body of modified cecropia shape, tapering at cephalic end; face parts scarcely elevated above the surface of the body; antennae pectinate throughout, the stem of the flagellum slightly elevated above the pectinations and about one-third the total width of the antenna; glazed eye-piece visible in the female; invaginations for the anterior arms of the tentorium distinct; clypeo-labral suture distinct; maxillae, measured on the meson, about one-seventh the length of the wings; tarsi of the first pair of legs adjacent on the margin in the female, covered by

the antennae in the male; second pair of legs not visible; median thoracic line distinct, sometimes elevated on the prothorax, faint on the mesothorax and metathorax; caudal part of mesonotum and metanotum not depressed adjacent to wings; wings with their distal margins slightly elevated above the dorsal surface of the body; first pair of wings with their anal angles broadly rounded, its exact location hard to determine; second pair of wings visible around the entire dorsal margin of first wing and produced below the anal angle to form a prominent angle opposite the third abdominal spiracle, but not reaching the caudal margin of the fourth abdominal segment; spiracular line curved ventrad; abdominal segments 8-10 distinctly segmented, tapering rapidly to form a cone.

This genus is found in Mexico and southward. The cocoons are brown, composed of two layers and are much like those of *Agapema galbina*. The outer layer is very thin and coarsely reticulate, usually attached to a leaf. The inner layer is much thicker, finely reticulate, and the cocoon has an opening at the end with loose fibers for the emergence of the moth.

Copaxa lavendera:- Color variable, usually yellowish brown to black, marked with darker brown, or dark brown to black, with traces of yellowish brown; face-parts with fine, indeterminate longitudinal striations, appendages and wings with indeterminate transverse striations, remainder of body surface with slightly wavy, interrupted ridges, mostly transverse, with distinct furrows between; antennae of male slightly raised above

the level of the wings, the length about two and three-quarters times the width, the sides approximately parallel for the greater part of the length, tapering to a point at distal end and lying adjacent on the margin for a distance equal to its width; antennae of female not raised above the level of the wings, the length three and one-half times the width, tapering to a point at the distal end, the tips meeting on the meson over the tips of the first pair of legs; labrum variable, the width a little greater than the length, usually five or six sided, slightly tuberculate, and broadly rounded or slightly bi-lobed at the distal end; maxillae triangular in outline or somewhat heart-shaped, the median length slightly less than the greatest width; spiracles free. Length, abdomen retracted, 1-1/8"--1-3/8", expanded, 1-1/4"--1-1/2"; girth 1-1/2"--1-5/4".

Genus Telea

Body of modified cecropia shape, abdominal segments 1-4 rounded out above the margin of the body dorsad and forming a distinct hump, segments 5-7 distinctly decreasing in size and caudal margin of segment seven joining cephalic margin of segment eight with only a slight indentation between; antennae pectinate throughout, varying greatly with the sexes, the stem of the flagellum in both always less than one-third the total width; eye-pieces not visible; invaginations for the anterior arms of the tentorium distinct; clypeo-labral suture distinct; maxillae, measured on meson, about one-fourth length of wings; legs in the male covered by antennae, in the female

tarsi of first pair and tips of second pair adjacent on the meson; median thoracic line carinate on all segments; mesothorax with a prominent tubercle at base of wings; caudal part of mesonotum and metanotum depressed adjacent to the wings; wings with their distal margin raised above the dorsal surface of body; dorsal cephalic margins of abdominal segments 5-7 form a heavy raised line extending laterad and cephalad of the spiracles to the proleg scars on the ventral surface; spiracular line curved ventrad; abdominal segments 7-10 tapering rapidly, forming an oblique convex cone-shaped piece; cremaster absent; tip of abdomen with a small oval area set with fifteen or more stout, black, slightly curved spines, usually arranged in two small groups and nearly all pointing outwards.

This genus consists of a single species, *Telea polyphemus*, found in all parts of the United States. Their cocoons consist of a thick, firm layer, never "papery" like those of *Tropaea luna*. The cocoons are pale grayish tan in color, ovoid in shape, blunt at the ends and usually fastened between two leaves. It never has an opening at the end with loose fibers across it, as many cocoons have. It is found suspended from twigs where it often fastens the leaf to a tree and is also found on the ground among the fallen leaves.

Telea polyphemus:- Color yellowish brown, with darker brown around margins of spiracles, and appearing at various places on surface as the age increases; face parts not ele-

vated, always white between the antennae, the white strip narrowing down to the proximal margin of the labrum and concave on its lateral margins; prothorax and mesothorax with faint transverse striations, remainder of body surface smooth, with the exception of longitudinal wrinkles on the metathorax and first abdominal segment and some slight dorsal impressions; antennae of male five-sixths the length of wings on the meson, length twice the width, meeting on the meson for more than half their length; antennae of the female two-thirds the length of wings on the meson, length three times the width, separated by the legs and ending slightly below tips of the first pair; labrum variable, tuberculate, generally five or six sided, the distal margin either slightly or deeply bilobed; maxillae triangular in outline, the mesal length greater than greatest width; mesothorax with wing tubercles prominent, broadly elevated, with a distinct apex marked by an angular furrow on the caudo-mesal margin; first wing with its anal angle broadly rounded, below cephalic margin of fourth abdominal segment; margin of second wing entire in the female, slightly emarginate in the male, visible along entire dorsal margin of first wing, and produced below anal angle of first wing, extending about two-fifths of the distance across its caudal margin; each prothoracic spiracle with its cephalic margin strongly convex and extending less than one-third the distance across caudal margin of prothorax to meson; spiracular line curved ventrad. Length, retracted, $7/8''$ -- $1-3/8''$, expanded, $1''$ -- $1-1/2''$;

girth about 2".

Genus *Tropaea*

Body of modified cecropia shape, abdominal segments 5-7 distinctly tapering, body round, but depressed as compared with cecropia type; face parts never elevated above the surface of the body; antennae pectinate throughout, the stem of the flagellum elevated above the level of the pectinations and more than one-third the total width; invaginations for the anterior arms of the tentorium distinct; eye-pieces both visible; clypeo-labral suture distinct; maxillae, measured on meson, about one-eighth the length of wings; about half the tibiae and the tarsi of the first pair of legs and the tips of the second pair of legs adjacent on the meson; median line distinct on all thoracic segments; each prothoracic spiracle about one-fourth the distance along the caudal margin of prothorax to meson; mesothorax with a prominent tubercle at base of wings and a slight depression along lateral margin of alar area; caudal part of mesonotum and metanotum not depressed adjacent to wings; wings with their distal margins not elevated above the surface of the body; abdominal segments 5-7 with the lateral aspects of the cephalic margins covered with sharp, slightly wavy, transverse ridges with distinct furrows between, the cephalic margin narrowed on the dorsum, the furrows extending dorsad about two-thirds of the distance between the spiracular line and the meson and ventrad less than half way between the spiracular line and the meson, the fur-

rows usually concealed when the abdomen is retracted; spiracular line curved slightly ventrad; abdominal segments 8-10 tapering quickly to form a convex cone-shaped piece; caudal end of body deeply rugose with a slight concavity containing a circular group of strongly recurved spines, the curved tips all pointing toward the center of the group.

This genus is found throughout the Atlantic States and the Mississippi Valley, and includes a single species in this country. The cocoon is ovoid, thin and "papery" on the outside, with a thin inner layer of loose fibers of silk, but it has no opening at the end with loose fibers of silk closing it, as in *Callosamia promethea*. The cocoon is usually brown in color, and is found among the leaves on the ground under the food plant.

Tropaea luna:- Color generally chestnut brown with an irregular white blotch extending between the proximal ends of the antennae; face parts and exposed portion of thorax with fine indeterminate, impressed lines, the first eight abdominal segments with fine punctures more numerous at the dorsal cephalic portion of segment; antennae of male tapering gradually until near distal end, then the mesal margin concave to tip, length two and one-half times the width, ending near the middle of exposed portion of tarsus of the second pair of legs; labrum variable, usually broadest on the distal portion, width more than twice the length, five-sided and pointed at the distal end; maxillae with each half quadrilateral, the median length much less than the greatest width; first wing with its dorsal

margin rounded from point of attachment so that the anal angle is almost impossible to determine; second wing visible around entire dorsal margin of first wing, its margin entire, not produced to form an anal angle and extending about half way across caudal margin of first wing. Length, abdomen retracted, 1-1/8" --1-1/4", expanded 1-1/4"--1-3/8"; girth from 1-1/2" to 2".

Genus *Agapema*

Body modified cecropia shape, tapering at cephalic end, abdominal segments 8-10 never forming a cone; antennae pectinate throughout, tapering to a point at the distal end; invaginations for the anterior arms of the tentorium distinct; eye-pieces both visible; labrum elevated above the surrounding surface, clypeo-labral suture obsolete; maxillae measured on meson about one-seventh the length of wings; median thoracic line distinct on prothorax and mesothorax, sometimes on the metathorax; strongly keeled on prothorax; caudal portion of mesonotum and metanotum slightly depressed at base of wings; wings with their distal margin slightly raised above the dorsal surface of body; lateral aspect of the cephalic margins of abdominal segments 5-7 with sharp, slightly wavy, transverse ridges with distinct furrows between, the cephalic margin narrowed on the dorsum and the furrows indistinct, furrows extending ventrad to the region of the proleg scars; spiracular line curved ventrad; cremaster absent; abdominal segments with distinct depressions between the segments, excepting on the dorsum; the tenth segment, as viewed from

above, a transverse plate, concave on the caudal margin and the lateral angles produced into lobes; as viewed from ventral aspect, the ventral surface strongly concave and five short, curved spines inserted close together in the lateral margin of each lobe.

This genus includes a single species in North America, *Agapema galbina*, found in Arizona and Mexico. The pale grayish tan cocoons consist of two layers, a very thin, coarsely reticulated outer layer, and an inner thicker layer with smaller reticulations, both layers having loose fibers at the cephalic end closing an opening made by the thicker walls. It is suspended by the side, as *Samia cecropia*.

Agapema galbina:- Color generally tawny or yellowish brown, with slightly darker transverse conjunctive and margins of spiracles; entire surface, except wings and antennae, covered with fine wavy impressed lines and coarse punctures; wings and antennae with similar lines, but much deeper impressions; face parts elevated; tips of antennae of male lie adjacent on the meson for a distance nearly equal their width, length two and one-half times width, stem of the flagellum elevated above the level of the pectinations; labrum slightly longer than broad, its distal end rounded or pointed; maxillae with each half somewhat triangular in outline, with lateral margins concave, surface almost smooth; space between maxillae and antennae filled in by part of the tibia and tarsus of the first pair of legs; prothoracic spiracles triangular, each extend-

ing about one-third the distance along caudal margin of prothorax to the meson; mesothorax with lateral part of alar area elevated and a smooth, rounded spot about two-thirds of the distance from the cephalic margin; first wing with its anal angle very broadly rounded on cephalic margin of fourth abdominal segment; second wing visible along entire dorsal margin of first wing, its margin entire, produced around angle of first wing but never reaching half way across its caudal margin; first and second abdominal spiracles partially covered by the wings. Length, abdomen contracted, from $3/4$ " to $7/8$ "; girth 1". Described from male specimens only.

Genus *Callosamia*

Body of typical cecropia shape; face parts slightly elevated; antennae pectinate throughout, tapering gradually to a point at the distal end, the stem of the flagellum raised above the level of the pectinations and one-third the total width of the antenna; invaginations for the anterior arms of the tentorium distinct; clypeo-labral suture obsolete; maxillae, measured on the meson, always about one-sixth the length of the wings, triangular in outline; tarsi of the first pair of legs and tips of the second pair adjacent on the meson; median line distinct on the prothorax and mesothorax; caudal portion mesonotum and the metanotum depressed adjacent to the wings; wings with their distal margin always raised above the level of the dorsal surface of the body; first pair of wings with their anal angles rounded and opposite the cephalic margin of the fourth abdominal segment; second pair of wings

visible along entire dorsal margin of first pair; spiracular line curved ventrad; abdominal segments 8-10 tapering rapidly to form a cone; cremaster absent.

This genus includes three species in North America. Of these *C. calleta* is reported from Arizona and Mexico. Its cocoon is very firm, flask-shaped, with loose fibers of silk forming a sort of valve across the open cephalic end. It is suspended from a twig by means of a very short band of silk which encircles the twig. *C. promethea* and *C. angulifera* are both found east of the Mississippi. The cocoons of *C. promethea* resemble those of *P. cynthia*, but are more common, dangling in clusters from almost every spice bush, wild cherry and many other food plants in regions where they occur. *Promethea* cocoons are grayish brown in color, usually darker than *cynthia* cocoons and cylindrical in shape, usually blunt at the caudal end. They are suspended by a long band of silk from the cephalic end which usually fastens the encircling leaf to a twig together with the cocoon. *C. angulifera* is comparatively rare and its cocoons are seldom found suspended from twigs but are usually found among fallen leaves at the base of a tree. They are ovoid, dull brownish gray in color, with the valvular arrangement of loose fibers of silk at one end. The walls of the cocoon are thicker than *promethea* cocoons and more readily separated into layers.

The following table will serve to separate the pupae of this genus:

A. Glazed eye-piece visible; tip of abdomen with ten or more short spines.

C. calleta

AA. No eye-piece visible; tip of abdomen never with spines.

B. Dorsal cephalic margins of abdominal segments 5-7 produced into a flange-like ridge, widest at meson and ending opposite spiracles; spiracular openings at the bottom of a lenticular depression; dorsal margin of second pair of wings scarcely bi-sinuate.

C. promethea

BB. Dorsal cephalic margins of abdominal segments never produced into a flange-like ridge; spiracular openings with a lenticular, elevated, smooth, rounded margin; dorsal margin of second pair of wings deeply bi-sinuate.

C. angulifera

Callosamia calleta:- Color generally dull black with a yellowish face-piece; exposed surface of thorax, face-pieces and appendages with fine indeterminate transverse striations, remainder of surface practically smooth; dorsal cephalic margin of abdominal segments 5-7 never produced into flange-like plates; never with an elevated line between the segment and the transverse conjunctiva; antennae of female extends to tips of first pair of legs and length is four times width, in the male they reach to tips of second pair and length is three and one-half times width; glazed eye-pieces visible; labrum variable, generally elevated, pentagonal or shield shaped; max-

illae with mesal length and breadth at cephalic end approximately equal; margin of second wing slightly sinuate, produced below anal of front wing to caudal margin of fourth abdominal segment and more than half way across caudal margin of first wing; each prothoracic spiracle extends about one-third of the distance along caudal margin of prothorax to meson; first and second abdominal spiracles partially covered by the wings; spiracular openings located at the bottom of lenticular depressions, margins of the openings felted; tip of abdomen rounded with ten or more short, rigid spines less than one millimeter long, forming a circular group. Length, abdomen retracted, 1"--1-1/4", expanded 1-1/4"--1-1/2"; girth about 2".

Callosamia promethea:- Color generally yellowish, dark brown on the middle of the back and around the margins of spiracles, sometimes on the wings; dorsal aspect of thorax and abdomen with deep, wavy, transverse striations, fine, indeterminate striations on face parts, wings and legs, the remaining surface practically smooth; dorsal cephalic margins of abdominal segments 5-7 produced into flange-like plates, widest at the meson and ending opposite the spiracles; line between segment and transverse conjunctiva elevated on dorsal aspect; tips of antennae generally separated by second pair of legs, ending in the female half-way between the tips of the first and second pairs of legs,ⁱⁿ the male opposite the tips of the second pair, tips of antennae in both sexes frequently

meet on meson, those of male slightly longer and wider than those of female, the length never more than three times width; no eye-pieces visible; labrum variable, broadly rounded distally; maxillae generally smooth, sometimes separated on meson to show coxal cases beneath, length on meson equals breadth at cephalic end; margin of second pair of wings scarcely bisinuate, produced into a rounded anal angle and extending less than half way across caudal margin of the first pair; each prothoracic spiracle extending less than one-fourth the distance across the caudal margin of prothorax to meson; first and second abdominal spiracles partially covered by the wings; spiracular openings located at the bottom of lenticular depressions, lips of the depression smooth and glossy and of the opening, rounded and of a different color; abdominal segments 8-10 taper rapidly to form a cone, occasionally with a button-like tip. Length, abdomen retracted, from $3/4$ "-- $1-1/8$ ", expanded, 1 "-- $1-3/8$ "; girth about $1-1/2$ ".

Callosamia angulifera:- Color generally yellowish or yellowish brown, darker brown on the middle of the back and around the margins of spiracles, usually a darker color pattern on wings; dorsal aspect of thorax and abdomen with deep, wavy, transverse striations, fine indeterminate striations on face parts and appendages, the remainder of the surface practically smooth; dorsal cephalic margins of abdominal segments 5-7 never produced into flange-like plates; line between segment and conjunctiva on dorsal aspect elevated and corrugated; an-

tannae of male meet on meson and lie adjacent to each other for a distance nearly equal to their width, their length three times the width, antennae of female separated to show first and second pairs of legs, their length three and one-third times width, ending just below first pair of legs; no eye-pieces visible; labrum variable, usually broadly truncate distally; maxillae with mesal length greater than breadth at cephalic end; margin of the second pair of wings deeply bi-sinuate, a narrow portion produced below anal angle of first wing and extending less than half way across its caudal margin; each prothoracic spiracle extends less than one-fourth the distance across caudal margin of prothorax to meson; first and second abdominal spiracles seldom partially covered by wings; spiracular openings with an elevated, rounded, smooth, lenticular margin, the lips of the openings rounded and pitted; tip of abdomen rounded. Length, abdomen retracted, $7/8''$ -- $1-1/8''$, expanded $1''$ -- $1-1/4''$; girth $1-1/2''$.

Genus Rothschildia

Body of typical cecropia shape; exposed surface of thorax and abdomen sparsely covered with fine setae; face-parts slightly elevated; antennae pectinate throughout, tapering gradually to a point at the distal end, length and width varying with the sexes and reaching more than half way between the tips of first and second pairs of legs; antennae of male elevated, with a depression on each side the stem of the flagellum; antennae of female with the stem of the flagellum raised

above the level of the pectinations; invaginations for the anterior arms of the tentorium indistinct; eye-pieces both visible; clypeo-labral suture generally distinct; maxillae, measured on meson, about one-fifth the length of wings, triangular in outline, its mesal length greater than the width at proximal end; tarsi of the first pair and tips of the second pair of legs adjacent on the meson; metanotum wrinkled at base of wings but not always depressed; wings with their distal margins raised above the dorsal surface; first wing with its angle on cephalic margin of fourth abdominal segment; second wing visible along dorsal margin of first wing, its margin entire and produced below the anal angle of first wing to the caudal margin of the fourth abdominal segment, extending more than half way across margin of first wing; spiracular line curves ventrad; cremaster wanting; abdominal segments 8-10 bluntly cone-shaped, the caudal end with a band of coarse setae about one millimeter long, either erect or closely appressed to the body.

This genus consists of two species found in Arizona and southward into Mexico. The cocoons are very firm, those of *R. orizaba* being about two inches long, three-fourths of an inch wide, rather ovoid in shape, usually slightly narrowed and rounded at the ends, while those of *R. jorulla* are vase-shaped, about of the same dimensions with a well defined opening laterally at the cephalic end, showing the valvular arrangement of loose fibers. Both species have very light grayish

tan cocoons, those of *R. jorulla* being suspended by a band of silk at the cephalic end. The pupae of the two species can be separated as follows:

A. Median thoracic line distinct on all segments; caudal part of mesonotum and metanotum depressed at base of wings; distal margin of wings strongly elevated above the dorsal surface of body; setae on metathorax and first four abdominal segments sparsely distributed, inconspicuous; spiracles.

R. orizaba

AA. Median thoracic line never distinct on metathorax and often indistinct on mesothorax; caudal part of mesonotum and metanotum not depressed at base of wings; distal margin of wings only slightly elevated above the dorsal surface of the body; setae numerous on metathorax and first four abdominal segments, conspicuous, at least a millimeter in length; spiracles.

R. jorulla

Rothschildia orizaba:- Color generally black with light brown transverse conjunctiva, sometimes abdominal segments 5-10 or 8-10 are light in color; exposed parts of thorax and abdomen sparsely covered with reddish setae, less than a millimeter long and almost invisible; thoracic segments, face parts and appendages with indeterminate, transverse striations, abdominal segments smooth; antennae of male with length two and three-fourths times breadth, female with length four times the breadth; face parts curving sharply to the level of the labrum and maxillae; labrum variable, width about twice



length, usually five-sided and slightly elevated above maxillae; maxillae, measured on meson, one-sixth the length of wings; median line distinct on all thoracic segments; mesothorax tuberculate at base of wings; caudal part of mesonotum and metanotum strongly depressed adjacent to wings; the distal margin of first wing always considerably elevated above the dorsal surface of body; prothoracic spiracles slit-like, each measuring about one-third the distance along caudal margin of prothorax to meson; abdominal spiracles free, second abdominal spiracle one-half the width of its margin away from the wing; caudal end of abdomen with band of stiff, straight setae, always erect. Length, abdomen retracted, $7/8''$ -- $1''$, expanded, $1-1/8''$ -- $1-3/8''$; girth about 2".

Rothschildia jorulla:- Color usually reddish brown; exposed surface of thorax, and usually the face parts, with fine, indeterminate, transverse striations, deeper on the prothorax; abdominal segments 1-4 with minute tubercles, remainder of body surface practically smooth; exposed surface of thorax and abdomen with conspicuous, coarse reddish setae, most numerous on the first four abdominal segments and sparsely distributed over the remainder; antennae in both sexes separated by the legs and extending more than half way between the tips of the first and second pairs of legs, length in the male three times the breadth, in the female almost four times the breadth; face parts convex, mostly in the clypeal region; labrum variable, always broader than long and generally with a rounded

median lobe; maxillae, measured on meson, one-sixth the length of wings; median thoracic line distinct on prothorax and part of mesothorax; mesothorax roughened and metanotum longitudinally wrinkled at base of wings, but never noticeably depressed; distal margin of first wing only slightly elevated above dorsal surface of body; each prothoracic spiracle less than one-third the distance along caudal margin of prothorax to meson; abdominal spiracles usually free, second abdominal spiracle adjacent to the wings; caudal end of abdomen with a narrow, transverse band of setae, sometimes extending on dorsal surface of tenth abdominal segment, either erect or closely appressed to body. Length, retracted, 1"--1-1/8"; girth about 1-1/2".

Genus *Samia*

Body of typical cecropia shape; face parts slightly elevated; antennae with the stem of the flagellum raised above the level of the pectinations, in the female the antenna is pectinate throughout, not prominently elevated above the surface of the wings, and tapering gradually to a pointed tip at the distal end, in the male strongly elevated above the surface of the wings, the sides approximately parallel for the greater part of their length and tapering gradually to a blunt, rounded tip at the distal end, the stem of the flagellum often extending beyond the pectinations; a portion of the glazed eye-piece always visible in the female, sometimes in the male; invaginations for the anterior arms of the tentorium distinct;

clypeo-labral suture usually distinct; labrum with width always much greater than length; maxillae, measured on meson, never less than one-fifth the length of wings, triangular in outline, and usually smooth in comparison with the other appendages, occupying a more or less sunken area between the elevated face parts and the first pair of legs; tarsi of the first pair of legs and tips of the second pair of legs adjacent on the meson; median line always very distinct on the prothorax, weak on the mesothorax and sometimes slightly indicated on the metathorax; each prothoracic spiracle extending about one-third of the distance along caudal margin of prothorax to meson; caudal portion of mesonotum and the metanotum depressed adjacent to the wings; wings with their distal margins always strongly raised above the dorsal surface of the body; first pair of wings with their anal angles rounded and opposite the cephalic margin of the fourth abdominal segment; second pair of wings visible along entire margin of first wing, but usually almost concealed by the first wing on the third abdominal segment and produced around the anal angle of first wing to the caudal margin of the fourth abdominal segment; abdominal segments usually with three rows of tubercle scars on each side the meson, one row situated laterad of the dorsal medial line about one-fourth the distance between the medial line and the spiracular line, the second row on the dorsum about half way between the first row and the spiracular line, the third row on the ventral surface, not quite half way be-

tween the spiracular line and the proleg scars; spiracular line curved slightly ventrad, abdominal segments 8-10 tapering rapidly to form a cone; cremaster absent.

The genus *Samia* is found in nearly all parts of North America. There are four recognized species in this genus, *S. cecropia*, reported from the entire region east of the Rocky Mountains, *S. gloveri*, from the Rocky Mountain region and Arizona, *S. columbia*, from the Northern Atlantic States, and *S. californica*, from the Pacific States. The cocoons are always fastened by one side to a twig with fibers of silk; the general shape is oval. *Cecropia* cocoons are large, the largest found in North America, usually at least three inches long with two distinct layers of silk. There are many different shapes and at least two distinct types of cocoons, those with a very loose, soft outer layer giving the cocoon a "baggy" appearance and those firmer on the outside which are seldom more than an inch in width, often only three-fourths, while the "baggy" ones usually reach a width of two inches or even more. No satisfactory explanation has been given for this variation. The cocoons of the other species are similar to those of *S. cecropia* but smaller and usually firm. The cocoon of *S. gloveri* may usually be recognized by its external coating of white silk, which is spun first by the larva. The other species usually have grayish-tan or brown cocoons. The pupae of these species may be separated by the following table:

A. Dorsal abdominal segments finely, deeply rugose, re-

sembling velvet; the row of tubercule scars on the ventral surface never present and conspicuous; abdominal segments 5-7 with their dorsal cephalic margins usually produced into a distinct flange-like plate, notched at meson, and extending laterad to the spiracular line; caudal end of abdomen always produced into a narrow, blunt tip; color usually black.

S. californica

AA. Dorsal abdominal segments not finely deeply rugose, resembling velvet; the ventral row of tubercule scars present and conspicuous; abdominal segments 5-7 with their dorsal cephalic margins seldom produced into a distinct flange-like plate, notched at meson, and ^{if} produced not extending as far laterad as the spiracular line; caudal end of abdomen sometimes produced into a narrow blunt tip; color rarely black.

B. Maxillae, measured on meson, one-fifth or less the length of the wings; never with prominent reddish tubercles or tubercule scars on the metathorax and first abdominal segment.

S. cecropia

BB. Maxillae, measured on meson, never as short as one-fifth the length of the wings; with prominent reddish tubercles or polished tubercule scars on the metathorax and first abdominal segment.

C. Metathorax with prominent tubercles each side the meson and usually on the first abdominal segment, reddish at tip; length, abdomen retracted, not over one inch.

S. columbia

CC. Metathorax without prominent tubercles and on the first abdominal segment, but with reddish, polished tubercle scars; length, abdomen retracted, always more than one inch.

S. gloveri

Samia californica:- Color variable, typical specimens black, the caudal abdominal segments often light brown or yellowish and occasional specimens almost entirely yellowish brown; face parts, appendages and exposed surface of the thorax with fine, wavy, indeterminate transverse striations; dorsal abdominal segments 1-8 finely, deeply rugose resembling velvet, glossy in appearance, remainder of surface practically smooth; antennae of male with the stem of the flagellum about one-fourth the total width of the antenna and with the tips sometimes extending beyond the pectinations; the length of the antenna a little more than twice the width and almost reaching the tips of the second pair of legs, the distal half of each antenna occasionally lying adjacent on the meson; antennae of female with the stem of the flagellum one-third or more the total width of the antenna, ending opposite the tips of the first pair of legs and slightly shorter in some abnormal specimens, length a little more than three times width; clypeo-labral suture usually distinct; the clypeus not prominently convex cephalad of the labrum; labrum variable, concave on its proximal margin, broadly rounded or slightly pointed at distal end, the width at least twice the length; maxillae, measured on meson, about one-fourth the length of

the wings, the mesal length usually greater than the greatest width; third pair of legs often showing between the wings; mesothorax with the alar area slightly polished, never showing a distinct tubercle or tubercle scar; metathorax without distinct tubercles; second pair of wings visible around entire dorsal margin of first pair of wings, and seldom concealed by them on the third abdominal segment, produced below the anal angles of first pair of wings to the caudal margin of the fourth abdominal segment; spiracles usually free, the first and second seldom partially covered by the wings; abdominal segments with the two dorsal rows of tubercle scars generally distinct, but never having the row on the ventral surface between the spiracular line and the proleg scars; abdominal segments 5-7 with their dorsal cephalic margins produced into narrow flange-like plates extending laterad to the spiracular line, with a distinct notch at meson and the median line indicated by oblique striations, also with a raised, wavy line between the segment and the transverse conjunctiva; abdominal segments 8-10 with the caudal end produced into a narrow blunt tip; the scars of the anal prolegs never distinct on each side the anal plate; cremaster absent. Length, abdomen retracted, 1-1/8"--1-1/4", expanded, 1-1/2"--1-5/8"; girth about 2".

Samia cecropia:- Color variable, usually chestnut brown with black on thorax and appendages, sometimes yellowish brown,

but never entirely black; face parts, appendages, and exposed surface of thorax with fine, indeterminate, transverse striations; dorsal abdominal segments 1-8 finely rugose, but dull in appearance, not resembling velvet, remainder of surface practically smooth; antennae of male with the stem of the flagellum about one-fourth the total width of the antenna and always extending beyond the pectinations, the length of the antenna about two and one-half times the width and almost reaching the tips of the second pair of legs; antennae of female with the stem of the flagellum at least one-third the total width, the length of the antenna about three and one-half times the width and never extending as far as the tips of the first pair of legs; clypeo-labral suture generally distinct, clypeus prominently convex cephalad of the labrum; labrum concave on its proximal margin, broadly rounded at distal end, the width more than twice the length; maxillae, measured on meson, about one-fifth the length of the wings, length and width approximately equal; third pair of legs very rarely showing between the wings; mesothorax with the alar area polished, usually showing a distinct tubercle or tubercle scar; metathorax without distinct tubercles; second pair of wings usually visible around entire dorsal margin of first wing, often almost concealed by first wing on the third abdominal segment and produced below the anal angle of first wing to the caudal margin of the fourth abdominal segment; spiracles usually free, the first and second sometimes partially concealed

by the wings; abdominal segments with the three rows of tubercle scars distinct; abdominal segments 5-7 with their dorsal cephalic margins very rarely produced into flange-like plates and these scarcely visible in lateral view, an elevated, longitudinally striate, wavy line between the segment and the transverse conjunctiva; abdominal segments 8-10 with the caudal end seldom produced into a narrow, blunt tip; in ventral view the scars of the anal prolegs usually distinct on each side of the anal plate; cremaster absent. Length, abdomen retracted, 1-1/4"--1-3/8", expanded, 1-1/2"--1-5/8"; girth about 2-1/4".

Samia columbia:- Color usually dark brown to blackish; face parts slightly elevated; face parts, exposed surface of thorax and dorsal surface of abdomen with fine, determinate, transverse striations, specially marked on the mesothorax, metathorax and face pieces; antennae of male with the stem of the flagellum about one-third the total width of the antenna, and not extending beyond the pectinations, the length of the antenna about two and three-quarters times the width, ending opposite the tips of the first pair of legs; clypeo-labral suture usually distinct; clypeal region strongly elevated, mound-like, above the labrum; labrum variable, its proximal margin concave, width at least twice length, the distal margin broadly rounded; maxillae, measured on meson, one-fourth the length of the wings, its mesal length usually greater than greatest width, the surface polished; third pair of legs very seldom visible between the wings; each prothoracic spiracle

slightly less than one-third the distance along the caudal margin of prothorax to meson; mesothorax with the alar area longitudinally rugose throughout, appearing somewhat polished to the unaided eye; metathorax with a prominent tubercule on each side the meson, a smaller one near each lateral margin, both tubercules reddish at tip; a similar pair usually present each side the meson on the first abdominal segment; second pair of wings not visible around entire dorsal margin of front, wing being covered by the first pair of wings between the first and third abdominal spiracles; abdominal segments with the three rows of tubercule scars present and conspicuous; abdominal segments 5-7 sometimes with indications of a flange-like plate notched at the meson but never extending as far laterad as the spiracular line, the caudal margin scarcely elevated adjacent to the conjunctive; spiracle of the third abdominal segment and sometimes of the second partially covered by the wings; tip of abdomen usually slightly produced into a blunt tip; the scars of the anal prolegs seldom distinct on each side the anal plate; cremaster absent. Length, abdomen retracted, $7/8$ "--1", expanded, 1"--1-1/8"; girth about 1-1/2". Described from male specimens only.

Samia gloveri:- Color variable, usually dark brown to black with traces of yellowish brown; face parts, appendages and exposed surface of thorax with fine, indeterminate transverse striations, abdominal segments finely, deeply rugose, but not velvety in appearance; antennae of male with the stem of the

flagellum about one-fourth the total width of the antenna, the stem of the flagellum projecting slightly beyond the pectinations, and extending almost to the tips of the second pair of legs, the length about two and three-quarters times the breadth; antennae of female with the stem of the flagellum about one-third the total width of the antenna, extending to the tips of the first pair of legs, the length four times the width; clypeus not prominently convex above the labrum; labrum variable, seldom concave at proximal end and, if concave, only slightly so, width greater than length and broadly curved at distal end; maxillae, measured on meson, between one-fourth and one-fifth the length of wings, seldom smoother than the other appendages, the median length and greatest width approximately equal; prothoracic spiracle partially covered by antennae, each spiracle extends about one-third the distance along caudal margin of prothorax to meson; mesothorax with alar area polished; second pair of wings never visible around entire dorsal margin of the first pair of wings, but concealed by the first pair of wings between the first and third abdominal spiracles; metathorax without prominent tubercles, a prominent reddish tubercule scar on each side the meson, and a small tubercule near each lateral margin of the metathorax; abdomen with three rows of tubercule scars, conspicuous and polished; cephalic margins of abdominal segments 5-7 with indications of a flange-like plate near the meson, the edges of the segment adjoining the transverse conjunctiva longitudinally ridged but scarcely elevated; first and second abdominal spiracles partially con-

cealed by the wings; abdominal segments 8-10 with the caudal end produced into a narrow blunt tip, in ventral view the scars of the anal prolegs distinct on each side the anal plate; cremaster absent. Length, abdomen retracted, 1-1/8"--1-1/4", expanded, 1-1/4"--1-3/8"; girth 1-3/4"--2".

Genus *Philosamia*

Body typical cecropia shape; face parts slightly elevated; antennae pectinate throughout, tapering gradually to a point at the distal end, the stem of the flagellum distinctly raised above the level of the pectinations and nearly one-third the total width of the antennae, similar in the sexes; glazed eye-pieces visible in both sexes; invaginations for the anterior arms of the tentorium distinct; clypeo-labral suture indistinct; maxillae, measured on the meson, about one-third the length of the wings; tips of first and second pairs of legs adjacent on the meson; median thoracic line distinct on all segments; caudal part of mesonotum and metanotum depressed adjacent to wings; wings with their distal margin raised above the dorsal surface of the body; first wing with its anal angle broadly rounded, opposite the second abdominal spiracle; second wing generally visible along the entire dorsal margin of first wing, its margin wavy, produced into a prominent anal angle reaching the caudal margin of the fourth abdominal segment; spiracular line curved ventrad; abdominal segments 8-10 tapering rapidly to form a blunt or truncate cone; cremaster absent.

This genus contains a single species, *Philosamia cynthia*, which is a native of China and was introduced into America from Europe. At first it was confined to the Atlantic Coast States, but is gradually spreading westward. The cocoons are on an average two inches long, half an inch wide and pointed at the caudal end. The cephalic end is open with a valvular arrangement of loose fibers of silk. The cocoons are encased in a leaf and suspended from the twigs by a band of silk spun over the petiole of the leaf, holding it to the stem. The cocoons are pale gray or grayish tan in color and closely resemble the cocoons of *C. promethea*.

Philosamia cynthia:- Color generally yellowish brown, darker on wings and dorsum; exposed surface of thorax and abdomen with fine, indeterminate, transverse striations; antennae reaching half way between the tips of the first and second pair of legs; labrum short and broad, its width usually six times the length; maxillae triangular in outline, lateral margin with the proximal two-thirds concave; abdominal segments with a heavy, raised, slightly wavy line on the dorsal and lateral aspects of the caudal margin, extending ventrad to the proleg scars, a similar line along the cephalic margin ending opposite the spiracles. Length, abdomen retracted, from $7/8$ " to $1-1/8$ ", expanded, $1--1-1/4$ "; girth about $1-5/8$ ".

IX. LIST OF ABBREVIATIONS

I	first pair of wings
II	second pair of wings
1	first pair of legs
2	second pair of legs
3	third pair of legs
abd	abdominal segment
al.a.	alar area
ant.	antenna
a.o.	anal orifice
a.p.sc.	anal proleg scar
ax.3	third axillary sclerite
c.m.	cephalic margin
cd.m.	caudal margin
cl.	clypeus
cr.	cremaster
cx.	coxa
e.p.	eye-piece
ep.	epipharynx
ep.a.	epicranial area
f.	femur
f.p.	face piece
fl.p.	flange-like plate
fulc.	fulcrum
g.e.p.	glazed eye-piece
g.o.	genital orifice

in.a.a.t.	invaginations for the anterior arms of the tentorium
in.p.a.t.	invaginations for the posterior arms of the tentorium
lb.	labrum
l.p.	labial palpi
m.	mentum
md.	mandibles
ms.	mesothorax
mt.	metathorax
mx.	maxillae
mx.l.	maxillary lobe
mx.p.	maxillary palpus
p.	prothorax
pf.	pillifer
p.sc.	proleg scar
s.e.p.	sculptured eye-piece
s-m.	submentum
sp.	spiracle
s.p.	sensory pits
t.	tubercule
tb.	tibia
t.c.	transverse conjunctiva
t.sc.	tubercule scar
tr.	tarsus
tro.	trochantin

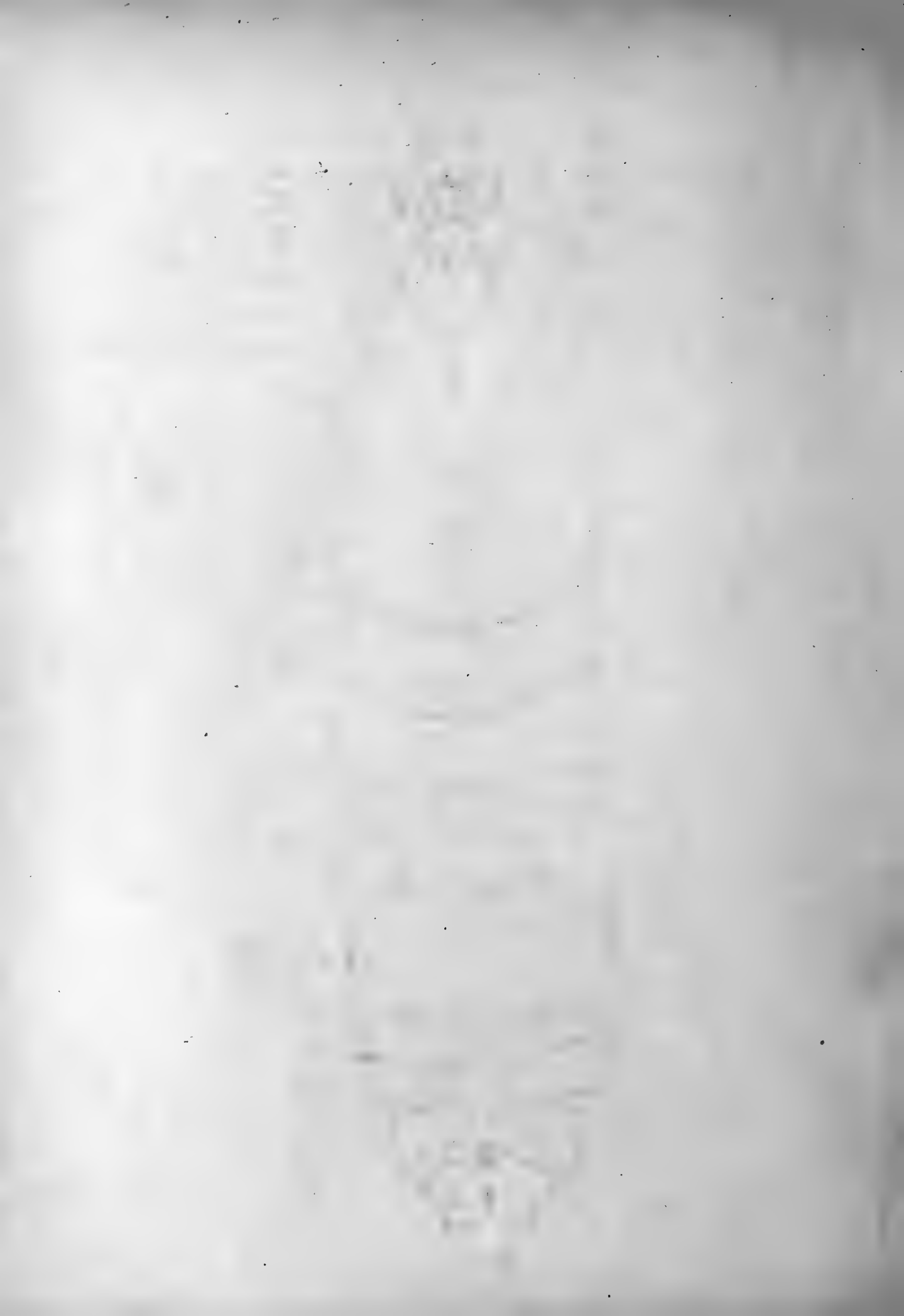
X. EXPLANATION OF PLATES

- 1 Ventral view of a pupa of *Sthenopsis thule*
- 2 Lateral " " " " " " "
- 3 Dorsal " " " " " " "
- 4 Ventral view of a preimago of *Sthenopsis thule*
- 5 Ventral view of a pupa of *Archips argyrospila*
- 6 Ventral view of a preimago of *Archips argyrospila*
- 7 Ventral view of a pupa of *Lymantria leucostigma*
- 8 Ventral view of a preimago of *Lymantria leucostigma*
- 9 Cephalic view of the mouth parts of a preimago of
Sthenopsis thule
- 10 Ventral view of the mouth parts of a preimago of
Sthenopsis thule
- 11 Cephalic view of the mouth parts of a preimago of
Archips argyrospila
- 12 Ventral view of the mouth parts of a preimago of
Archips argyrospila
- 13 Ental surface of the cephalic aspect of the head of
Phlegethontius carolina
- 14 Cephalic view of the mouth parts of a preimago of
Lymantria leucostigma
- 15 Cephalic view of the mouth parts of a preimago of
Citheronia regalis
- 16 Lateral view of the mouth parts of a preimago of
Citheronia regalis
- 17 Cephalic view of the mouth parts of a preimago of

Dryocampa rubicunda

- 18 Ventral view of the mouth parts of a preimago of
Dryocampa rubicunda
- 19 Lateral view of the mouth parts of a preimago of
Dryocampa rubicunda
- 20 Cephalic view of the mouth parts of a preimago of
Automeris io
- 21 Ventral view of the mouth parts of a preimago of
Automeris io
- 22 Lateral view of the mouth parts of a preimago of
Automeris io
- 23 Cephalic view of the mouth parts of a preimago of
Telea polyphemus
- 24 Ventral view of the mouth parts of a preimago of
Telea polyphemus
- 25 Lateral view of the mouth parts of a preimago of
Telea polyphemus
- 26 Cephalic view of the mouth parts of a preimago of
Callosamia promethea
- 27 Lateral view of a maxilla of *Callosamia promethea*
- 28 Ventral view of the mouth parts of a preimago of
Callosamia promethea
- 29 Cephalic view of the mouth parts of a preimago of
Samia cecropia
- 30 Ventral view of the mouth parts of a preimago of
Samia cecropia
- 31 Lateral view of a maxilla of *Samia cecropia*

- 32 The wing sclerites of a preimago of *Telea polyphemus*
33 Ventral view of a pupa of cecropia type
34 Lateral " " " " " " "
35 Dorsal " " " " " " "
36 Lateral view of a pupa of io type



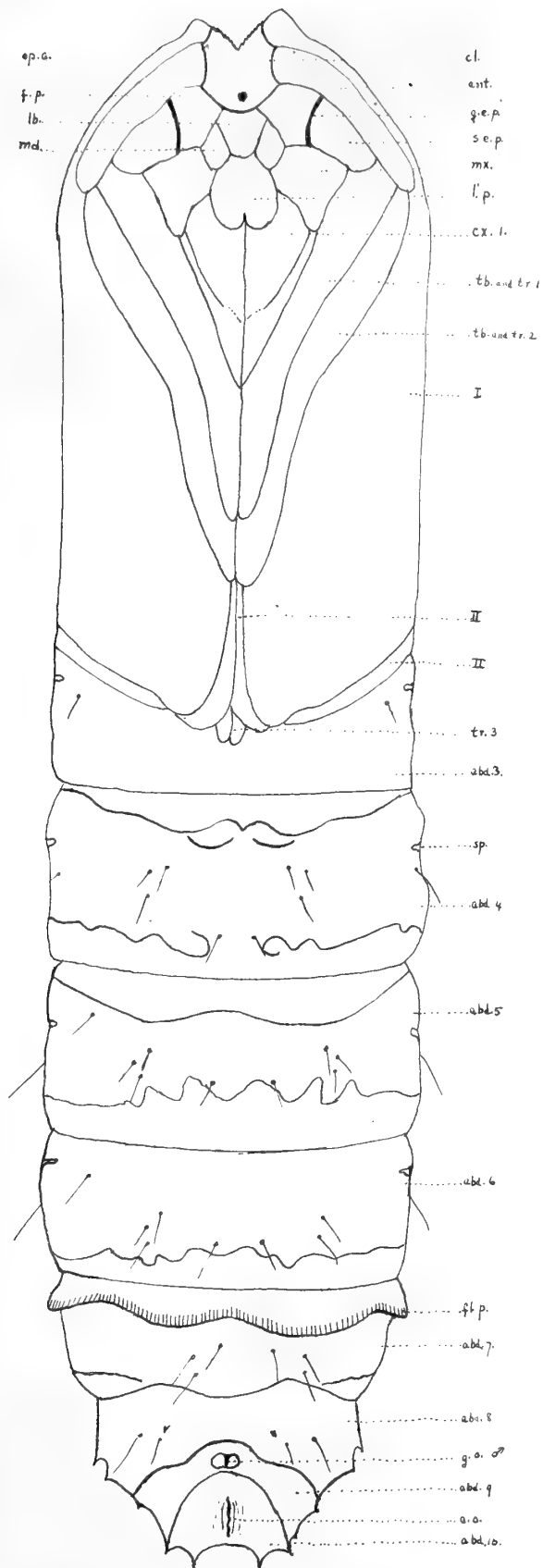


FIG. 1.

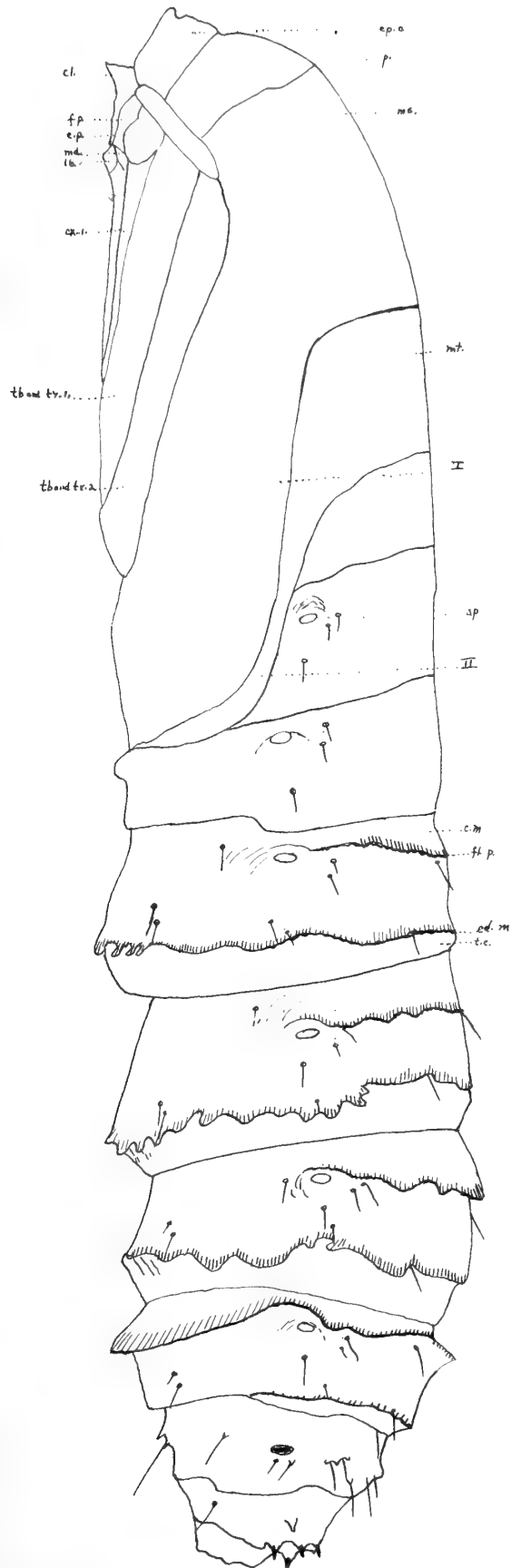


FIG. 2.

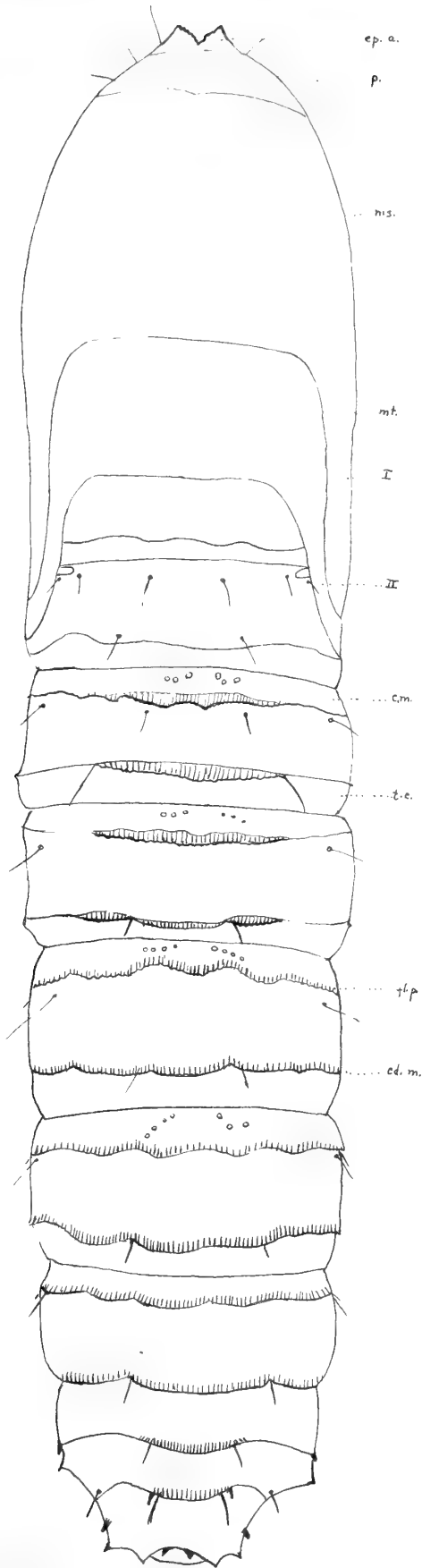


FIG. 3.

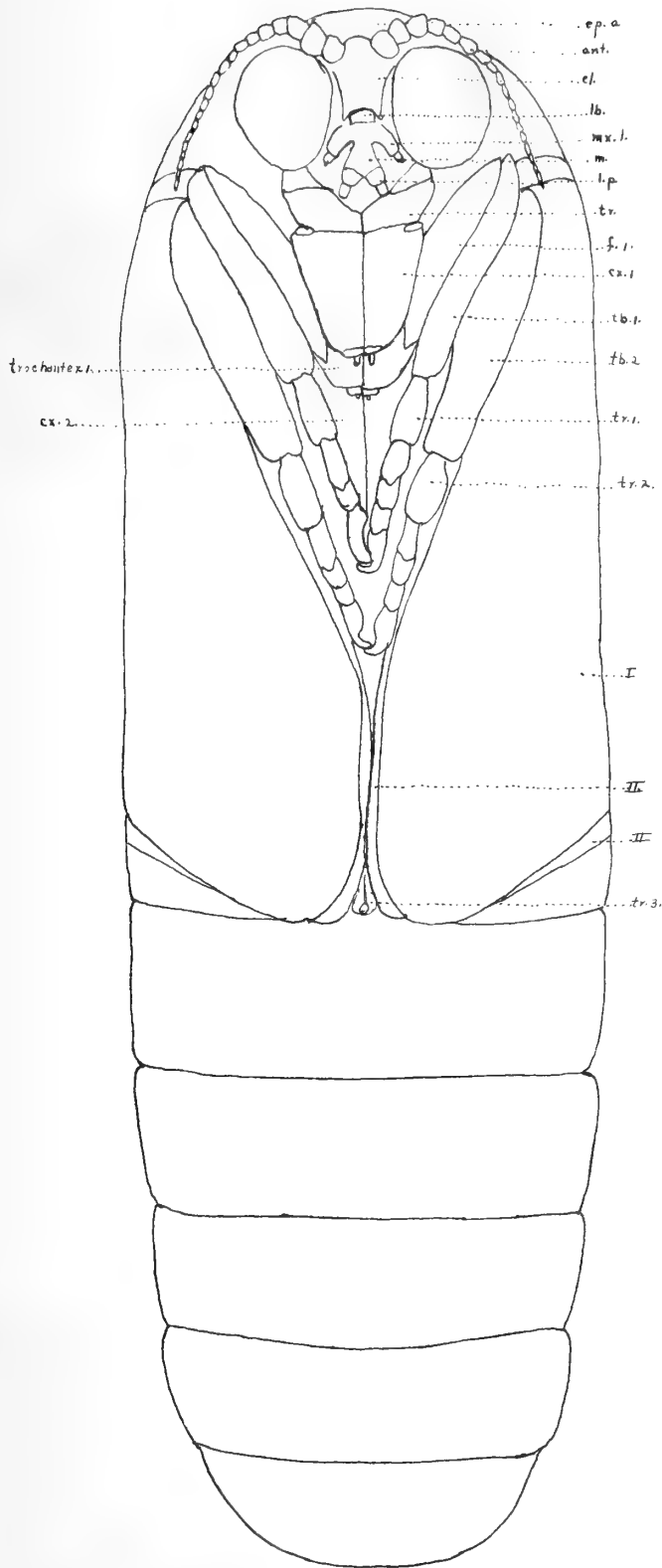


FIG. 4

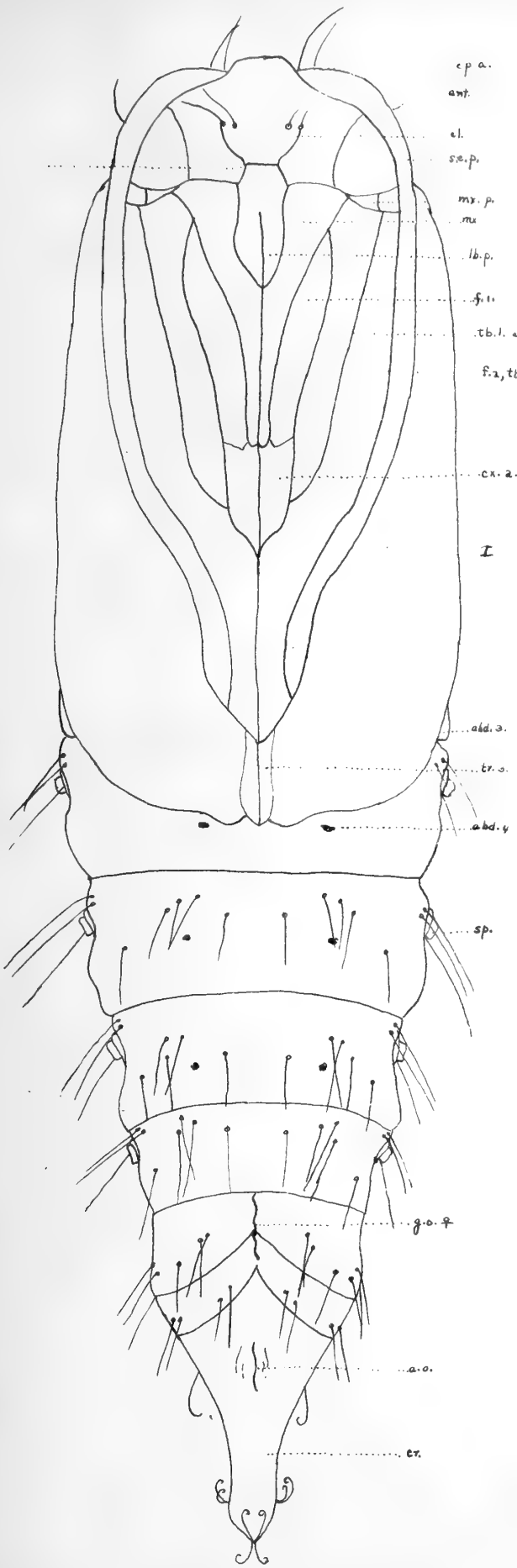


FIG. 5

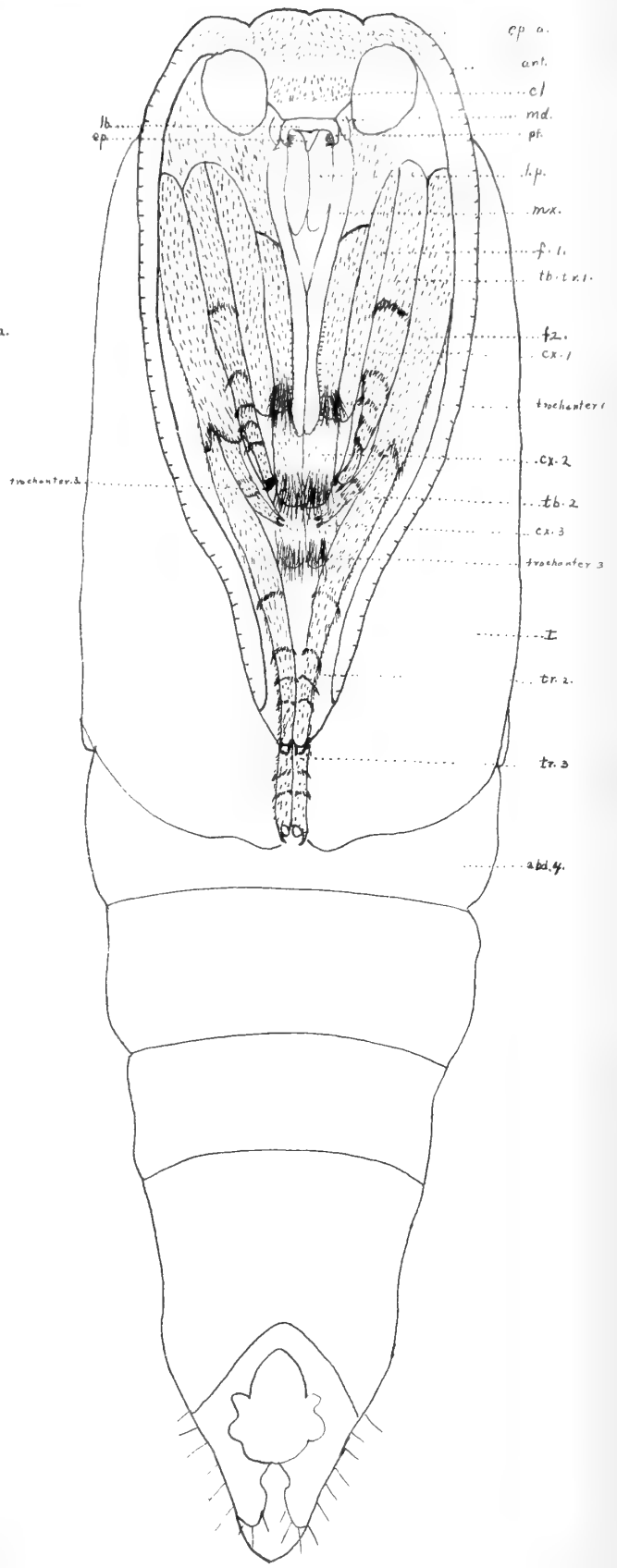
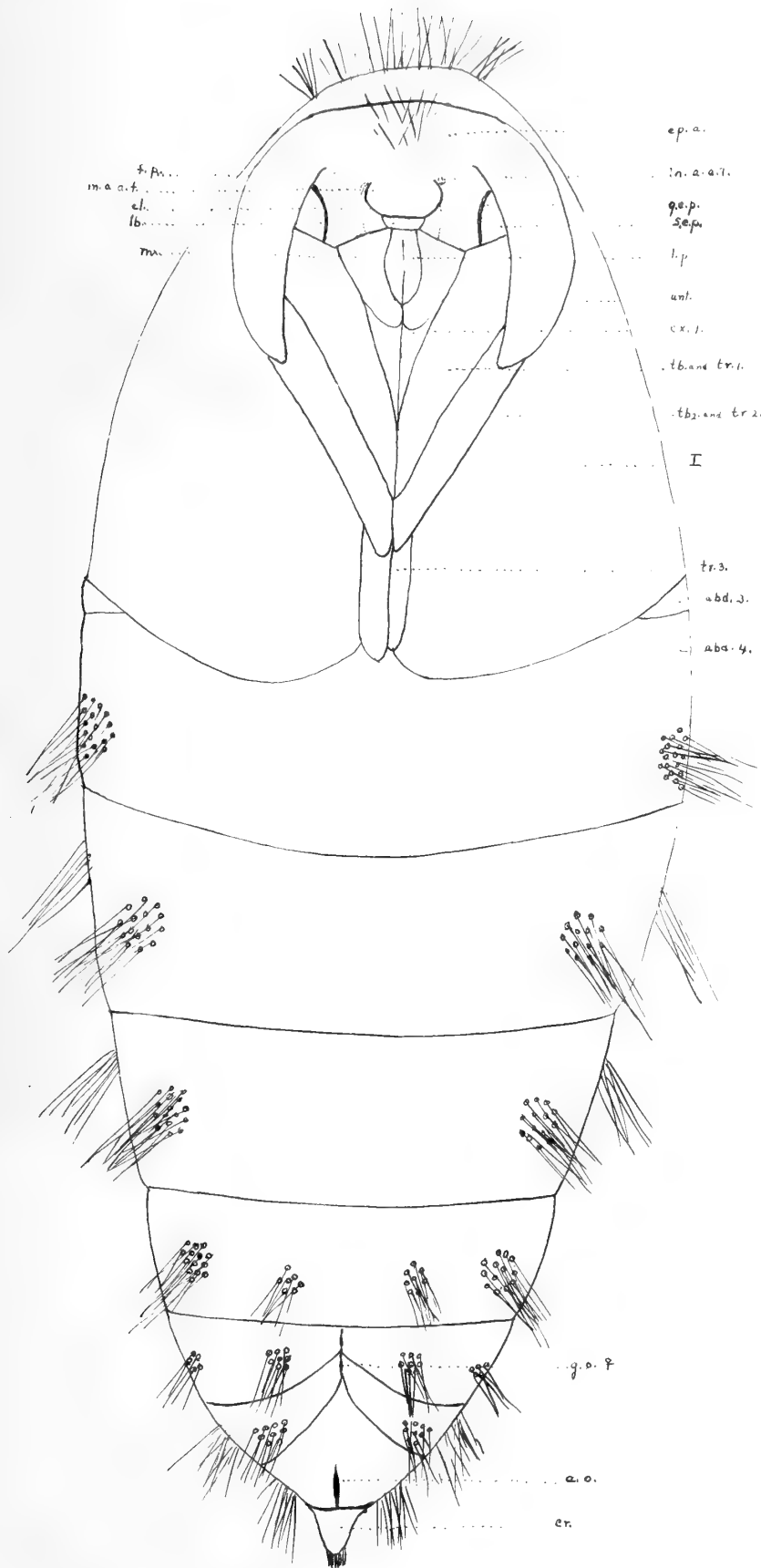


FIG. 6.



f. p.
m. a. f.
cl.
lb.
m.

ep. a.
in. a. a. 7.
g. p.
S. e. p.
l. p.
ant.
cx. 1.
tb. and tr. 1.
tb. and tr. 2.

I

tr. 3.
abd. 3.
abs. 4.

g. p. f.

a. o.

er.

FIG. 7.

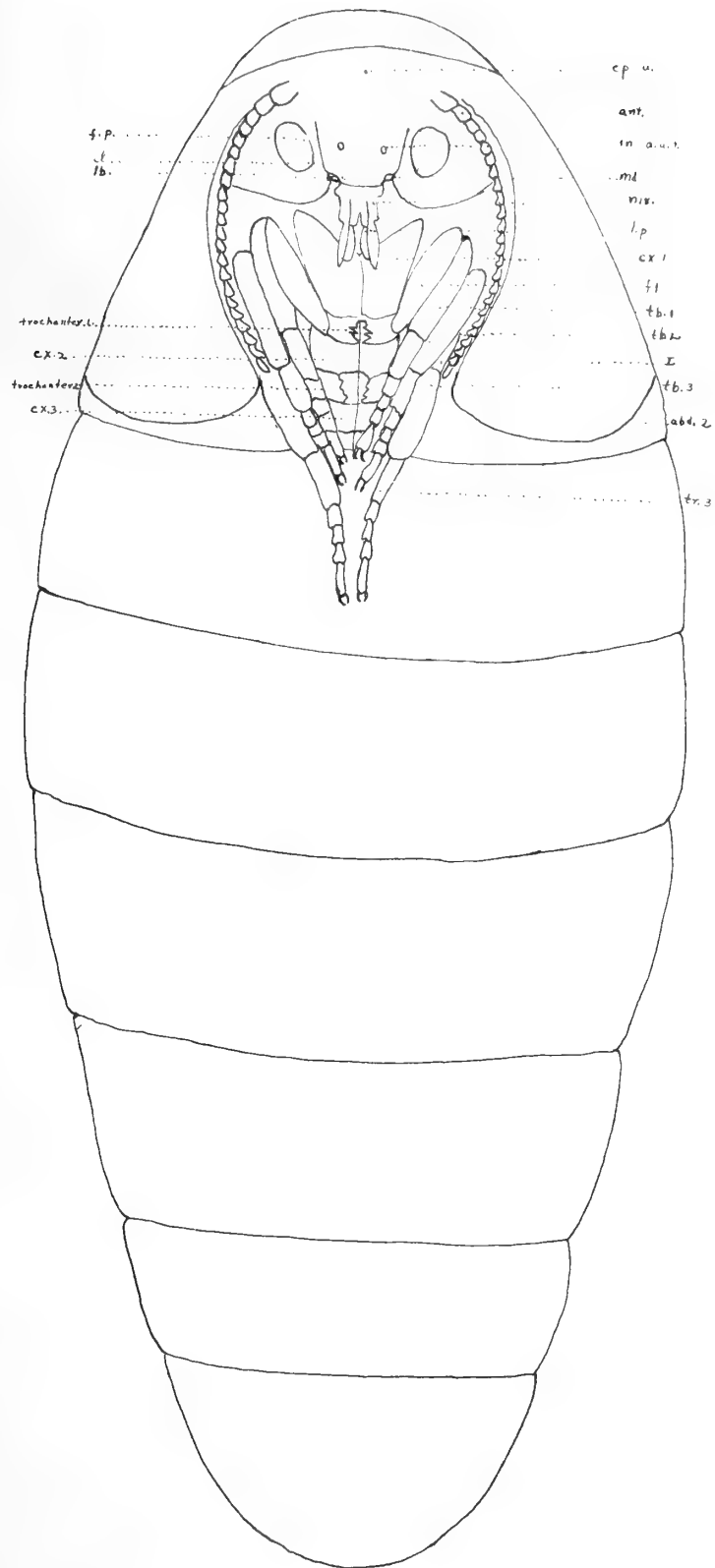


FIG. 8.

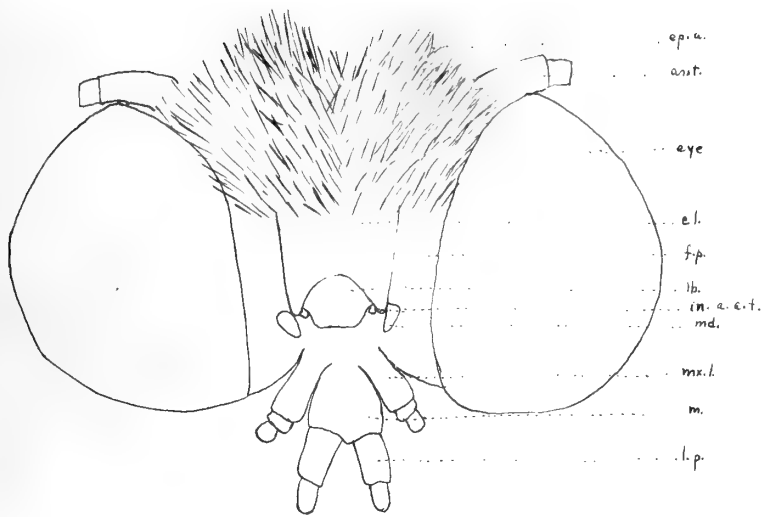


FIG. 9

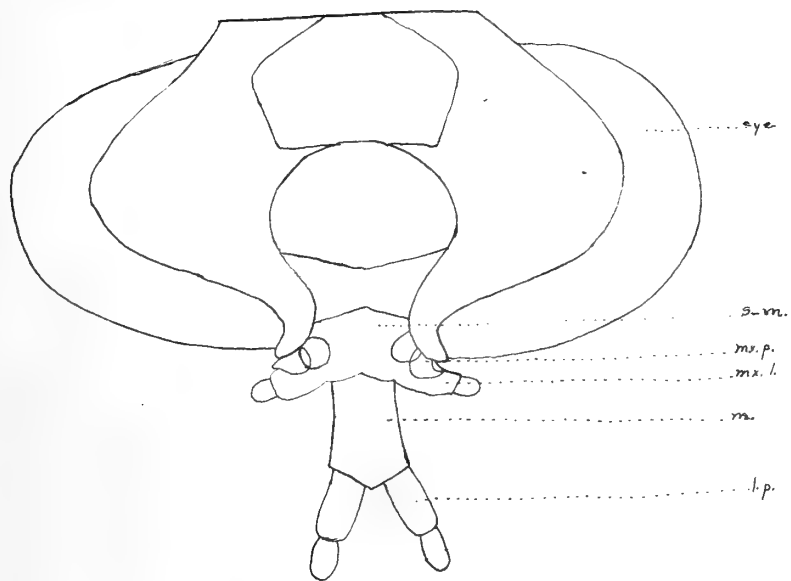


FIG. 10.

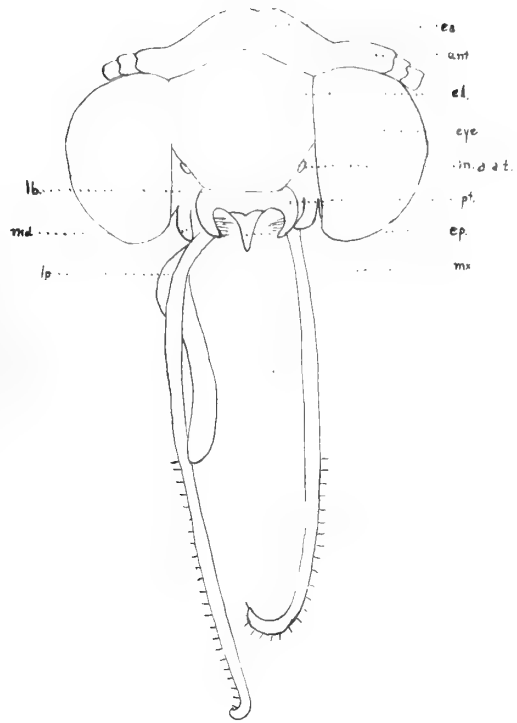


FIG. 11.

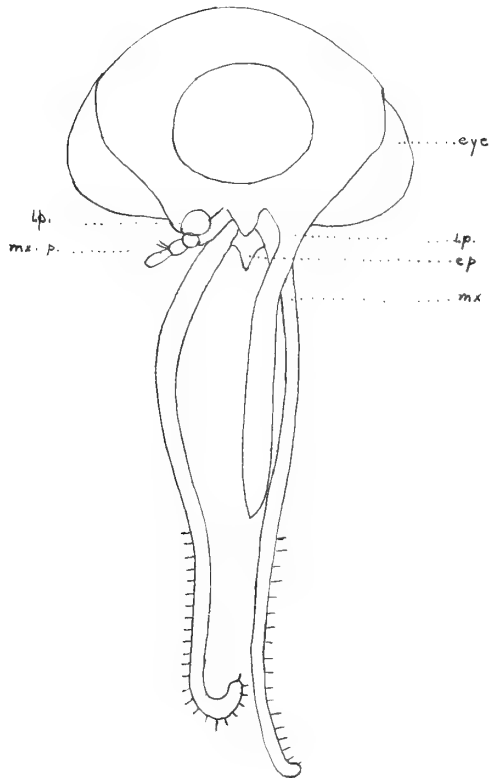


FIG. 12.

UNIVERSITY OF ILLINOIS . . .

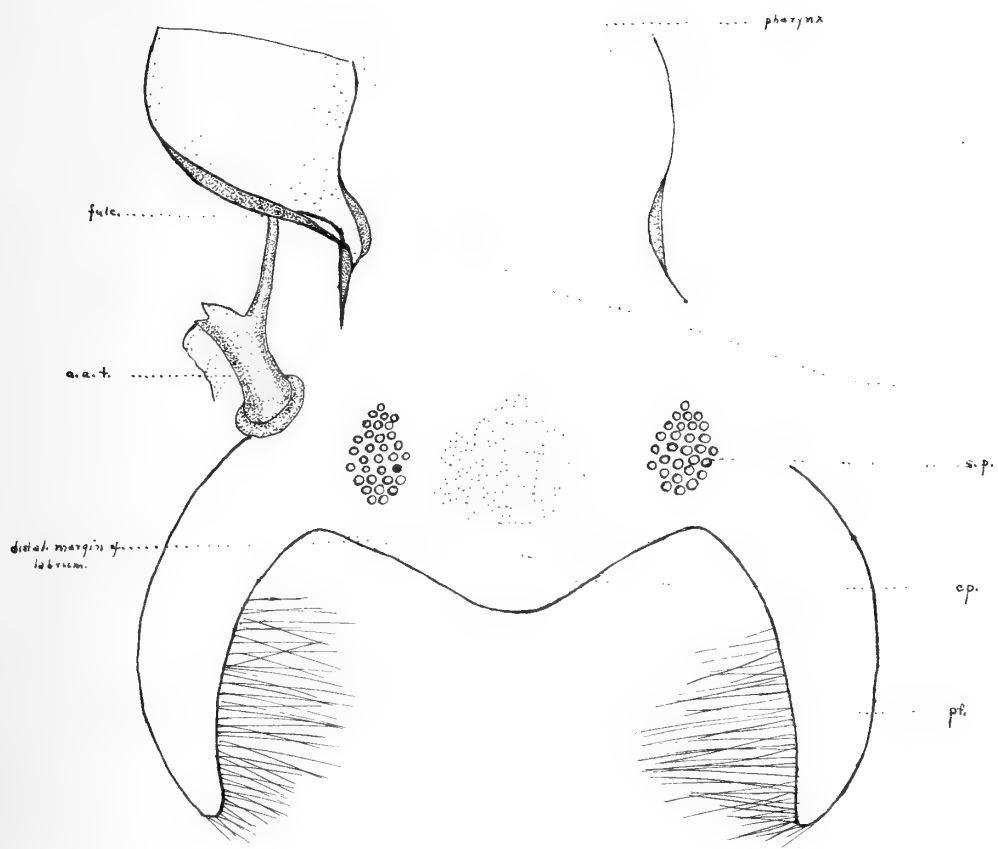


FIG. 13.

OF THE
STATE OF ILLINOIS

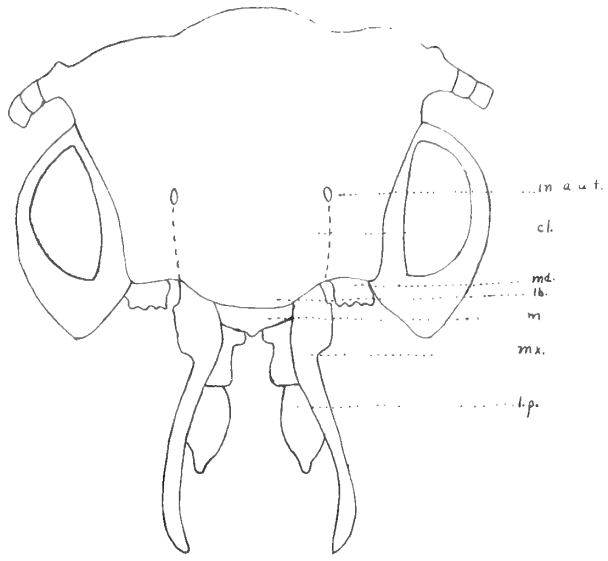


FIG. 14.

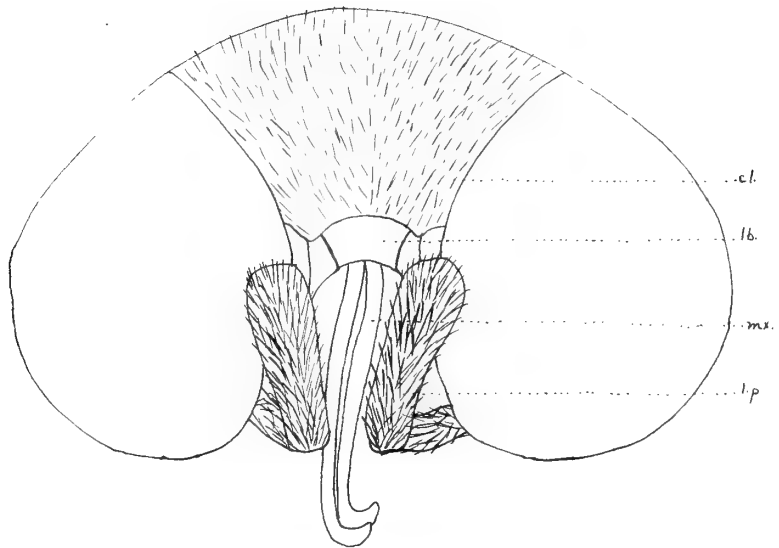


FIG. 15.



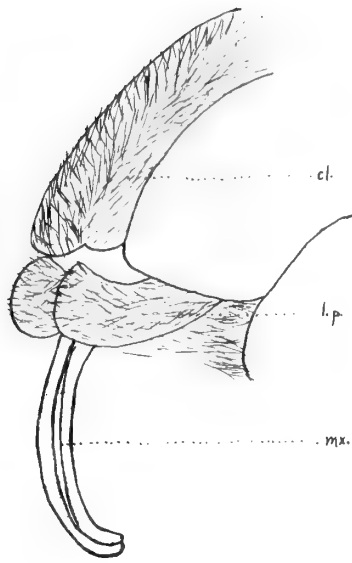


FIG. 16.

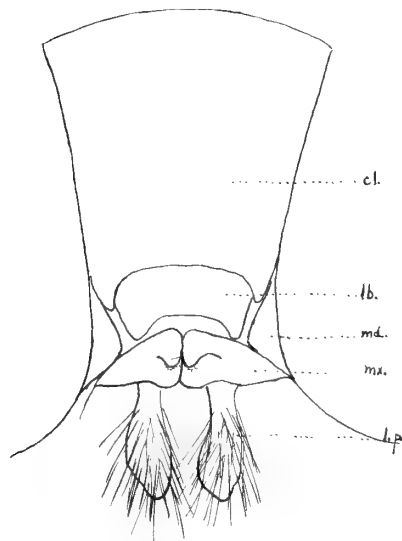


FIG. 17.

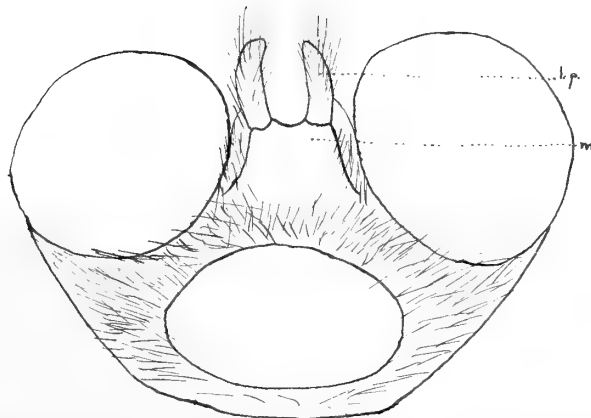


FIG. 18.

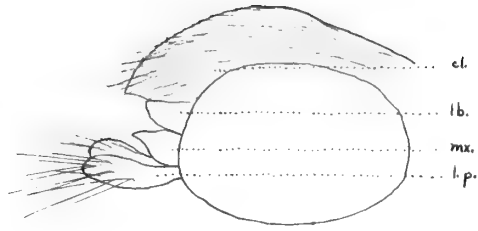


FIG. 19.

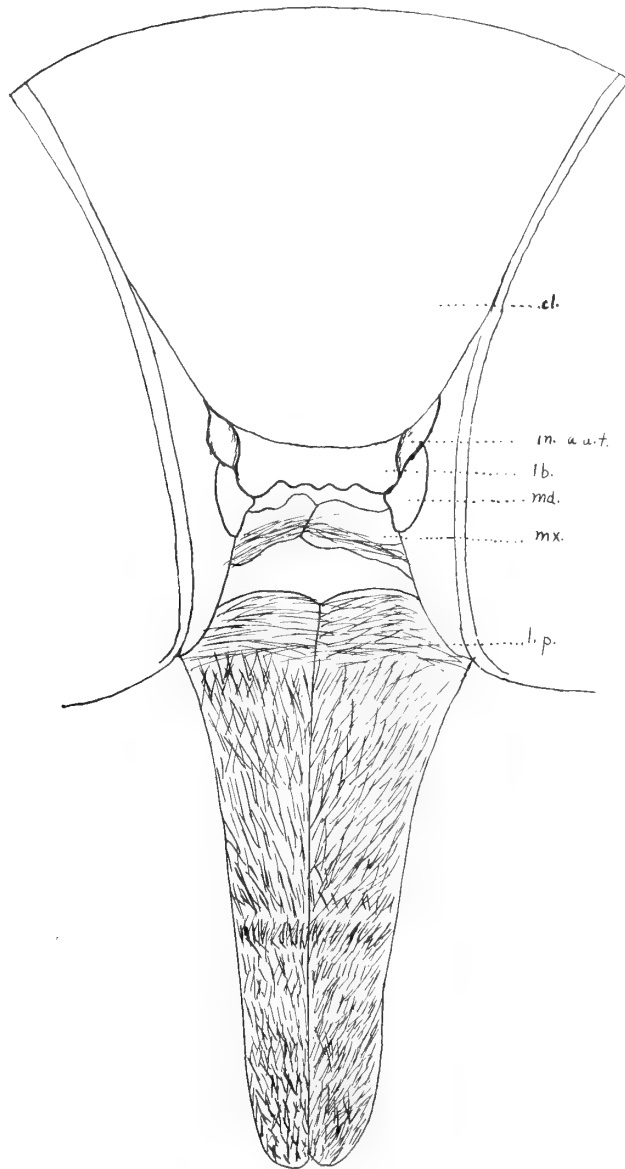


FIG. 20.

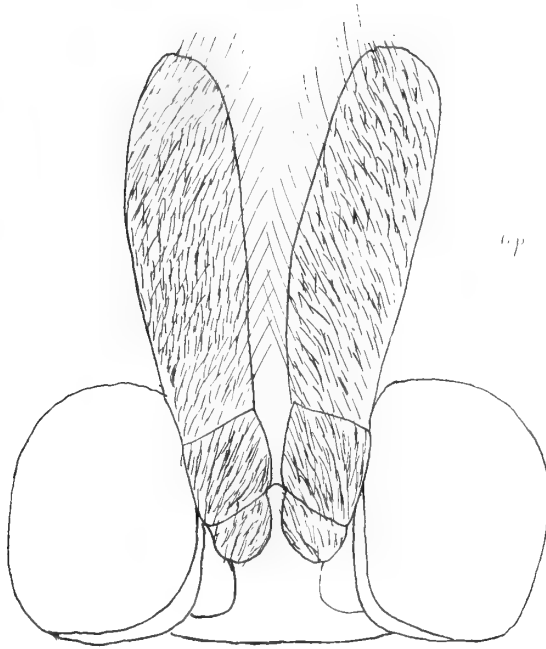


FIG. 21

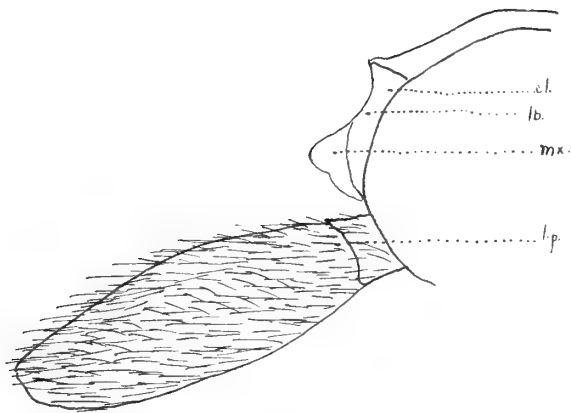


FIG. 22.

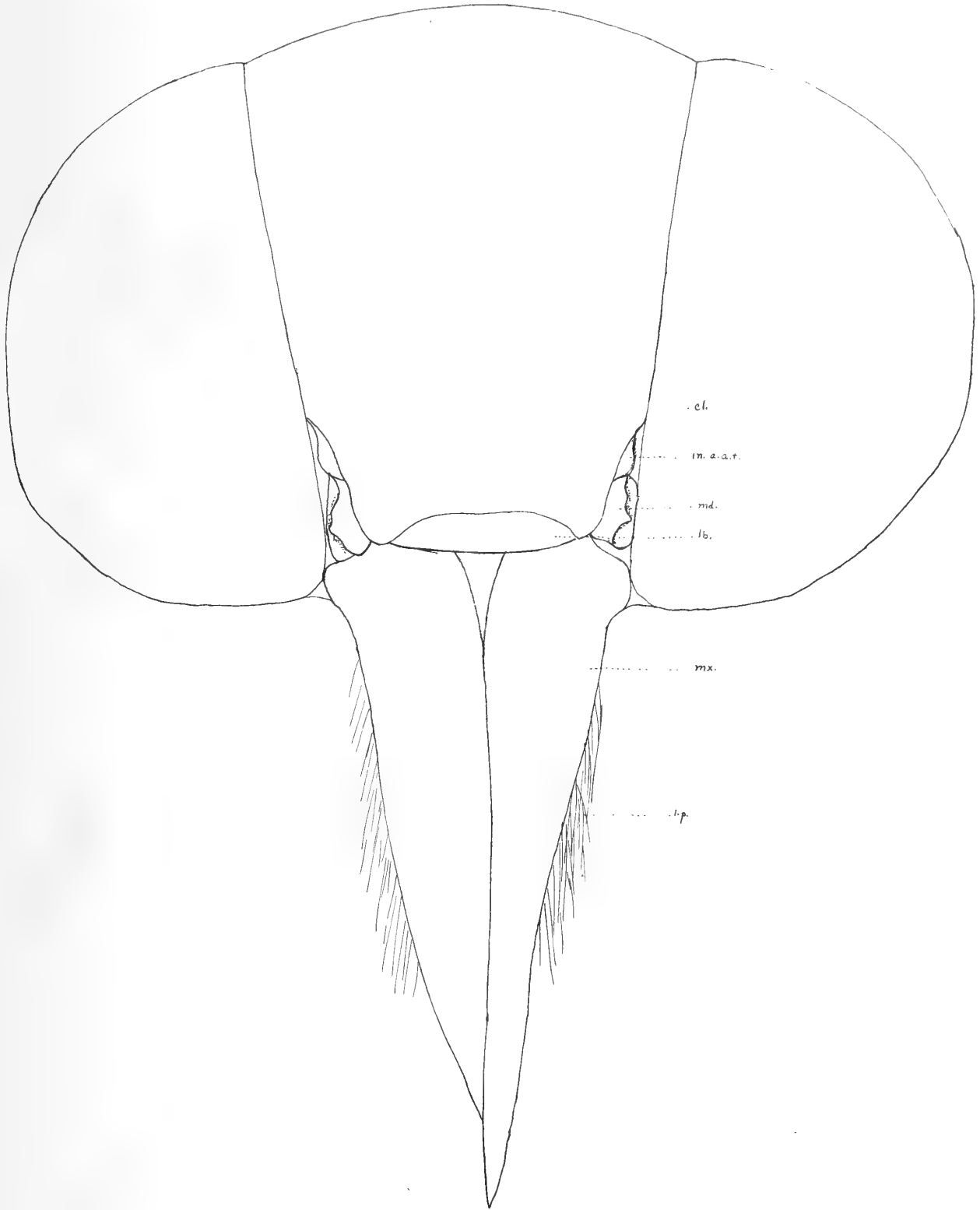


FIG. 23.

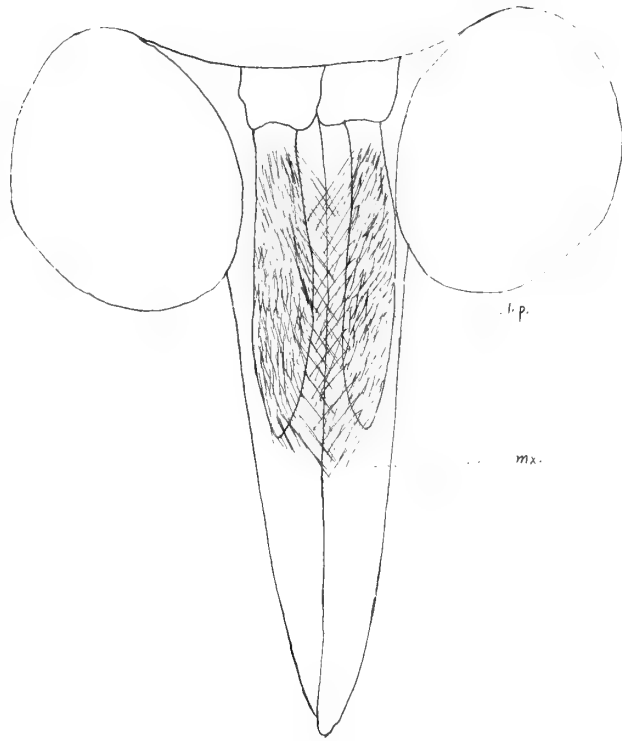


FIG. 24.

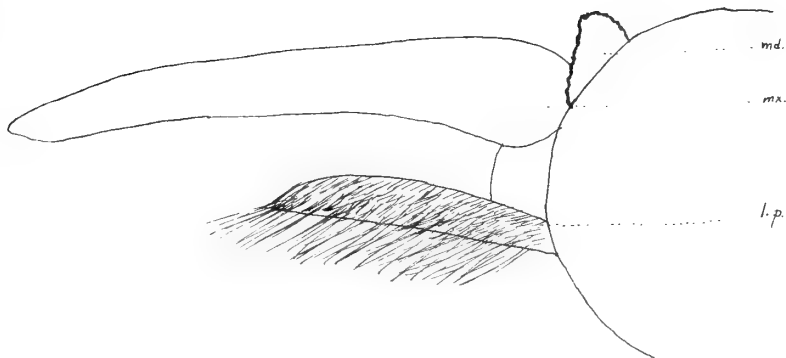


FIG. 25.

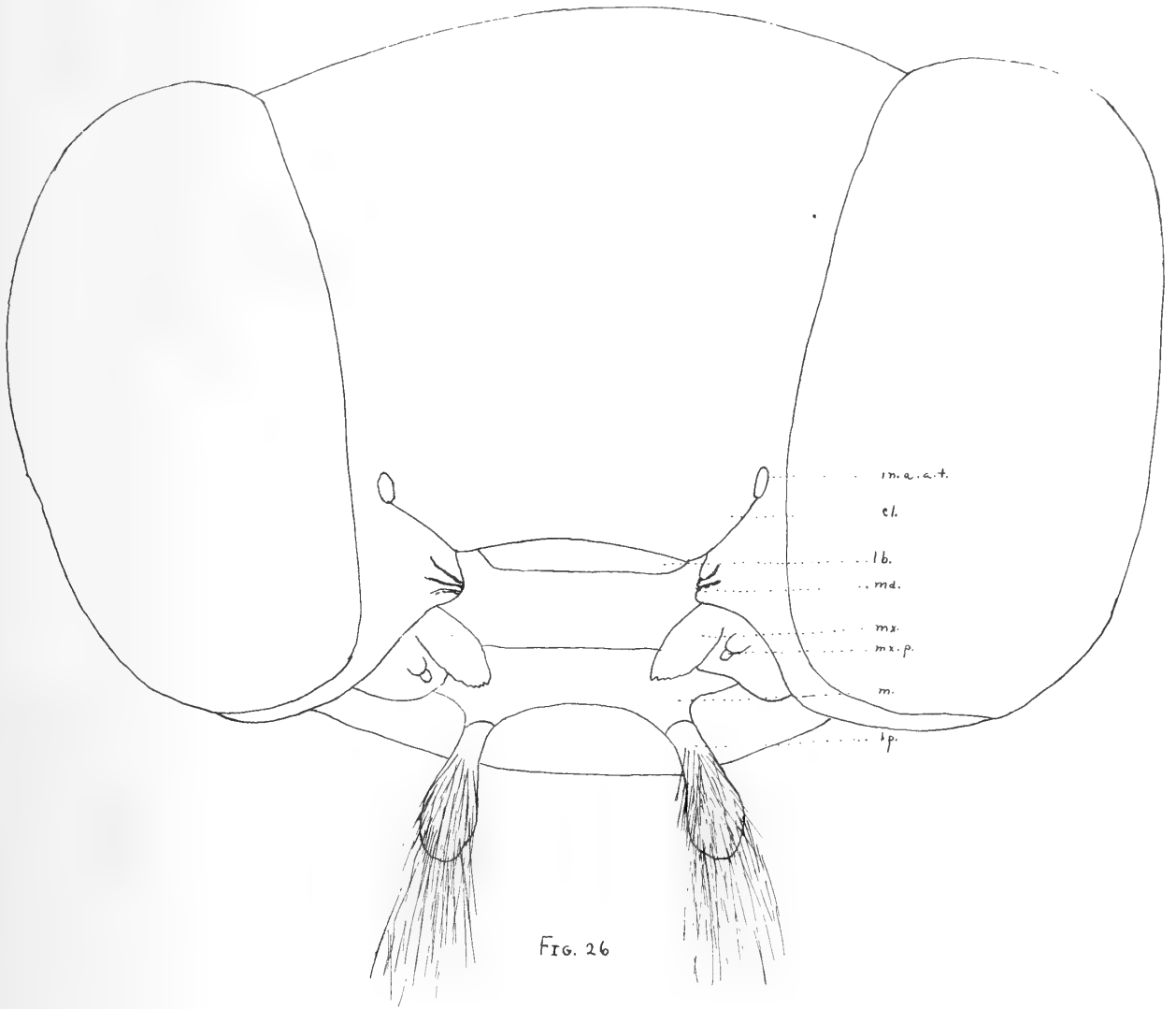


FIG. 26

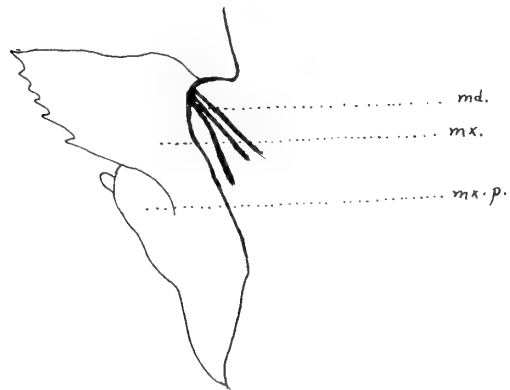


FIG. 27.

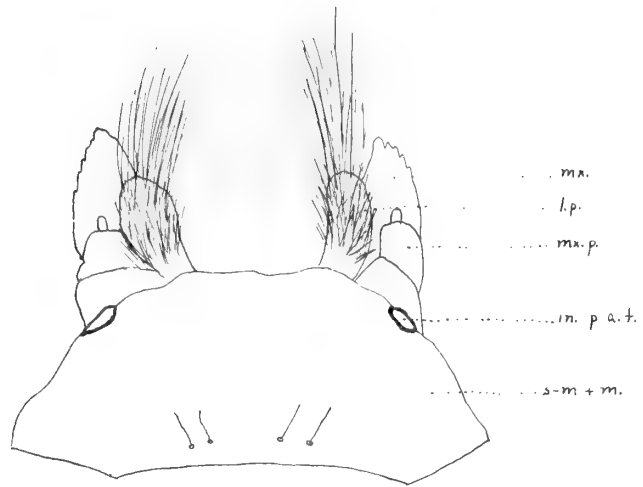


FIG. 28.

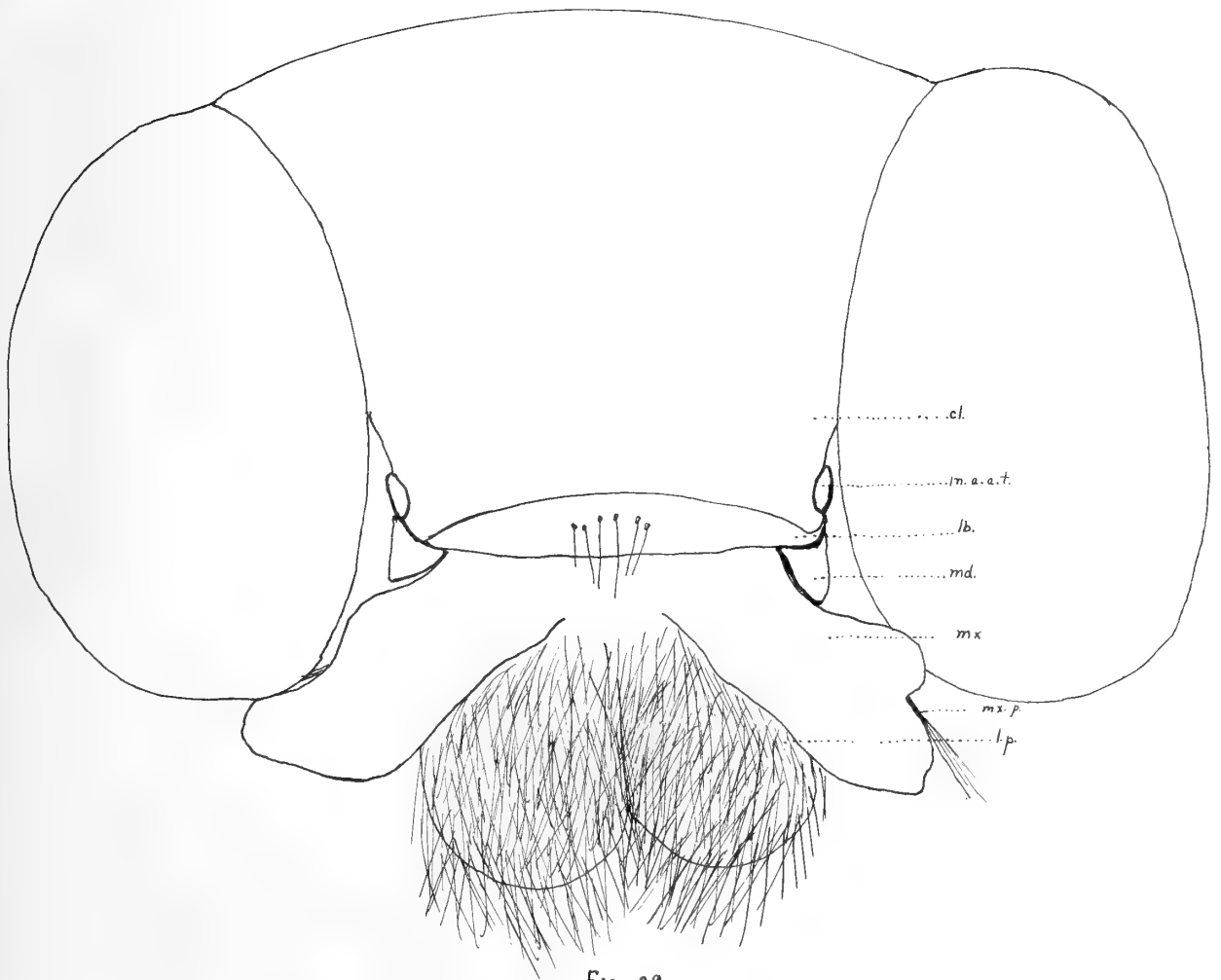


FIG. 29.



FIG. 30.

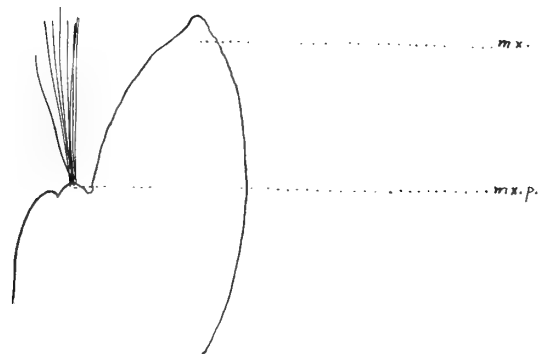


FIG 31.

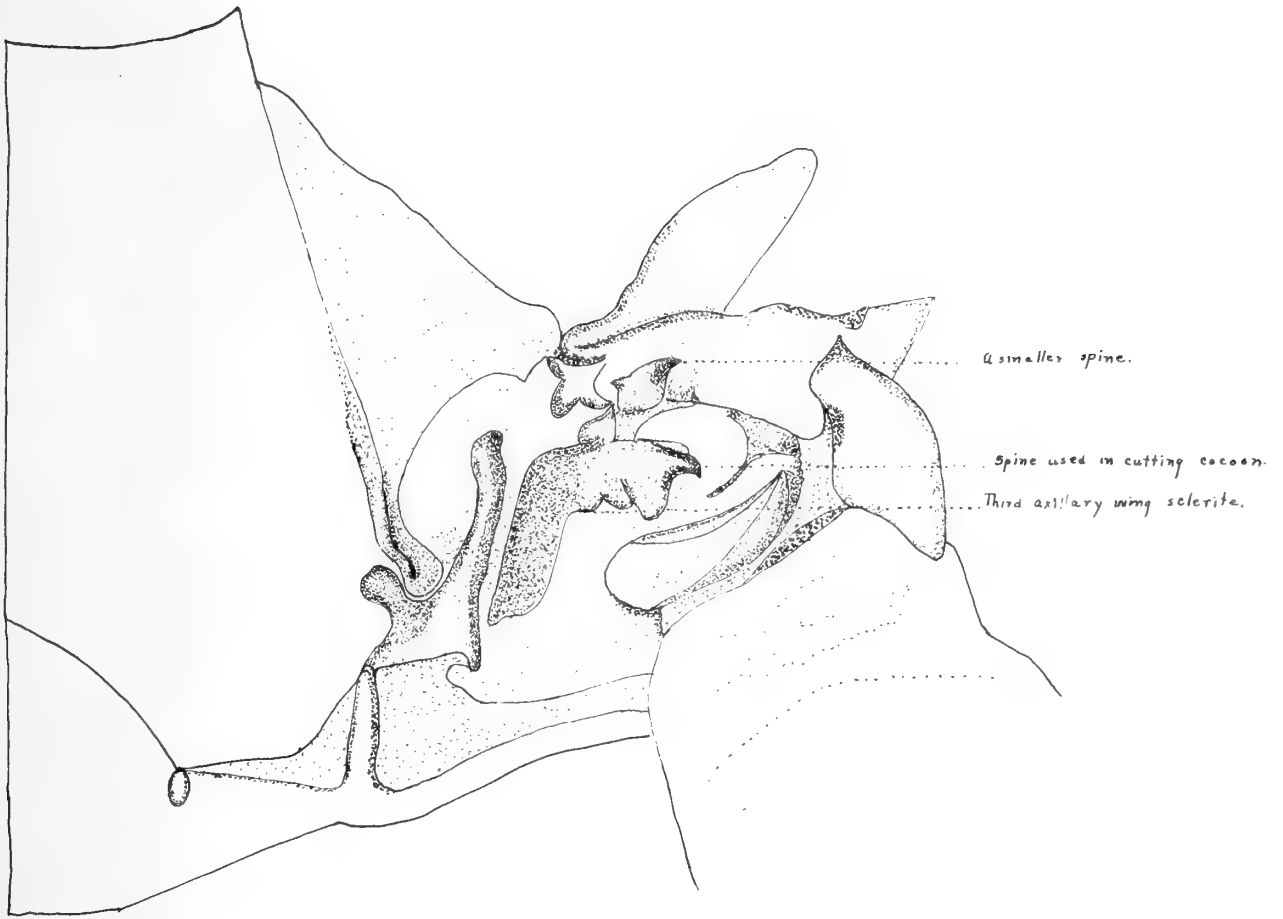


FIG. 32.

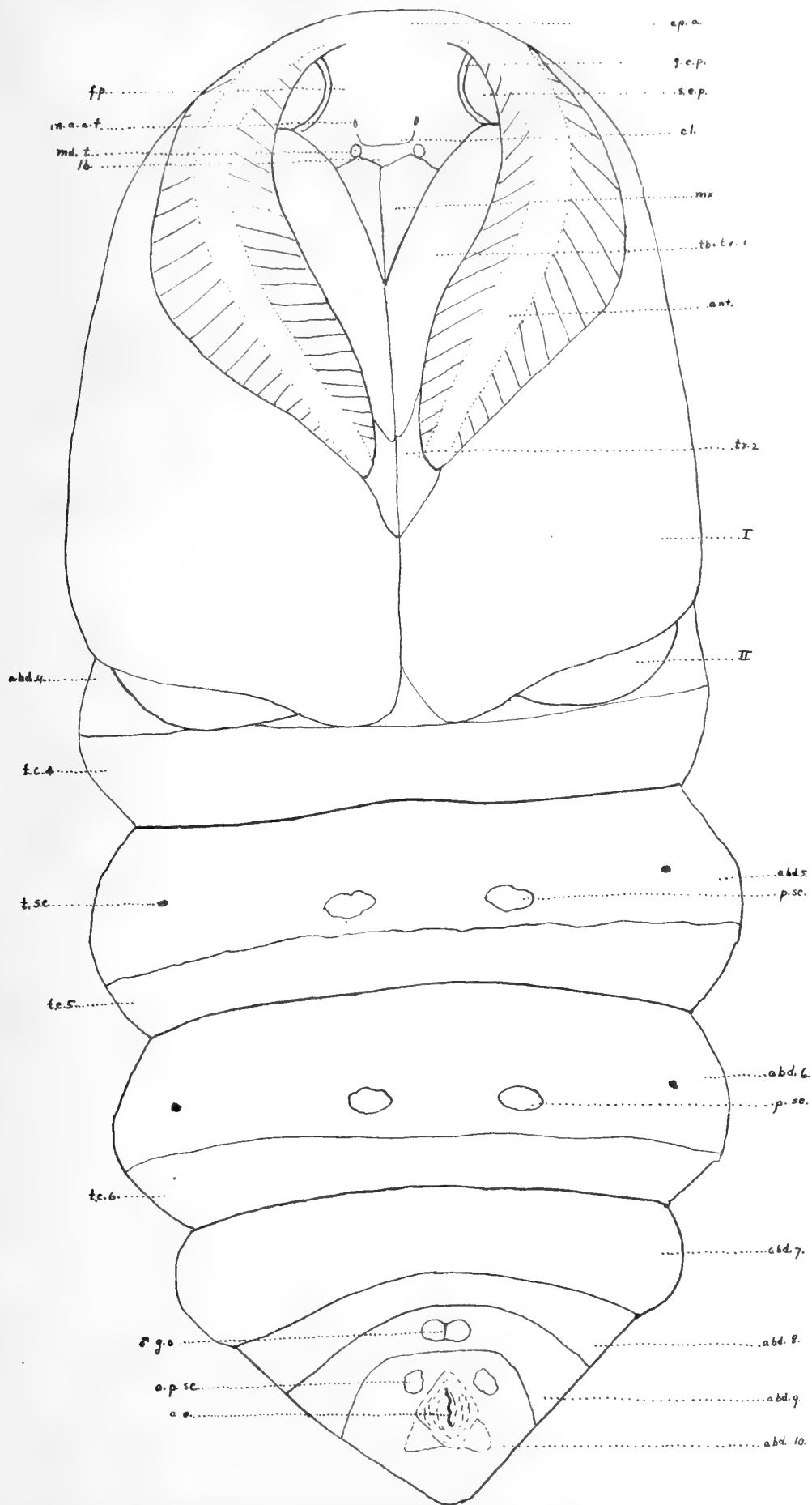


FIG. 33

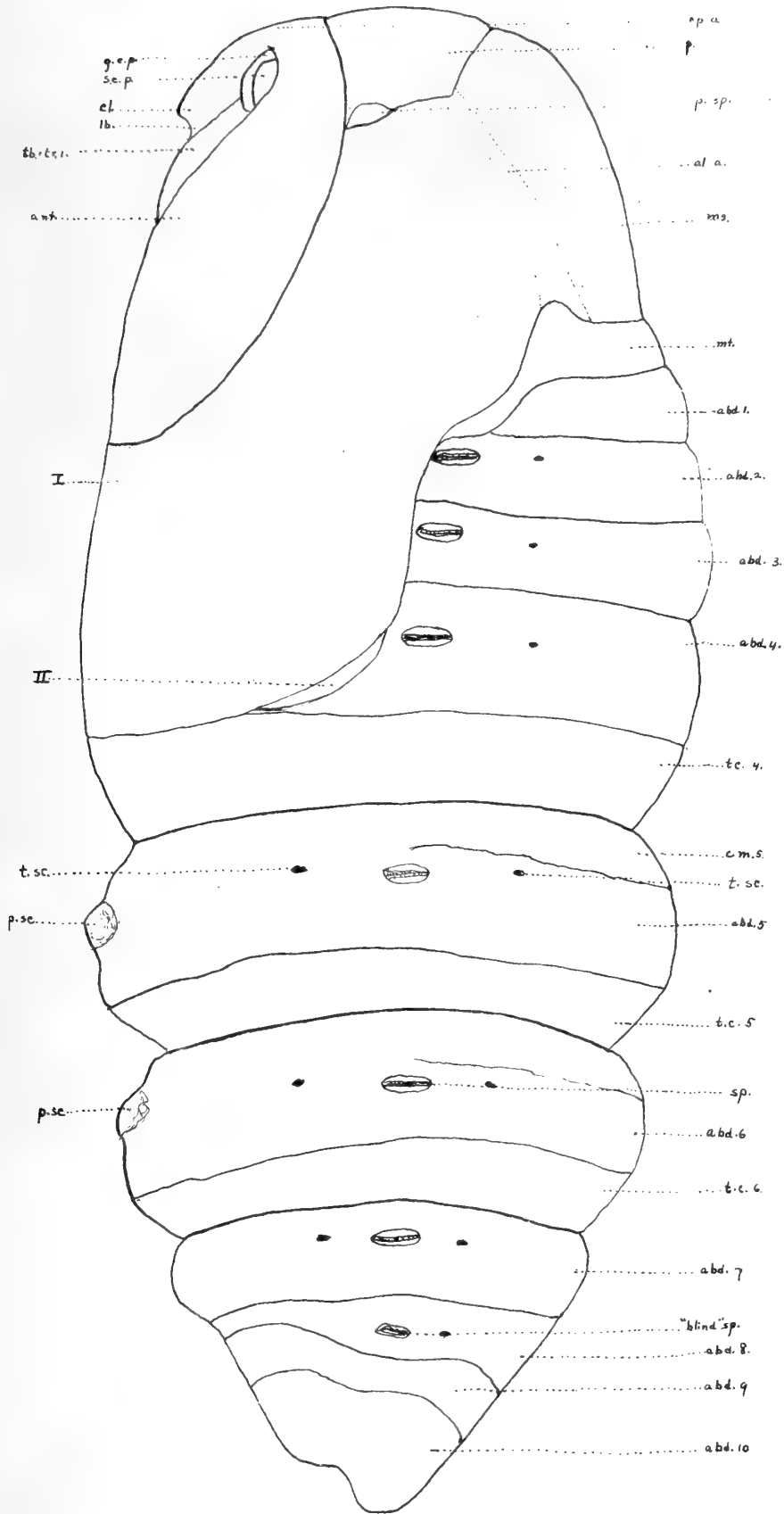


FIG. 34.

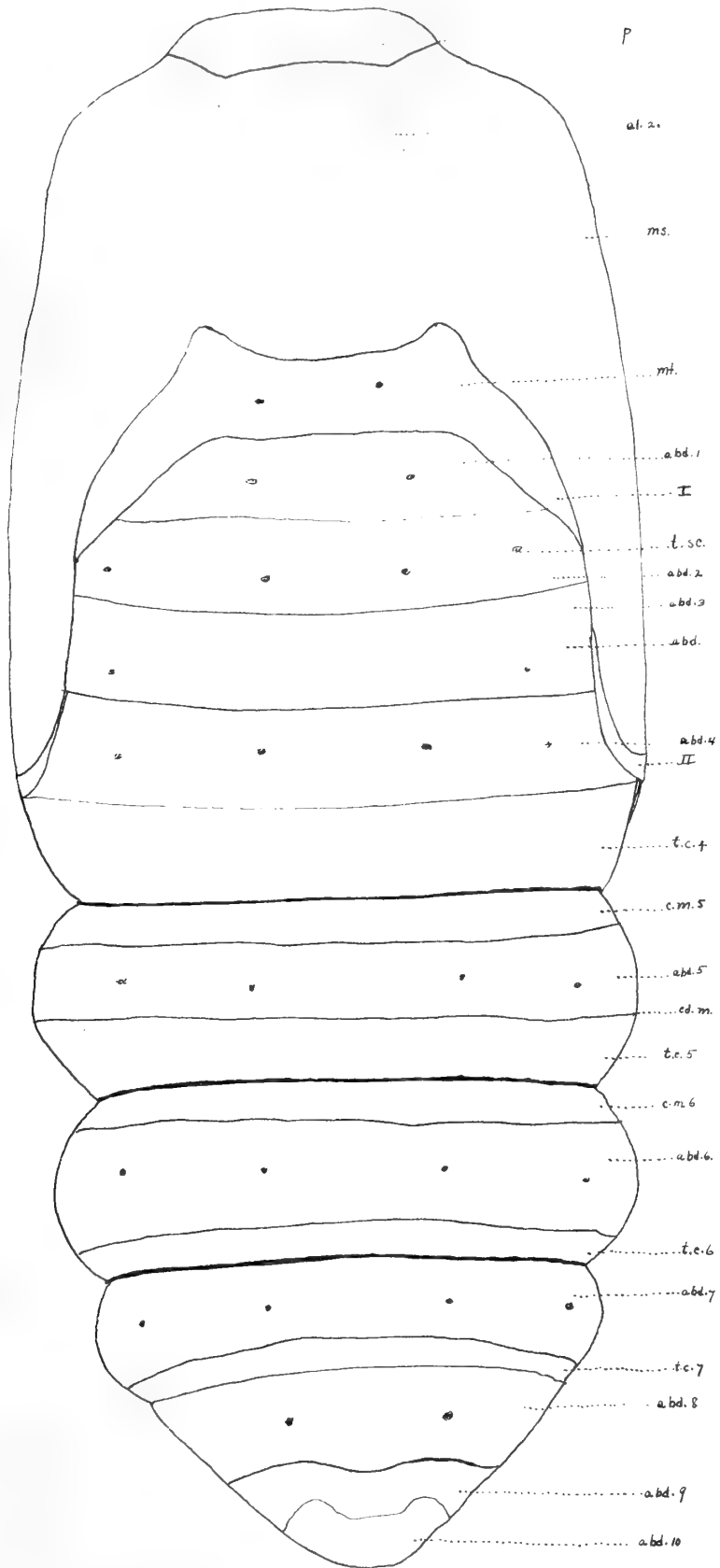


FIG. 35.

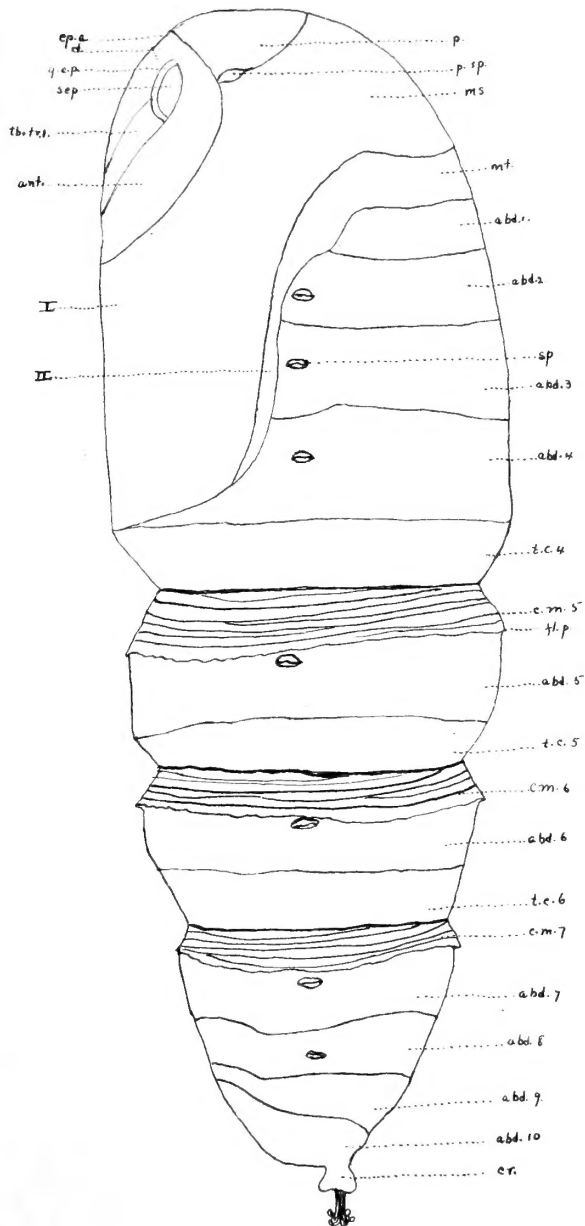
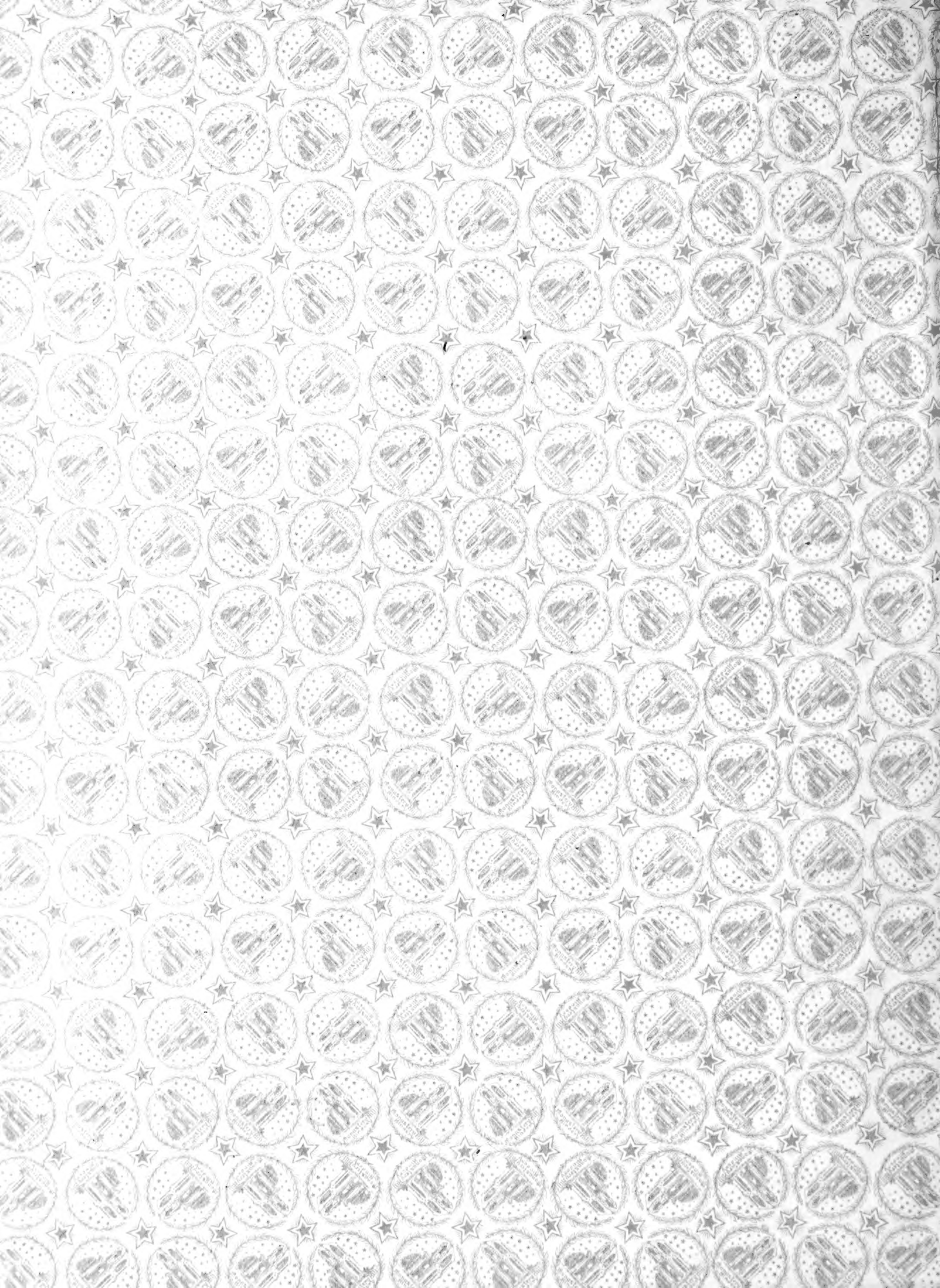
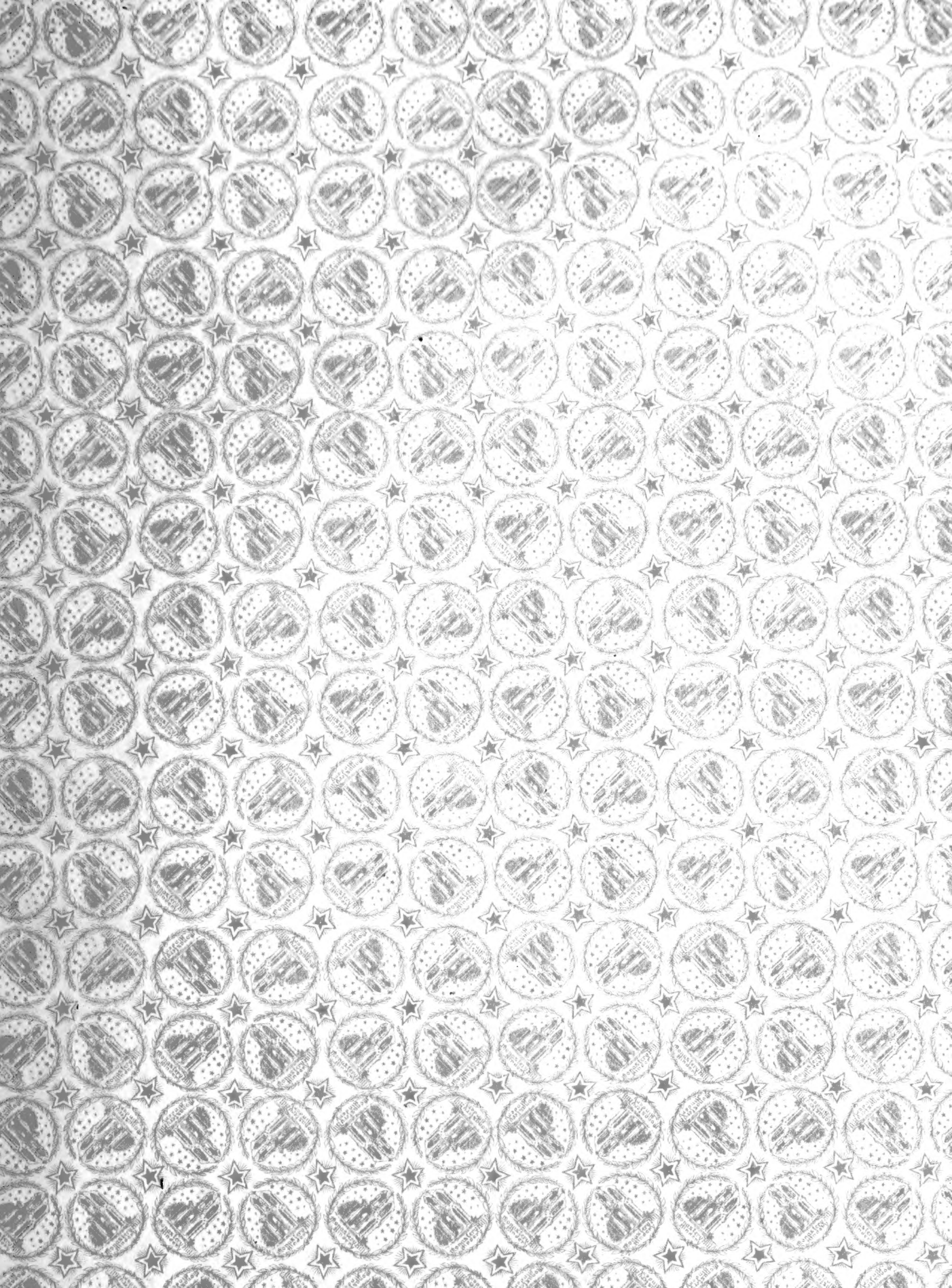


FIG. 36.





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