

THE ANATOMY OF THE TONGUE OF RANA HEXADACTYLA.

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INTRODUCTION.

As is well known the frog's tongue is attached to the tip of the lower jaw by its anterior end, its hind end being free. The frog is capable of turning forward the hind end of the tongue to strike any insect prey and flick it back into the mouth. The movement is so quick and interesting to watch that it has attracted the attention of many workers. Dugès as early as 1827 expressed the opinion that the intrinsic muscles of the tongue were aided by the muscles of the jaw and of the hyoid. In 1857, Fixsen studied the structure of the frog's tongue and put forward the view that the genioglossus muscle acts as the protractor and that the hyoglossus muscle as the retractor of the tongue. This view was later supported by Weidersheim in 1882, by Ecker in 1889 and by Gaupp in 1901. In 1850 Kleine put forward the theory that the hyoglossus is the protractor and the genioglossus the retractor muscle, while in 1894, Ferdinand, from his study of the tongues of several animals, was convinced that the hyoglossus acts both as the protractor and as the retractor. In 1901, Hartog made the suggestion that the tongue is projected by the pressure of lymph into the hollow spaces in the tongue and that the withdrawal of the fluid retracts the tongue. In the same year Gaupp studied the anatomy of the tongue in great detail and supported Fixsen's conclusion that the genioglossus is the protractor and the hyoglossus the retractor muscle of the tongue. As neither a criticism of these views of Gaupp and Hartog nor a detailed study of the anatomy of the tongue has been published, the author has studied in detail the muscles of the tongue which aid it in projection and retraction. A detailed description of the structure and working of the tongue is further called for by the fact that even in the latest edition of the "Biology of the Frog" by Holmes—a handbook for students, the error of associating Gaupp's name with the lymph-pressure theory of tongue-projection has been repeated.

I am of the opinion, that the movements of the frog's tongue are brought about entirely by muscles, and that when the tongue is in a state of rest the long hyoglossi are contracted; but that in functioning they are relaxed, and by their relaxation help the forward movement of the tongue from behind. The front part of the tongue being attached to the symphysis by the genioglossi, the posterior part is free to move forward; the upper mucous secreting surface thus comes into contact with the prey, which adheres firmly to the tongue, and is thus drawn into the buccal cavity.

The hyoid and its muscles are also described so as to give a clearer understanding of the exact relations of the hyoid muscles with those of the tongue, and in order to determine the degree of participation of the hyoid muscles in the mechanism of the projection of the tongue. Further, as the hyoid apparatus participates in the movements of the

tongue in the Squamata, the relation of the hyoid and its muscles in the frog should be of interest for purposes of comparison. It may also be remarked that even the most detailed accounts of the hyoid muscles, hitherto given, are not clear in reference to the actions of the various muscles.

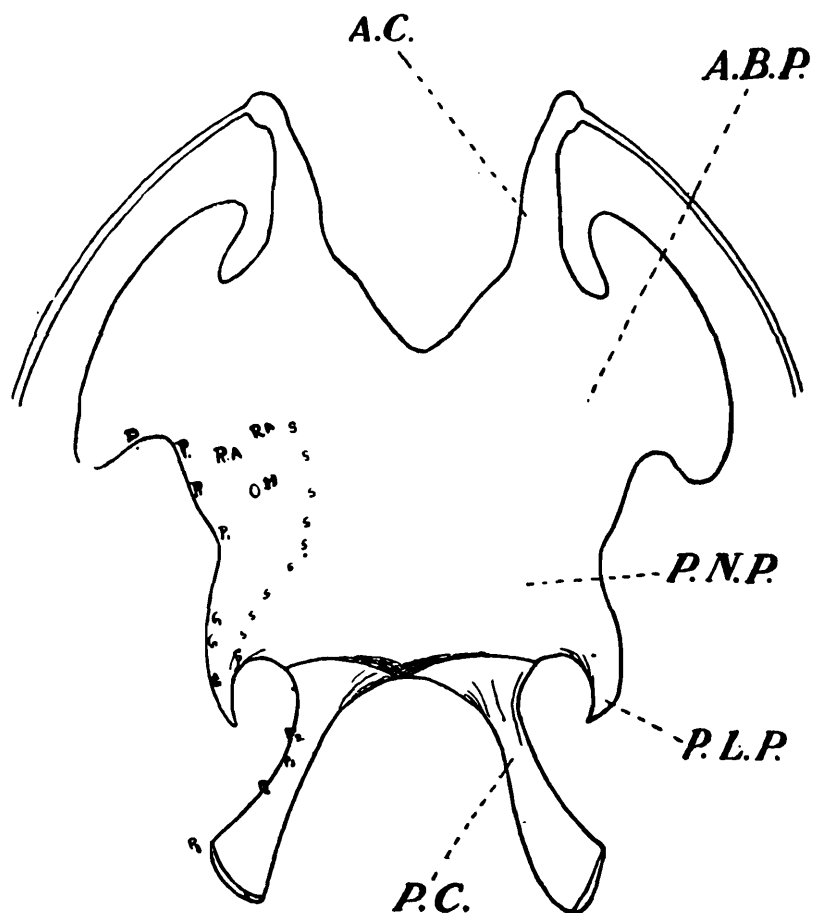
TECHNIQUE.

I dissected several freshly killed, as well as preserved specimens of *Rana hexadactyla*, and also studied the structure of the tongue of *Rana cyanophlyctis* from longitudinal and transverse sections of the entire tongue. The latter species was selected for its smaller size. The tongue was removed in every case with portions of the mandibular symphysis, the transverse muscles and the skin of the chin and the lower jaw, and was fixed in Bouin's picro-formol and embedded in paraffin. The sections were stained in alcoholic borax-carminc followed by Picro-indigo carmine, cleared in clove oil and mounted in Canada balsam.

THE HYOID APPARATUS.

(Fig. 1).

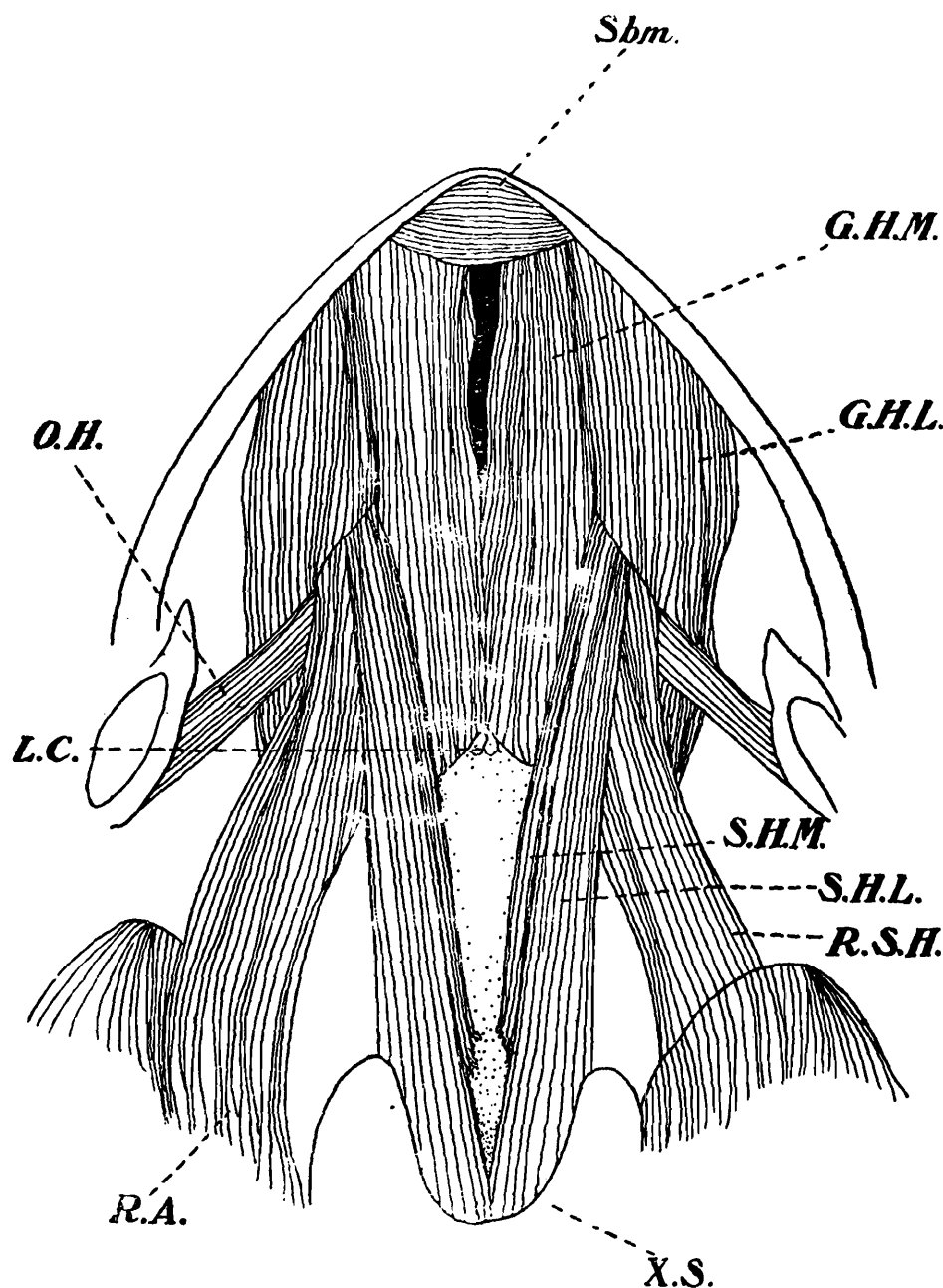
The hyoid (*os hyoideus*) consists of a thin cartilaginous plate broad in front and narrow behind. In the broad part, the antero-lateral



TEXT-FIG. 1.—The hyoid apparatus.

A. B. P.—Anterior broad part; A. C.—Anterior cornua; O. H.—Insertion of omohyoidens; P. C.—Posterior cornua; P_1, P_2 —Petrohyoid insertions; P. L. P.—Postero-lateral process. P. N. P.—Posterior narrow part. R. A.—Insertion of Rectus abdominis continued as sternohyoideus; S_2 —Line of insertion of sternohyoideus. G.—Insertion of geniohyoideus.

margin is slightly constricted on either side to form a wing with an anterior and a posterior projection, and curves evenly from before backwards. The anterior margin bears a pair of elongated processes, the anterior cornua (A. C.). In the narrow part of the hyoid the postero-lateral margin is produced on either side into a pointed process (P. L. P.) which curves inwards. The posterior margin of the hyoid bears a pair of elongated processes, the posterior cornua (P. C.).



TEXT-FIG. 2.—View of deeper muscles. (The anterior parts of the sternum have been removed. *Same size.*)

G. H. L.—Geniohyoideus lateral; *G. H. M.*—Geniohyoideus median; *L. C.*—Laryngeal cartilage; *O. H.*—Omohyoideus; *R. A.*—Rectus abdominis; *R. S. H.*—Rectus abdominis continued as sternohyoideus; *S. H. L.*—Sternohyoideus lateral; *S. H. M.*—Sternohyoideus median; *Sbm.*—submental; *X.S.*—Xiphisternum.

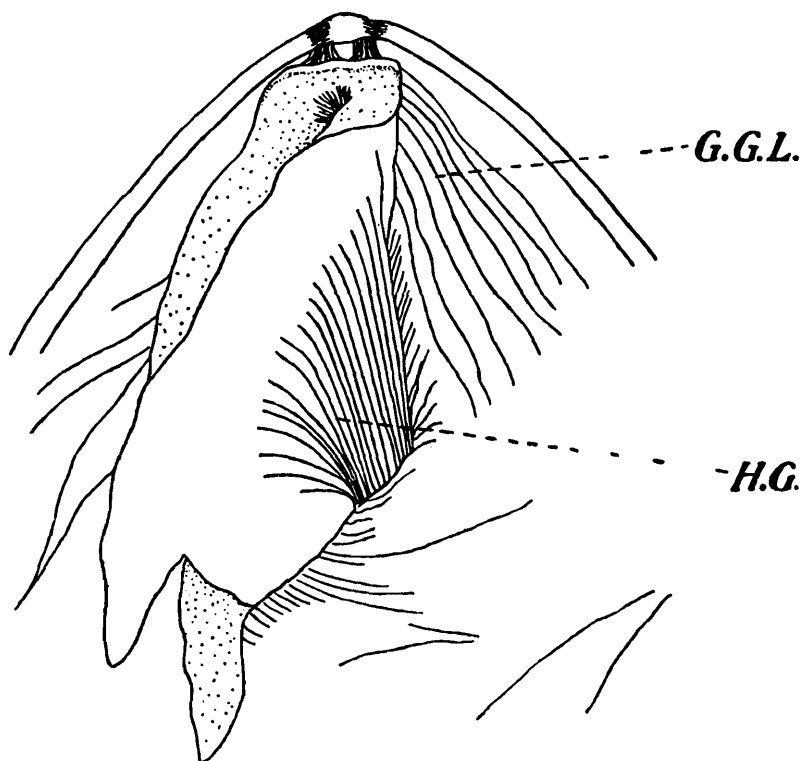
The anterior cornua consist of two parts, a stout proximal part terminating in a knob, and arising from the outer edge of this, a long slender distal part. The latter runs backwards almost parallel to the mandible near to the buccal floor and in close approximation to the fibrous tissues between the mylohyoid muscle and the buccal floor;

its distal ends are attached to the tympanic region. The posterior cornua are two flat bony rods, the anterior ends of which fit into corresponding notches in the posterior border of the hyoid plate: the posterior ends are flatter and have cartilaginous epiphyses.

The flat plate-like form of the hyoid apparatus is eminently adapted for affording attachment to various muscles, and for various movements connected with respiration. It is clear, however, that it does not play any direct part in the movements of the tongue.

TRANSVERSE MUSCLES.

M. Submaxillaris (Figs. 7-15. M. H.).—This forms the most ventral of the sheet of muscles of the lower jaw and corresponds to the mylohoideus of the higher animals. It covers the submaxillary area. Its fibres run transversely from one half of the lower jaw to the other. The most posterior fibres run close to the lower end of the septum maxillare. Some of the posterior most fibres have their origin in the fibrous tissue which lies between the skin and the septum maxillare as the latter bends anteriorly to the corner of the jaw. In *R. hexadactyla*, I have not been able to trace the origin of some of these fibres from the distal process of the anterior cornua, which curves round to the back part of the head, as Ecker seems to have found in the species that he examined. The rest of the submaxillaris has its origin on the superior border of the lower jaw, and extends across to unite with the muscle from the oppo-

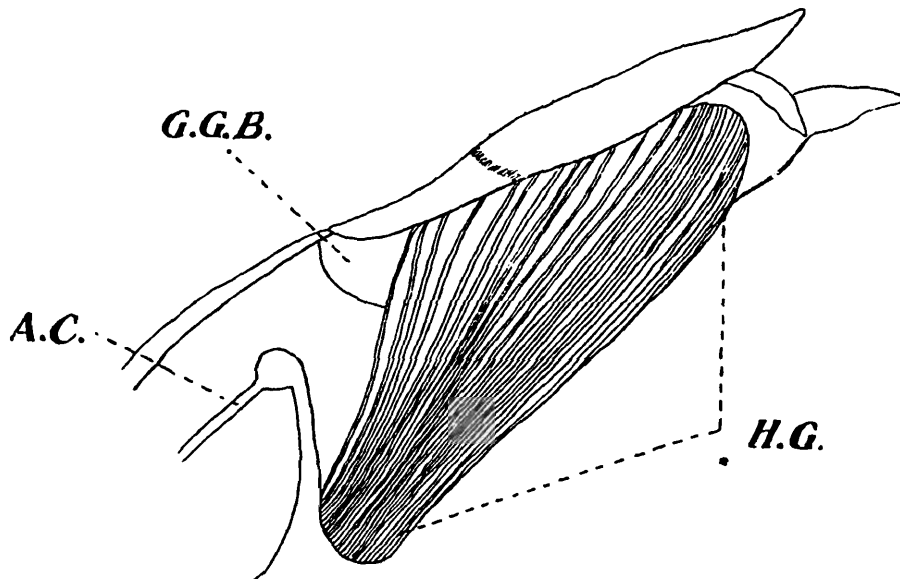


TEXT-FIG. 3.—View of tongue turned over to one side to show the “linguae peduncle”.
G. G. L.—Genioglossus lateralis; H. G.—Hyoglossi.

site side in the middle line by interdigitation. Anteriorly the fibres are directed obliquely forwards and the fibrous fascia in which they meet extends medially over the chin, *i.e.*, the angle of the symphysis, overlapping the submentalis muscle. Though the fibres of the submaxillaris muscle cannot be described as having a double origin, one

on the superior and the other on the inferior border of the jaw, as Kleine seems to have found, this muscle is unmistakably connected with the inferior edge of the lower jaw by a fibrous lateral extension of the fascia of the muscle. Through the space between the insertion on the superior border and the fibrous layer covering the lower edge run the nerves and blood vessels, as Ecker has described, but this alone does not account for the appearance of a twin insertion of the muscle fibres. The submaxillaris is also connected to the sides of the buccal floor by fibrous tissue developed on its fascia.

The Submentalis (Sbm. figs. 2, 7 and 8).—This is a very thick spindle-shaped muscle, the tendons of which are inserted on the dentaries on either side, while its short stout belly occupies the angle of the symphysis. The contraction of these fibres, which are arched ventrally, brings the sides of the lower jaw nearer and, according to Dugès and



TEXT-FIG. 4.—View of tongue partially drawn forwards.

A. C.—Anterior cornua ; G. G. B.—Genioglossus basalis ; H. G.—Hyoglossus.

Ecker, raises the premaxillae and closes the nostrils. It is not clear how the various functions assigned to the submentalis can be brought about, but it is probable that these fibres, which arch downwards and backwards, can by their contraction raise the floor of the mouth above it and push the genioglossi, which lie above it, upwards and forwards. In my opinion this muscle also serves to draw the two halves of the mandible together and lends to it the rigidity and firmness which the flexible cartilaginous union alone would not provide.

THE HYOID MUSCLES.

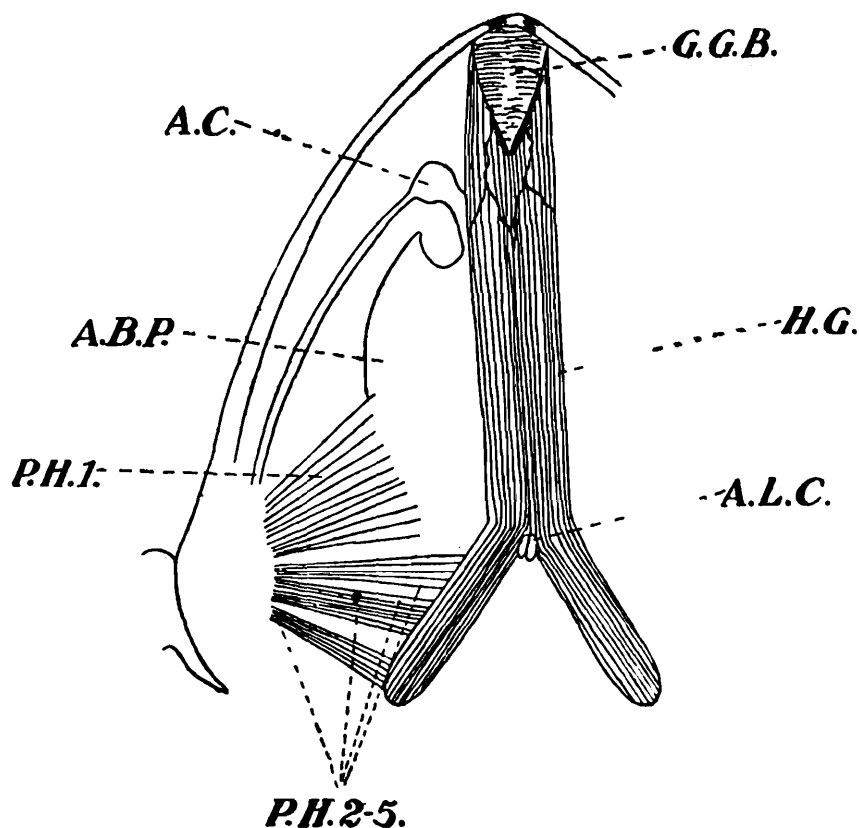
(Figs. 1 and 2).

The Geniohyoideus.—The geniohyoideus of either side rises partly from the median tendon (*vide infra*) behind the symphysis and partly from the mandible where it lies external to the submentalis. The

median and lateral parts run backwards as one muscle but have separate insertions as follows :—

- (a) The median division (G. H. M.) is inserted on a tendinous sheet which springs from the body of the hyoid between the proximal ends of the posterior cornua, and descending below is extended under the fasciae of the hyoglossi as they approach each other. This tendon sheet is in close union with the fibrous tissues which connect the anterior tips of the arytenoid cartilages with the hyoid ;
- (b) the lateral bundle (G. H. L.), after running backwards with the median portion, separates from it to be inserted on the postero-lateral process of the hyoid.

The Sternohyoideus.—This is the anterior continuation of the *rectus abdominis*, which in the frog is considerably modified. It consists of three portions, a lateral and two median. The lateral part of the sternohyoideus (R. S. H.) of each side is really more ventral being the continuation of the *rectus abdominis* (R. A.) passing beyond the fifth “*inscriptio tendinae*” Running along close to but at a lower level than the median portions it ascends between the two divisions of the geniohyoideus, and its fibres, together with those of the median parts, become inserted on the lower surface of the hyoid plate. Of the two



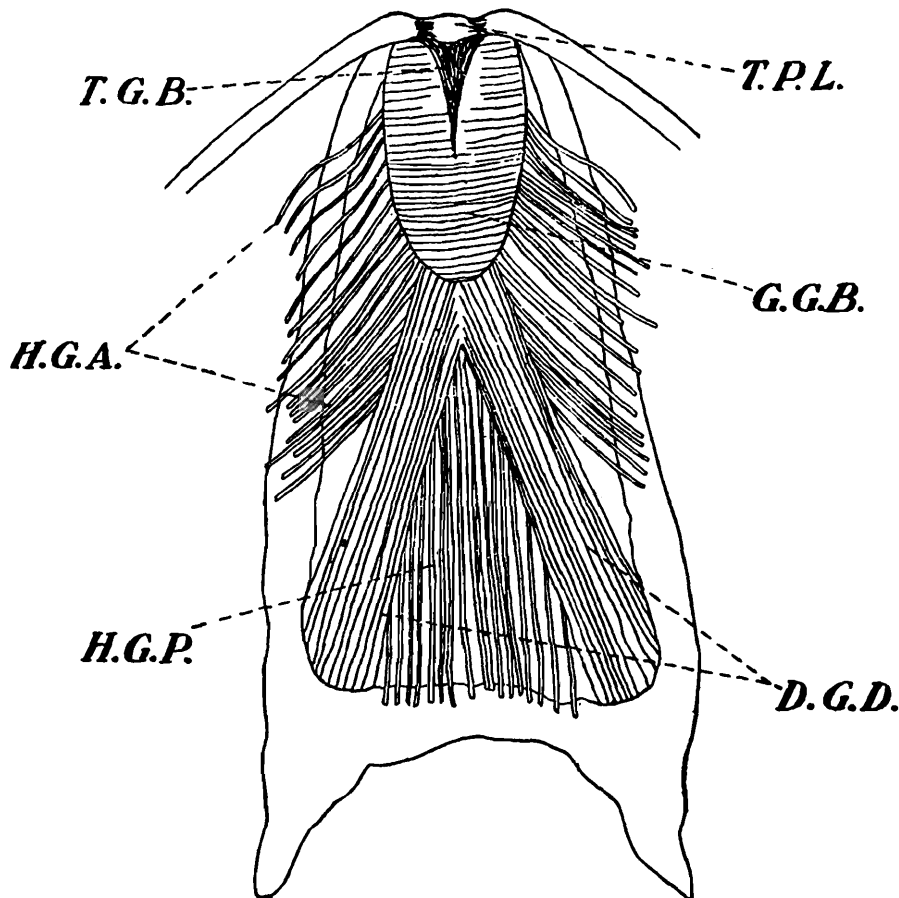
TEXT-FIG. 5.—View of deepest set of muscles.

A. B. P.—Anterior part of basilinguae plate ; A. L. C.—Anterior laryngeal cartilage ; P. H.₁₋₅.—Five bundles of petrohyoidei. (Other letters as in Fig. 4.)

median parts of the sternohyoideus, the outer (S. H. L.) is longer, and arises on the xiphisternum. Owing to its being close to its fellow of the opposite side both in origin and in the short length of its forward course, it appears as a single muscle but divides into two anteriorly. The second median part (S. H. M.) of the sternohyoideus is much shorter

and springs from the sides of the anterior end of the sternum proper. The median portions run with the lateral to their insertion on the hyoid plate.

The Omohyoideus (O. H.).—This is a comparatively slender muscle which arises on the anterior border of the bony scapula, descends anteriorly, and passing above the more superficial sternohyoideus reaches the hyoid bone between the divisions of the geniohyoideus, slightly external to the sternohyoideus.



TEXT-FIG. 6.—Ventral view of tongue with the Hyoglossus teased and spread out.

D. G. D.—Divergent bundles of genioglossus dorsalis; *G. G. B.*—Genioglossus basalis; *H. G. A.*—Hyoglossus anterior fibres. *H. G. P.*—Hyoglossus posterior fibres; *T. P. L.*—Tuberculum prelinguae—*T. G. B.*—Tendon connecting g. basalis with the geniohyoideus median.

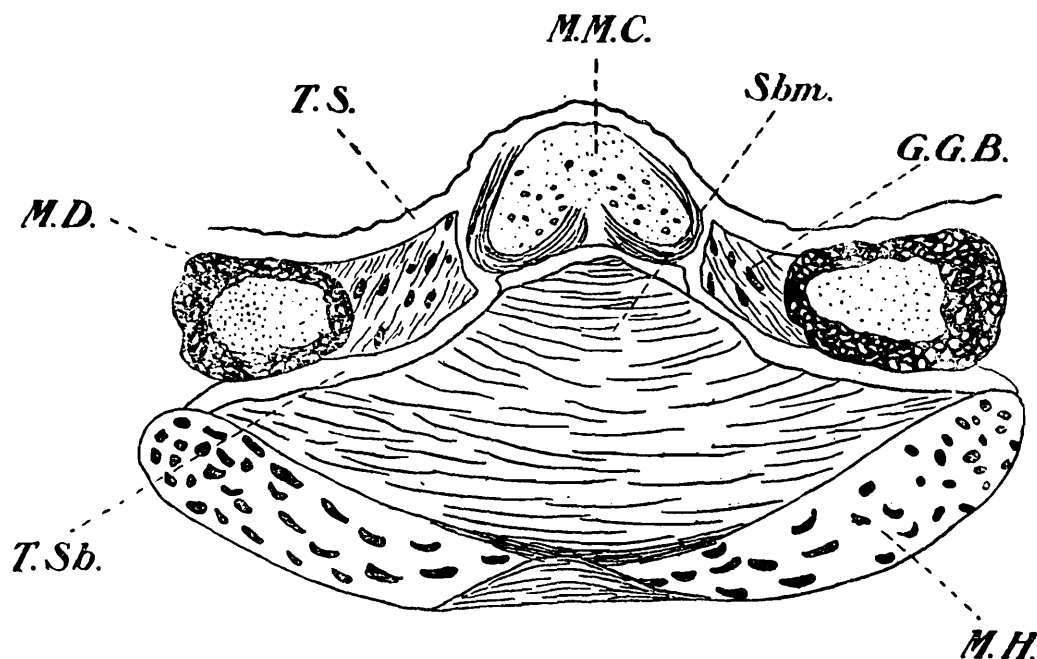
The Petrohyoidei. (Fig. 1 P_1 — P_5).—The petrohyoidei arise from the prootic region of the skull, and curve round the pharynx to the ventral side in the region of the hyoid apparatus. From the nature of their insertion and from the difference in size of the muscles two groups can be recognized. The first, or *petrohyoideus anterioris*, is a thin flat muscle much wider than the rest. Though narrow at its origin it broadens as it descends. It is inserted on the sides of the posterior part of the hyoid, where the latter passes into the broader front part. *Petrohyoidei posteriores* are four in number, and curve round close to the pharynx spreading out to their insertion on the outer sides of the posterior cornua. Though they do not appear to have a direct and distinct insertion on the pharyngeal wall, it is not improbable that they function to some extent as constrictors of the pharynx.

The hyoid muscles appear to be adapted for moving the hyoid apparatus but not the tongue.

TONGUE MUSCLES.

(Figs. 3-16).

The two muscles of the tongue, the genioglossus and the hyoglossus, are both well developed, but, unlike the condition in the Reptilia, the genioglossus is chiefly a muscle of the tongue and is spread out on the buccal floor only as a very thin lateral extension. Further the genioglossal fibres are dorsal to those of the hyoglossus and not ventral to them as in the reptiles.

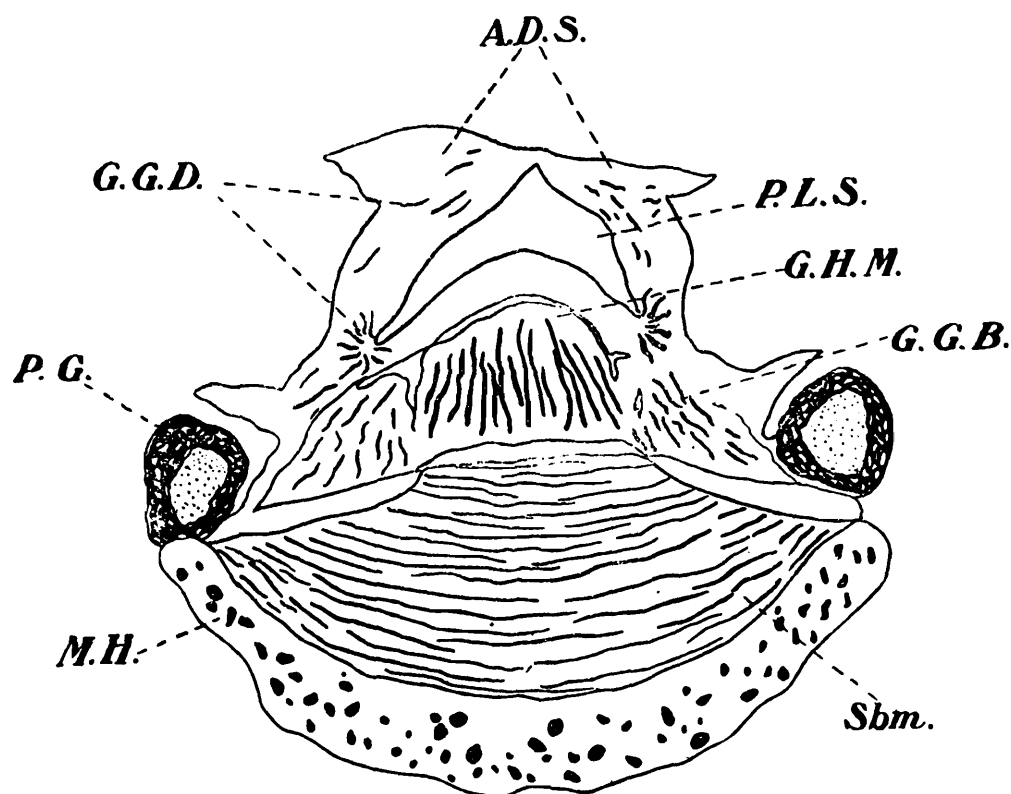


TEXT-FIG. 7.—Transverse section through mandibular symphysis.

G. G. B.—Genioglossus basalis; *M. D.*—Mandibular rami; *M. H.*—Submaxillaris; *M. M. C.*—Mentomeckelian cartilage (*Tuberculum prelinguae*); *Sbm.*—Submentalis; *T. S.*—Tendon sheet; *T. Sb.*—Tendon of submentalis.

Genioglossus (figs. 3, 5).—Wherever present, in the frog and other animals, this muscle arises anteriorly at the symphysis of the lower jaw and extends backwards. Its origin in the frog, however, is not on the mandible itself but on a tendinous sheet springing from its superior aspect on either side of the *tuberculum prelinguae* (Fig. 6 T. P. L., Fig. 7 M. M. C.). The anterior fibres spring vertically from the lateral edges of the sheet, which stretches behind as two narrow strips, and the median fibres of the geniohyoideus arise below the central part of this tendinous sheet. The posterior fibres of the genioglossus spring both from above and below the two posterior extensions. As a consequence, the genioglossus appears to consist of a dorsal part arising from above the two tendinous strips, and a ventral and lateral part proceeding from their lower surface. The origin of the dorsal fibres from the posterior extensions of the tendinous sheet instead of from the upper surface of the sheet itself, indicates the apparently greater development of the ventral than of the dorsal part (which has a depression at its anterior end). Furthermore, as most of the fibres arise only from the posterolateral extensions of the tendinous sheet, the medial fibres incline towards one another, arching over the space between the two tendinous strips. A lymph sinus is formed at the anterior end of the tongue and is continued as a blind recess to some distance posteriorly. As the

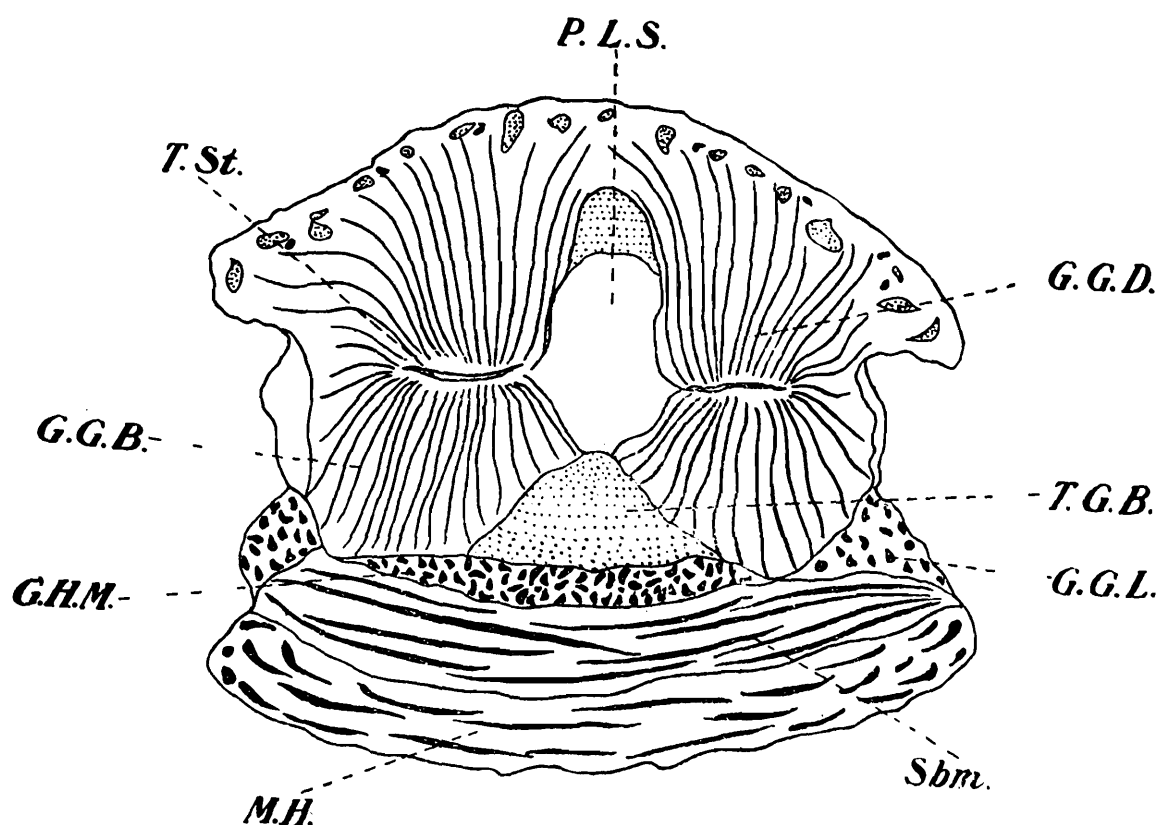
course of the dorsal fibres varies from that of the ventral and the lateral fibres, the three parts of the genioglossus may be described separately.



TEXT-FIG. 8.—Transverse section through the anterior end of tongue.

A. D. S.—Anterior edge of dorsal surface of tongue ; *G. G. B.*—Genioglossus basalis ; *G. G. D.*—Genioglossus dorsalis ; *G. H. M.*—Geniohyoidens median ; *P. G.*—Mandible ; *M. H.*—Submaxillaris ; *P. L. S.*—Prelingual sinus ; *Sbm.*—Submentalis.

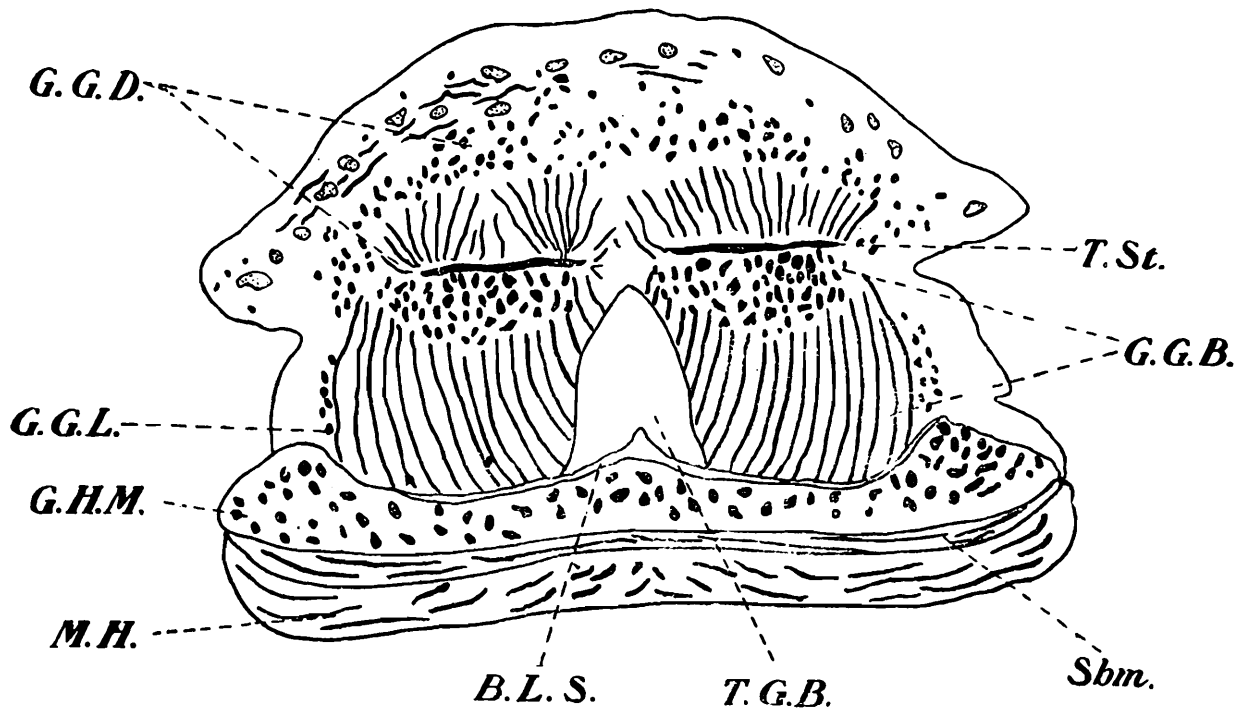
Genioglossus dorsalis. (G. G. D.).—As mentioned above, this part of the genioglossus begins a little behind the ventral part. (Figs. 9



TEXT-FIG. 9.—Transverse section through "Conical bodied muscle".

G. G. L.—Genioglossus lateralis ; *T. G. B.*—Tendon of genioglossus basalis ; *T. St.*—Tendon strips. (Other letters as in Fig. 8.)

and 10, T. St.). The first few fibres, springing from the two strips of tendon, radiate upwards into the surface of the tongue. The next few fibres run upwards and backwards, while the succeeding ones bend backwards to run parallel to the surface of the tongue. At about a sixth of the length of the whole tongue the lateral fibrous fascia of the whole genioglossus passes below the dorsal part of the muscle as an inward lateral extension, separating it from the thick cone-shaped genioglossus basalis. The lateral penetration of the fascia on either side is accompanied by fibrous extensions into the dorsal part of the genioglossus, dividing it into about three bundles. It is on this mass of fibrous tissue that the hyoglossal fibres are inserted (*vide infra*). The fibres of the dorsal part of the genioglossus serve to rotate its anterior end and to shorten the tongue, and as they diverge in the broad posterior region, they also serve to contract this part. As the cone-shaped genioglossus basalis extends backwards beyond the tendinous strips, the truncate



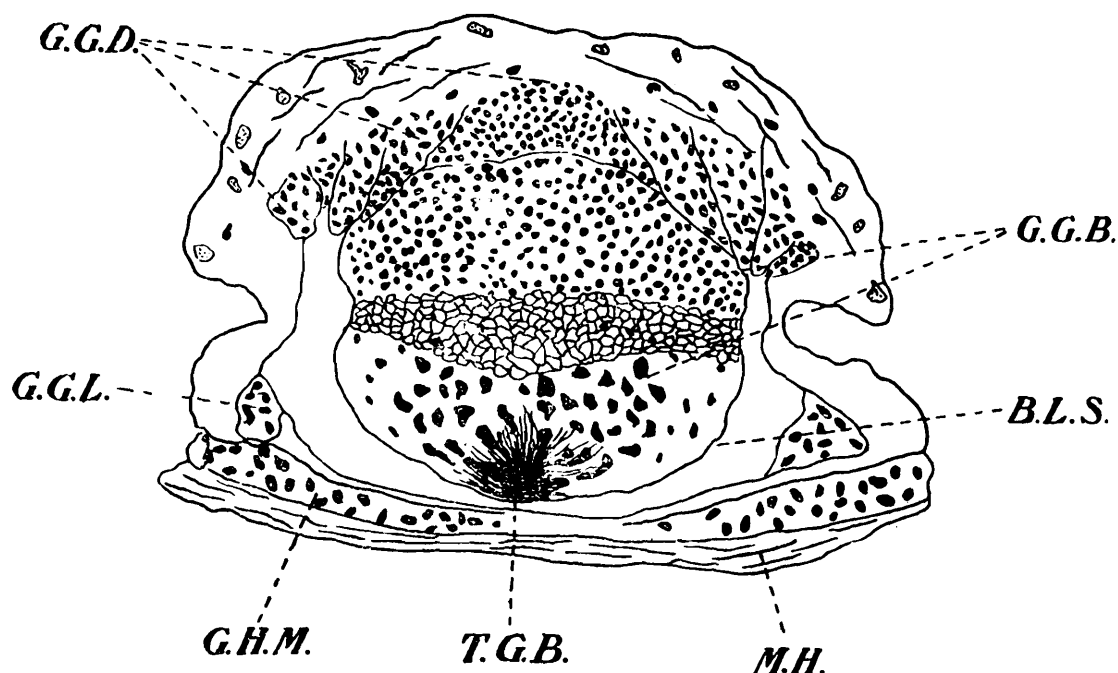
TEXT-FIG. 10.—Transverse section through middle part of "Conical bodied muscle".

B. L. S.—Basilingual sinus. (Other letters as in Figs. 8 and 9.)

end of the median tendinous thickening of its ventral fascia curves upwards and separates the hindmost fibres of the genioglossus dorsalis into two divisions, which diverge (Fig. 6, D. G. D.) as they run into the tips of the tongue. Each division is formed of several bundles consisting of many fibres twisted as in a rope, and serves to draw up the tips of the tongue and to approximate them medially as well. Gaupp has not adequately explained the function of this muscle—especially its role in the play of the tongue.

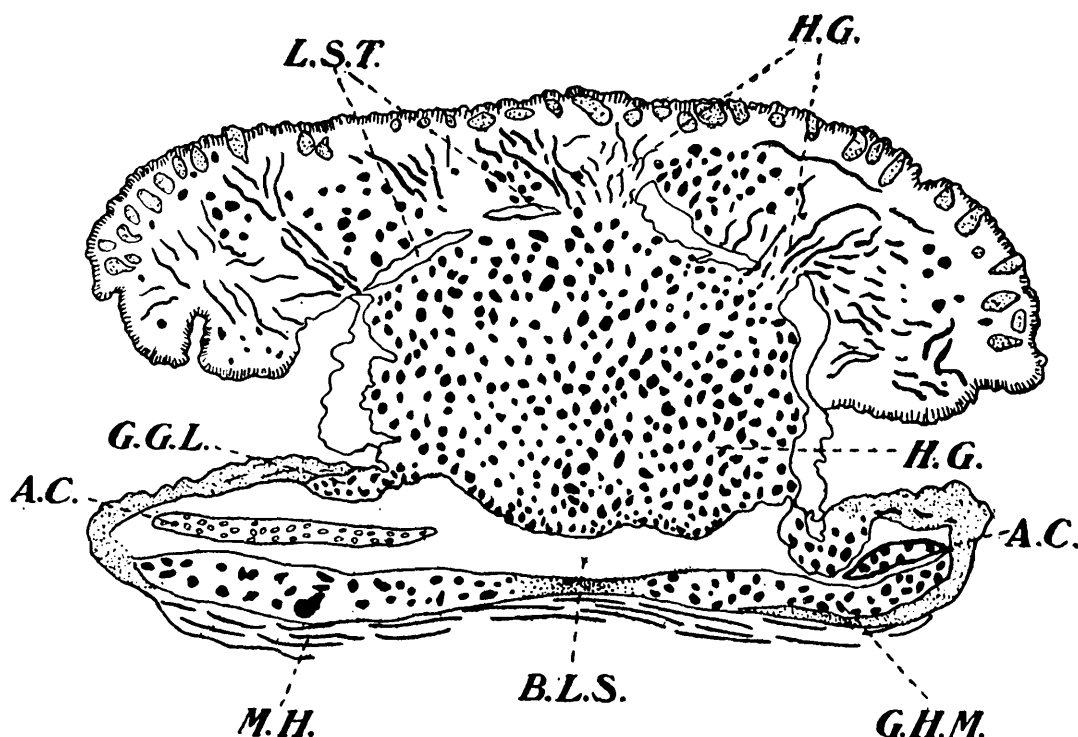
Genioglossus basalis. (G. G. B.).—This is a thick conical muscle, nearly one-third the length of the tongue, and lies at the front end of the tongue below the genioglossus dorsalis. The fibres of this muscle vary in their course. (a) The anteriormost fibres, which spring from the tendon sheet on either side of the *tuberculum prelinguae*, incline outwards and are inserted on the upper aspect of the tendinous sheath of the submentalis (*vide fig. 8*). A little behind where the tendinous

sheet of origin ends in two flat strips, the fibres are all oblique ; those directed outwards end in fibrous tissues of the buccal surface of this part, while those which incline inwards are inserted on the upper fascia of the median geniohyoideus. (b) Still further behind, all the fibres incline towards a median insertion and a thick tendon (Figs. 9 and 10,



TEXT-FIG. 11.—Transverse section through hinder part of "Conical bodied muscle".
(Letters as in Figs. 8, 9 and 10.)

T. G. B.) is formed on the middorsal region of the fascia of the median geniohyoideus. Near the posterior limit of the prelingual sinus (Fig. 9, P. L. S.) (*vide infra*) this tendon becomes separated from the geniohyoideus by the sinus basi lingualis (Fig. 10, B. L. S.) (*vide infra*) and



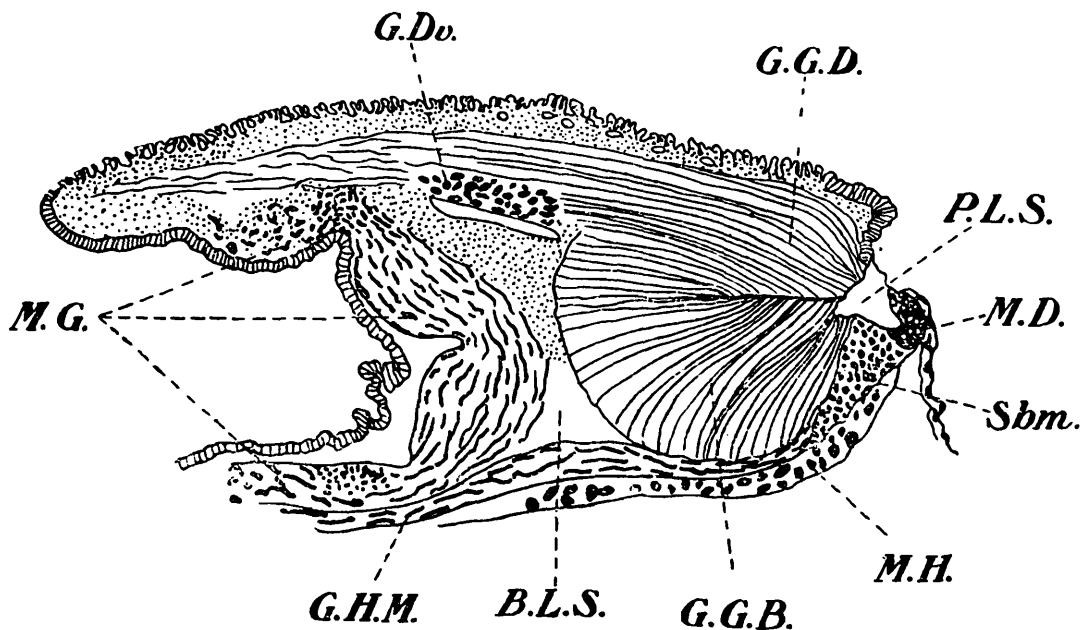
TEXT-FIG. 12.—Transverse section behind the conical muscle.

A. C.—Anterior cornua ; H. G.—Hyoglossus ; L. S. T.—Lymph sinuses of tongue.
(Other letters as in Figs. 8, 9 and 10.)

runs within the ventral part of the genioglossus itself. Not only do these fibres of the ventral part of the genioglossus run inward from their lateral origins to the median tendon, but, owing to the great length of the more posterior fibres, run parallel to the long axis of the body for some distance and then turn downwards to their insertion (figs. 10 and 14). (c) The hindmost fibres are more or less horizontal and run nearly parallel to the tongue. As the fibres of the genioglossus basalis are much shorter than those of the genioglossus dorsalis, they form a thick cushion-shaped mass of muscle with a truncate hind end.

Genioglossus lateralis. (*G. G. L.*).—The fibres forming this division the genioglossus spring anteriorly from the fibrous tissues at the sides of the *G. basalis*, and spread backward fanwise, extending into the fibrous tissue below the buccal epithelium. They are few in number and lie far apart forming a sheet one fibre thick.

It is evident that the function of this peculiar and complicated muscle is to move the tongue forwards. The fibres of the dorsal part draw the posterior part of the tongue towards the tendinous sheet, which is thus made taut, resulting in the shortening of the tongue. The function of the several fibres of the basal part of the muscle differs according to their varied courses. The anterior-most fibres draw the tendon running along the lower side of the fascia, more forwards than upwards, while the fibres of the extreme posterior part draw the posterior end of the muscle distinctly forwards. The net result of the action of these fibres is to curve the hind end of the muscles upwards and forwards.



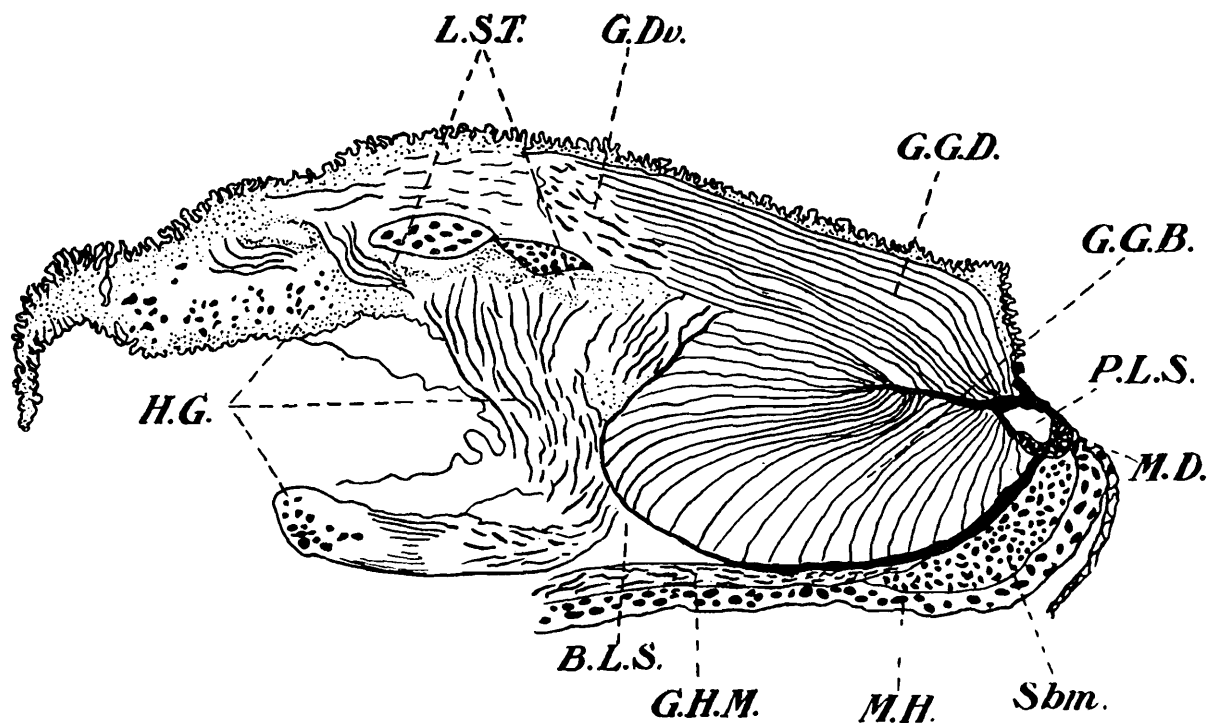
TEXT-FIG. 13.—Longitudinal section through median region.

G. Dv.—Genioglossus dorsalis divergent bundles. (Other letters as in Figs. 8 and 10.)

This gives the pivotal movement necessary to enable the tongue to turn forward. As the ventral part of the genioglossus is attached at the front end to the submentalis and the geniohyoideus median, only the hinder end of the muscle is tilted forwards and upwards. The buccal floor is pulled forwards by the contraction of *g. lateralis*, thus facilitating the projection of the tongue. Here again owing to the

attachment of a part of the g. basalis to the buccal floor by the g. lateralis, as also by fibrous tissues, the front end of tongue cannot turn forwards.

Hyoglossus (*H. G.*) (figs. 4-17).—This is a paired muscle springing on either side from the distal end of the posterior cornua of the hyoid. It passes ventrally to the posterior cornu till the basihyoid is reached, then over the joint of the posterior cornua with the basihyoid, and, finally, joins its fellow of the opposite side, the two running forward close together and parallel to each other. Owing to the inconspicuousness of the fascia between them the two appear as one muscle in a transverse section. Running straight across the basihyoid, the hyoglossus turns upwards round its anterior curved edge, breaks out from its fibrous sheath and its fibres spread forward on either side of the ventral part of the genioglossus. The anterior-most fibres are inserted on the

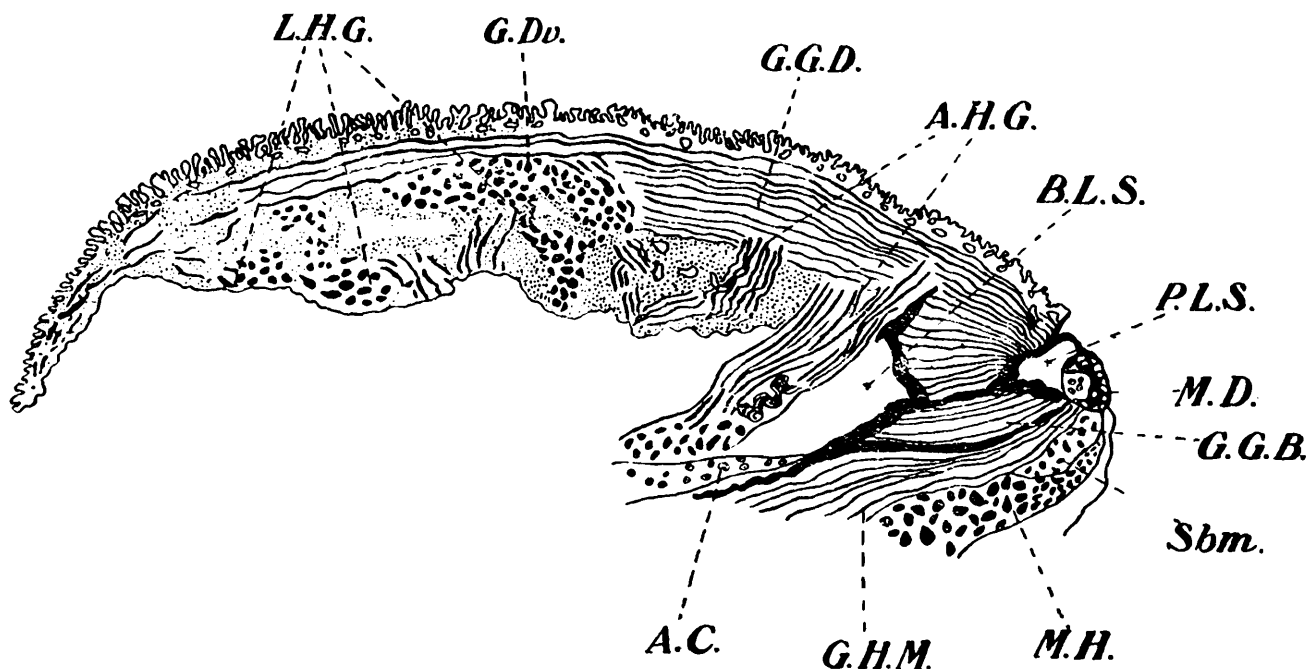


TEXT-FIG. 14.—Longitudinal section through slightly more median region.
(Letters as in Figs. 8, 10, 12 and 13.)

front one-eighth of the length of the tongue. Other fibres are inserted in the fibrous tissues of the lower surface of the tongue on either side of the basal part of the genioglossus. The hyoglossal fibres are inserted between the two stout oblique bundles of the genioglossus dorsalis behind the genioglossus basalis. They are so numerous that they appear to form a peduncle by which the middle of the tongue is attached to the buccal floor. The distribution of the hyoglossal and genioglossal fibres in the tongue, will be clear from the diagram (fig. 16). The hyoglossal fibres which enter the middle of the tongue and radiate backwards to the hinder part of the tongue, appear to be short when the tongue is retracted, but when the tongue is swung out forwards, they appear to be long.

The surface of the tongue when projected is slightly reduced in area owing to the contraction of the genioglossus dorsalis, and when the tongue is resting the hyoglossal fibres running into the anteriormost

part of the projected tongue are really bent back. Even allowing for these facts, it is obvious that the hyoglossus running as it does from

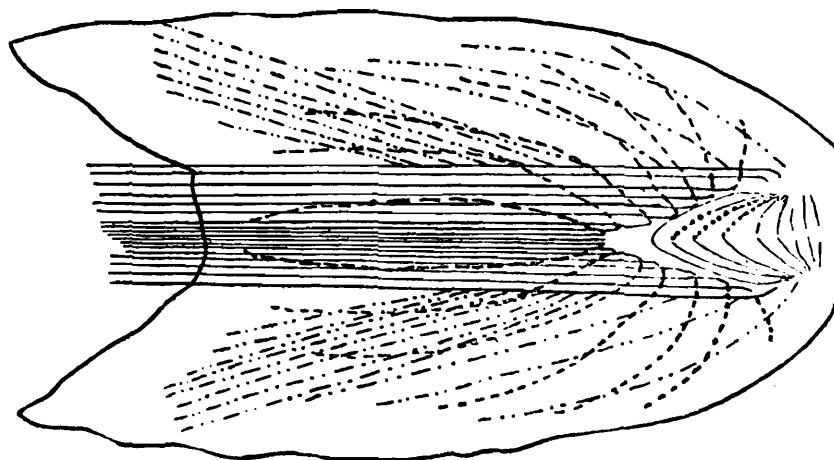


TEXT-FIG. 15.—Longitudinal section through lateral part of tongue.

A. H. G.—Anterior hyoglossal fibres ; L. H. G.—Lateral hyoglossal fibres. (Letters as in Figs. 8, 10, 12 and 13.)

its origin up to the middle of the retracted tongue, must be in a considerably contracted state, not unlike the very highly contracted hyoglossus of the Chameleon.

Some of the earlier investigators have maintained that there are three intrinsic muscles in the tongue of the frog, viz.—(a) the muscle, *transversum linguae*, present in the ventral region of the posterior part of the tongue, (b) a median longitudinal muscle present in the hinder part of the tongue, and (c) very fine muscle fibres spreading in a curve on the ventral surface of the whole tongue. Of these investigators

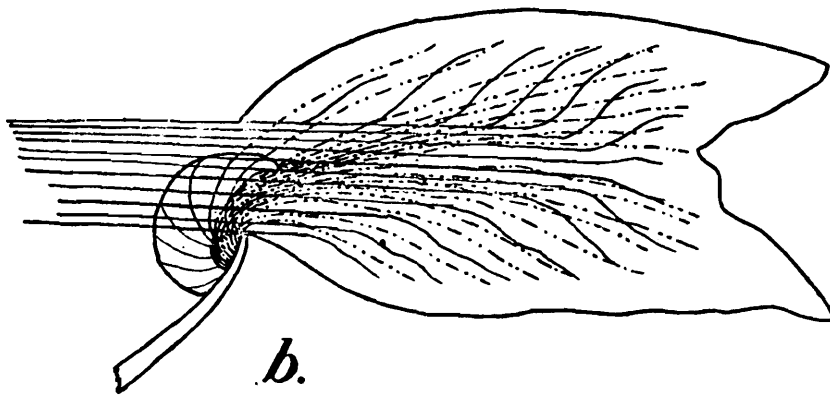


a.

TEXT-FIG. 16a.—Diagram to show the distribution of the hyoglossal and genioglossal fibres in a resting tongue, as seen from the Ventral Side.

- = Genioglossus basalis fibres.
- - - - - = Genioglossus dorsalis fibres.
- = Hyoglossus fibres.

Gaupp alone appears to have made an accurate study of the microscopic structure of the intrinsic muscles, but beyond mentioning them he gives no description. A close study of serial transverse and longitudinal sections of the muscles shows that there are no intrinsic muscles in the tongue, and it is formed by the genioglossus and the hyoglossus alone. If the course of the genioglossus dorsalis be followed it is found that the fibres deviate in places to the borders of the tongue ; this is especially so in the part of the tongue behind the conical genioglossus basalis, where the posteriormost of the dorsal fibres run to the tip of the tongue as divergent bundles. These fibres serve to reduce the width of the tongue and may be mistaken for transversalis linguae. The greater number of the fibres of the genioglossus dorsalis runs backward through the entire length of the tongue to appear in the middle and posterior parts as several separate but similar bundles. All the fibres serve to shorten the tongue and so function as longitudinalis linguae ; they should not, however, be mistaken for a separate and distinct intrinsic muscle.



TEXT-FIG. 16b.—Diagram to show the distribution of the hyoglossal and genioglossal fibres in an extended condition of the tongue.

- = Genioglossus basalis fibres.
- · · · · - · · · · = Genioglossus dorsalis fibres.
- - - - - = Hyoglossus fibres.

As already described, the fan-shaped hyoglossal fibres in the tip of the tongue appear to be independent fibres which curve and radiate in the ventral region of the tongue. It may be pointed out that the tongue is not capable of much movement within the mouth. The front portion of the tongue may be raised by the contraction of the submentalis while the whole tongue may be raised or lowered with the buccal floor by the movements of the hyoid. The length of the tongue may be reduced by the contraction of the longitudinal fibres of the genioglossus dorsalis and the breadth by the contraction of the divergent fibres of the same muscle. In this manner the tongue accomplishes the necessary adjustments after the retraction of the tongue into the mouth, and during swallowing.

THE MECHANISM OF THE TONGUE.

The sudden relaxation of the hyoglossus from a state of tonus enables the tongue to be pushed forwards, and as the tongue is attached to the tip of the lower jaw by the genioglossus which in contracting

gives an upward and forward jerk, the tongue turns over with the mandible as its fulcrum, till the posterior end is flung forward bringing the dorsal sticky surface of the tongue down on the prey. This mechanism of the tongue is comparable to that of a lever of the third order. The rôle, however, of the various parts of the genioglossus differs. The genioglossus lateralis aids in drawing the buccal floor forwards. The genioglossus dorsalis helps in the projection of the tongue in two ways : (1) by contracting and thus reducing the length of the tongue and (2) by the contraction of the longitudinal fibres, especially of the two twisted cord-like bundles which radiate from the point of origin of the hyoglossal fibres in the middle of the tongue to its tip, the tongue is made somewhat rigid along its long axis, enabling it to take the push of the hyoglossus. The genioglossus basalis, however, aids more directly in the projection of the tongue. The fibres of this conical muscle bring about by their contraction the tilting upwards and forwards of the posterior blunt end of the muscle, to such an extent as to give the anterior end of the tongue a pivotal motion. There are thus two protractor linguae working together and not a single protractor as previous investigators have maintained. In the retraction of the tongue the hyoglossi play a more prominent part than the genioglossus, though the latter, by the relaxation of its fibres, may facilitate it. The hyoglossi thus play an active part both in the projection and the retraction of the tongue, as in the Chameleons.

It will be obvious from the descriptions of the hyoid and its muscles, that they cannot have a share in the mechanism of projection of the tongue, as Dugès seems to have maintained.

DISCUSSION.

The explanations of the mechanism of projection of the tongue given by previous investigators fall into two main classes : (1) Hartog's theory of lymph-pressure, (2) theories of muscular action.

Lymph-pressure theory. Hartog alone appears to have been responsible for this theory, though Holmes in his "Biology of the frog" has associated it with Gaupp also. That some body-fluid must be responsible for the extension of protrusible organs is an explanation which may appear plausible on the analogy of protrusible probosces and erectile organs in certain animals, but that such an explanation does not hold good in the case of the frog's tongue is apparent. The movements of the frog's tongue are quicker than those of the Chameleon because it is smaller and needs no preliminary adjustments, and the rapid whisking of the tongue cannot be due to the rushing in of a fluid and its running back almost at once. Hartog suggests that the lymph is squeezed into the tongue when it is to be projected. From the position of the tongue in the buccal cavity it is difficult to imagine how the tongue can be raised, rotated and thrown forwards by the mere rush of lymph into the tongue. The only possibility is that, the tongue will remain in a state of turgescence so long as the flow of lymph into the cavities of the tongue is maintained. Hartog proved his contention both by injecting air and some fluid into the mylohyoid to induce turgescence in the tongue and thus force it out of the mouth. "If

melted cocoa butter coloured with Carmine or alkanet is injected and the pressure kept up till the mass sets", he says "it is found that the mass fills an enormous lymph sac (between the mylohyoid and the body of the hyoid) which extends through the median intermuscular fissure in the tongue, sending branches between the fan-shaped ramifications of the intrinsic muscles on the margin of the tongue and into its terminal dilatations" Hartog's evidence for the existence of the lymph spaces and the intermuscular fissure is based on his experiment only. The tongue is a fairly compact muscular organ with a few small lymph lacunae, actually within its substance, though there are two large sinus connected with it (*vide* figs. 8-12) while Hartog's theory presupposes the existence of large spaces and cavernous tissues in the tongue itself.

Theories of muscular action.—Fixsen, Kleine, Weidersheim, Ferdinand and Gaupp were convinced that the tongue is operated only by muscles. The theories of these authors may be grouped in two classes: (1) Theory of Fixsen, and (2) theories of other authors.

1. *Fixsen's theory.*—Fixsen made the suggestion that the genioglossus is concerned with the projection of the tongue and the hyoglossus in its retraction. This view was supported by Ecker and others who had no accurate knowledge of the anatomy of the genioglossus. It was confirmed by Gaupp who has described the important part "*Genioglossus pars basalis*" more accurately. As has been pointed out above the "*genioglossus pars basalis*" has a structure which is adapted to move its blunt hind end forwards and upwards. But it seems improbable that this muscle *alone* is responsible for the projection of the whole tongue, as Gaupp maintains. Accurate measurements of the length of this conical muscle show it to be a third of the total length of the tongue measured from its attachment to the base of the cleft tips. In specimens of *R. cyanophlyctis* the length of the genioglossus basalis was 2 mm. while that of the tongue was 6.4 mm. In *R. hexadactyla* the g. basalis was 7 mm. long and the tongue 22 mm. The ratio, in these cases, of the length of the conical muscle to the entire length of the tongue is even less than a third. Considering the relatively small size of the genioglossus basalis, it seems very improbable that it could vault over the tip of the lower jaw and take with it the whole tongue, nearly twice as long as itself, and the heavy and thick hyoglossi. A close examination of the course of the fibres of the genioglossus basalis shows that all the fibres of the muscle are not concerned in this forward and upward movement, which, therefore, cannot have the maximum force the entire muscle is capable of. As has been pointed out in the general account of the genioglossus basalis there are three classes of fibres, the vertical, the obliquely horizontal, and the horizontal. In longitudinal sections through the thickest part of this muscle these fibres occur in the ratio of 9 : 21 : 6. The second set of fibres most suited to give the muscle a forward and upward movement preponderate but do not form the entire muscle. Even if these fibres contract very forcibly the depth of the muscle is such that the posterior end may at the most be rotated through about 45°. In view of all this, it is difficult to resist the conclusion that Gaupp has by referring to it as the *protrusor linguae*, over-

emphasised the significance of the genioglossus basalis. Further Gaupp has not explained the function of g. dorsalis.

It is true, however, that the genioglossus as a whole has a share in the projection of the tongue. The genioglossus reduces the length of the tongue while increasing its rigidity. The genioglossus basalis gives a slight upward and forward jerk to the anterior end of the tongue. This facilitates the turning forward of the tongue when the relaxed hyoglossi also give it a push. Thus both the muscles are used in the forward movement of the tongue while the hyoglossus by its forcible contraction helps directly in retraction also. Inserted as the hyoglossal fibres are to the middle and the posterior parts of the tongue, farther from the front hinge than the genioglossus, they are very effective in working the tongue on the principle of the third order of levers.

2. *Theories of Kleine and Ferdinand.*—These are based on vague conceptions of the function of the hyoglossi which really have a double rôle. Kleine put forward the view that the powerful hyoglossi alone rotate the tongue forwards and that the genioglossi are responsible for its retraction. Ferdinand also appears to have ascribed a double rôle to the hyoglossus, namely, that of projection and retraction of the tongue. Although both these investigators connected the forward movement of the tongue with the action of the hyoglossi, they failed to note the degree of participation of the genioglossi in this movement. The hyoglossi by themselves would be inefficient as protrusor linguae; for, the tongue is a fleshy flabby structure, and if the front end of the tongue by which it is attached, sags down, all the force the hyoglossi can impart would be lost and the tongue would not have the precision of movement, directness of aim, and the rigid extension which make it so useful in capturing prey. The forward rotation of the tongue round the tip of the lower jaw along, thus bringing about the reversal, of surfaces necessary to bring the sticky dorsal surface downwards, the reduction of the length of the tongue necessary to enable it to pass out of and back into the mouth, and the degree of firmness necessary to take the force imparted by the hyoglossi, cannot be achieved without the genioglossi. It is significant, however, that both Kleine and Ferdinand considered the hyoglossi more responsible for the movements of the tongue than the genioglossus.

The mechanism of the projection of the frog's tongue is interesting from various points of view other than that of anatomy alone. It has been stated by Weidersheim and others that the intermaxillary glands at the front end of the buccal roof secrete mucous which is taken up by the tongue as it turns forward, so that its free end thus becomes extremely sticky. The assumption in such a statement is that the tongue is longer than the height of the gape of the mouth, and that consequently the free end of the tongue hits against the front part of the buccal roof. I have found the tongue to be actually longer than would be necessary to do this. In over thirty dead frogs the tongue was measured from the tip of the lower jaw to that of the upper jaw by a pair of callipers. Owing to postmortem rigidity, the jaws had to be forced open and the measurements were recorded when the jaws were at an angle of not less than 75° . It is obvious that a muscular organ like the tongue would

be much shorter in the dead frog than in the living, and the jaws in the living frog would probably not be opened so wide as to make an angle of 75° , and, therefore, the measurements of the gape of the mouth were somewhat exaggerated. In spite of this, the ratio between the gape of the mouth and the length of the tongue was found to be 2.62 : 2.91. This shows that the tongue is so long that it cannot come out of the mouth without hitting the upper jaw. Though the free end of the tongue may come into contact with the secretion of the intermaxillary glands, it is very improbable that the tongue should rub against the sharp maxillary teeth or against the vomerine teeth, and in view of these facts, it may be concluded that though the tongue is long, it is actually reduced in length in order to come out through the mouth. In sections of the tongue the entire upper surface appears to be glandular, and the sticky secretion of mucous on the surface of the tongue is probably the product of these glands rather than that of the intermaxillary glands. It is noteworthy that in the two species of frog that I have studied, namely, *Rana hexadoctyla* and *R. cyanophlyctes* the animal uses its tongue only occasionally. From the few observations that I have been able to make these frogs make a dash for an insect which flies in the air close to its snout or swims in water and seize it between the jaws, rather than secure it with the tongue. When the prey is, however, settled on the ground the tongue is used as a predacious organ.

The exact picture of the whole process of tongue projection is difficult to portray because of its extreme rapidity. It is not surprising, therefore, to find that the popular sketches by different observers of the various stages of the process, differ so widely. A careful study of the anatomy of the tongue shows the impossibility of the anterior region of the tongue being swung forwards for the conical genioglossus basalis is attached anteriorly to the geniohyoideus and submentalis, and, however, much these muscles may aid in the movements of the tongue they will not permit the genioglossus to project forward as a whole.

If I am correct in my belief that the hyoglossus is kept contracted when the tongue is at rest, and is relaxed when projected, then this muscle belongs to the interesting group of muscles which are said to be always in a state of "Tonus". The "Tonus" muscles are known to occur in some invertebrates and the higher vertebrates but their occurrence in cold-blooded vertebrates has been observed by only a few investigators. The structure and working of the "Tonus" muscles are reserved for a separate treatment, and it is hoped that a thorough investigation of the innervation, histology and mechanism of action of these muscles will shed considerable light on the general physiological and physical problems connected with muscular tissues.

CONCLUSION.

1. The submaxillaris and the lymph spaces below the hyoid by their form and relation to other muscles and those of the tongue, are not adapted to participate in the projection of the tongue. Of the transverse muscles the submentalis may serve by its contraction to lift the

front part of the tongue; this facilitates the front part of the tongue turning forwards.

2. The hyoid muscles and the hyoid apparatus, unlike those of the Lacertilia, are adapted to enable the buccal cavity to perform various other movements rather than to participate in the tongue projection.

3. The tongue is pushed forward slightly by the relaxation of the contracted hyoglossi. Owing to the attachment of the tongue to the mandible by the genioglossi, and the upward and forward movement of the fibres of the genioglossus basalis this forward push is converted into a rotatory motion and the tongue turns forwards as if hinged at the front end.

4. The tongue consists of only two muscles—the hyoglossus and the genioglossus. The hyoglossus remains in a contracted or tonic state when the tongue is at rest, and relaxed when the tongue is pushed out of the mouth. The genioglossus is peculiarly modified; its dorsal part serves to reduce the length and breadth of the tongue while the ventral or basal part serves to give the anterior part of the tongue a forward pivotal movement.

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CESTODES OBTAINED FROM ANIMALS DYING IN THE CALCUTTA ZOOLOGICAL GARDENS DURING 1931.

By F. J. MEGGITT (*Helminthological Institute, University of Rangoon*).

For the opportunity of studying this collection I am indebted to Dr. Maplestone of the Calcutta School of Tropical Medicine, to whom I wish to express my thanks. The material, with a few exceptions, was in extremely good condition. In many cases no cestodes have previously been recorded from the hosts and approximately one-third of the species are new. All measurements are given in mm. The names of the hosts are according to the List of Vertebrate Animals Exhibited in the Gardens of the Zoological Society of London, 1828-1927

Order CYCLOPHYLLIDEA Carus 1863.

Family DAVAINIIDAE Fuhrmann 1907

Subfamily DAVAINIINAE Braun 1900.

Cotugnia Diamare 1893.

Cotugnia joyeuxi Baer 1924.

Host.—*Sphenocercus sphenurus* (Vigors 1831). (Columbiformes.)
The first record of any cestode from this genus of host.

Cotugnia seni Meggitt 1926.

Host.—*Psittacula manillensis* (Bechstein 1794). (Psittaciformes.)
Cirrus-sac 0.15—0.2 × 0.035—0.05. Testes 79—87 Otherwise agreeing with the previous description (Meggitt 1926, 231). First record of any cestode from this genus of host.

Raillietina Fuhrmann 1920.

Raillietina (Paroniella) compacta (Clerc 1906).

Host.—*Oriolus chinensis indicus* Jerdon 1847 (Passeriformes.)
A few fragments devoid of scolex. The first record of any cestode from this species of host.

REFERENCE LETTERS FOR TEXT-FIGURES.

cav. internal cavity of scolex ; *c. r.* bars of scolex ; *c. s.* cirrus-sac ; *e. c.* egg-capsule ; *l.* lumen of cirrus ; *ov.* ovary ; *p.* paruterine organ ; *r. s.* receptaculum seminis ; *s.* internal sucker of scolex ; *ś.* column supporting internal sucker ; *t.* testes ; *ut.* uterus ; *ut'* strand connecting the two uterine portions ; *v.* vagina ; *v. d.* vas deferens ; *v. g.* vitelline gland ; *v. s.* vesicula seminalis ; *w'* wall of scolex ; *w.* wall of cirrus ; *w''.* wall of cirrus-sac,

Raillietina (Paroniella) cruciata (Rudolphi 1819).

Host.—*Brachypterus aurantiacus* (L. 1766). (Piciformes.)

A few fragments with a single scolex. Maximum breadth 0.6. Scolex 0.4 dia. Rostellum 0.11 dia.: rostellar hooks approximately 200, 0.01—0.011 long. Acetabular hooks present though most had fallen off. Genital pore unilateral, at anterior quarter of proglottis margin. Cirrus-sac 0.086—0.092 $\times$ 0.056—0.066, extending to nerve. Testes 10-16, but the exact number difficult to ascertain owing to the macerated condition of the proglottides. Egg capsules not extending laterally to excretory vessels. Gravid proglottides absent.

The above description corresponds with that of *R. cruciata* except for the slightly smaller size of the rostellar hooks and the rather larger size of the cirrus-sac. The first record of a *Raillietina* from this genus of hosts.

Raillietina (Paroniella) facile Meggitt 1926.

Host.—*Tragopan satyra* (L. 1758). (Galliformes.)

Raillietina (Paroniella) fulvia. sp. nov.

Host.—*Pterocles orientalis* (L. 1758). (Pterocletiformes.)

Numerous fragments but no complete strobilae. Maximum breadth 6.0. Scolex 0.11—0.12 dia. Rostellum 0.035—0.04 dia., hooks absent. Acetabular hooks in several rows. Genital pore unilateral, at centre of proglottis margin. Cirrus-sac in proglottides with mature male but immature female organs 0.092—0.106 $\times$ 0.054—0.064, not extending to excretory vessels. Testes 1-3 poral, 6-8 aporal, total 8-10. Onchospheres 0.035—0.04. Egg-capsules 0.092—0.19 $\times$ 0.074—0.086, extending laterally to excretory vessels.

The above combination of characters sufficiently separates the present species from all others of the same sub-genus except the following: *R. blanchardi* (Parona 1898) from rodents, the description of which is incomplete, and *R. conopophilae* (Johnston 1912) from Passeriformes, the description of which is inaccessible to me in Rangoon.

Raillietina (Raillietina) paucitesticulata (Fuhrmann 1909).

Host.—*Pterocles orientalis* (L. 1758). (Pterocletiformes.)

The first record of this cestode from Pterocletiformes.

Raillietina sp.

Host.—*Dendrocitta rufa* (Latham 1790). (Passeriformes.)

A few strobilae, 12 long, 0.4 wide. Scolex 0.336 dia. Rostellum 0.104 dia., rostellar hooks 100—150, 0.016—0.018 long. Acetabular hooks absent. No signs of genitalia. The first record of any species of Davaineidae from this genus of hosts.

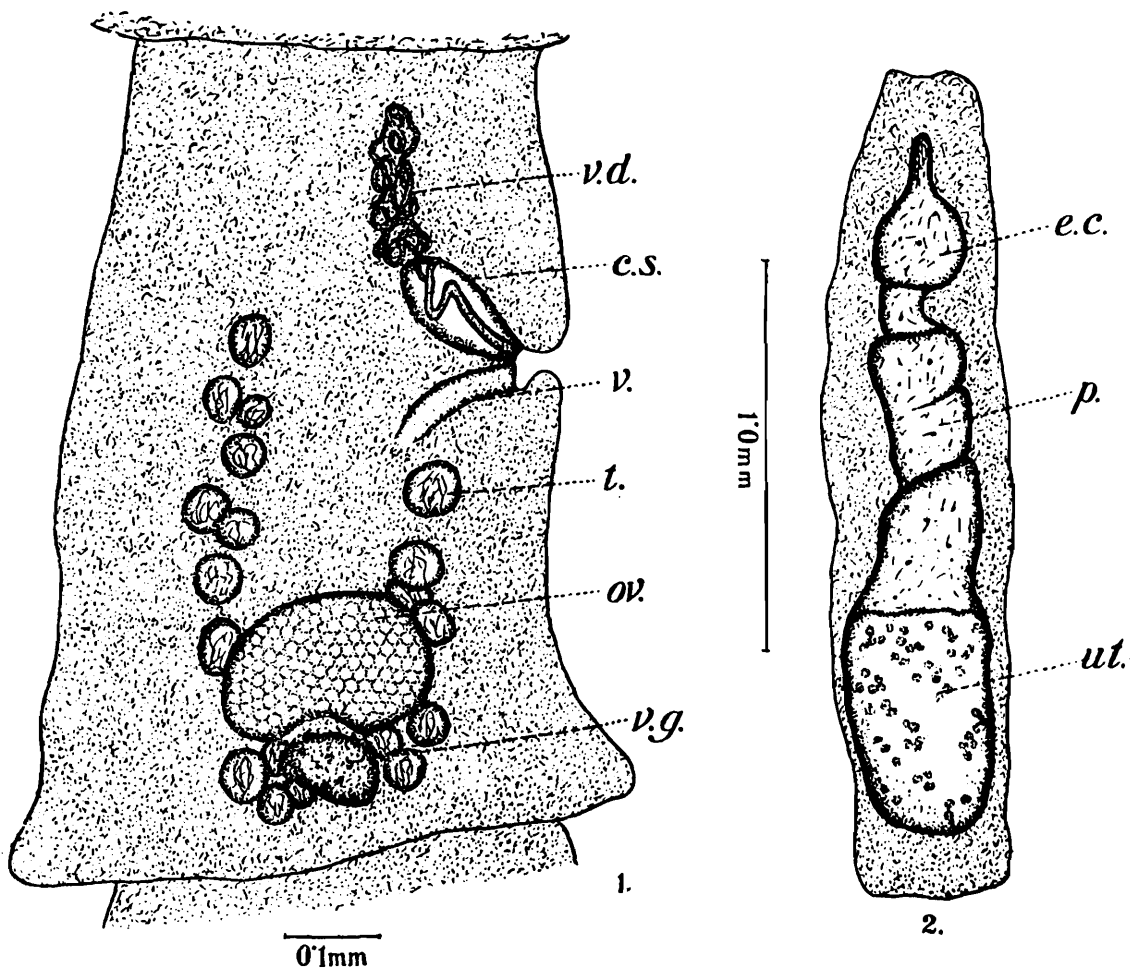
Subfamily IDIOGENINAE Fuhrmann 1907.

Idiogenes Krabbe 1868.**Idiogenes furtiva**, sp. nov.

(Figs. 1, 2.)

Host.—*Falco peregrinus peregrinus* Tunstall 1771. (Accipitriformes.)

A few fragments of strobilae. Scolex absent. Genital pore irregularly alternating, at centre of proglottis margin. Cirrus-sac 0.15—0.18 × 0.06—0.074, tapering towards genital pore, extending past excretory vessels one-third across proglottis. Testes 0.052 dia., 6-8 poral, 6-10

*Idiogenes furtiva*, sp. nov.

TEXT-FIG. 1.—Mature proglottis.

TEXT-FIG. 2.—Gravid proglottis.

aporal, total 14-18, forming a group posterior to female glands and extending anteriorly approximately to level of genital pore. Egg-capsules and eggs not fully developed.

The number of testes and their arrangement sufficiently distinguish the present species from all others of the same genus.

Schistometra Chlodkovsky 1912.**Schistometra togata** Chlodkovsky 1912.

Host.—*Choriotis kori* (Burchell 1822). (Charadriiformes.)

Genital ducts pass between longitudinal excretory vessels, in one case dorsal to them. Cirrus-sac reaching outer excretory vessel but not passing it. Testes in several rows dorso-ventrally, 80 in one transverse section. Ovary and vitelline gland very poral, may be situated between the two longitudinal vessels of the same side or just internally to the inner: in any case with the ovary touching the inner vessel. Vitelline gland internal and slightly anterior to ovary. Genitalia embedded in excretory commissure. Otherwise agreeing with the description of Skrjabin (1914, p. 402).

Family DIOICOCESTIDAE Southwell 1929.

Dioicocestus Fuhrmann 1900.**Dioicocestus fevita**, sp. nov.

(Figs. 3-5.)

Host.—*Podiceps ruficollis* (Pallas 1764). (Podicipediformes.)

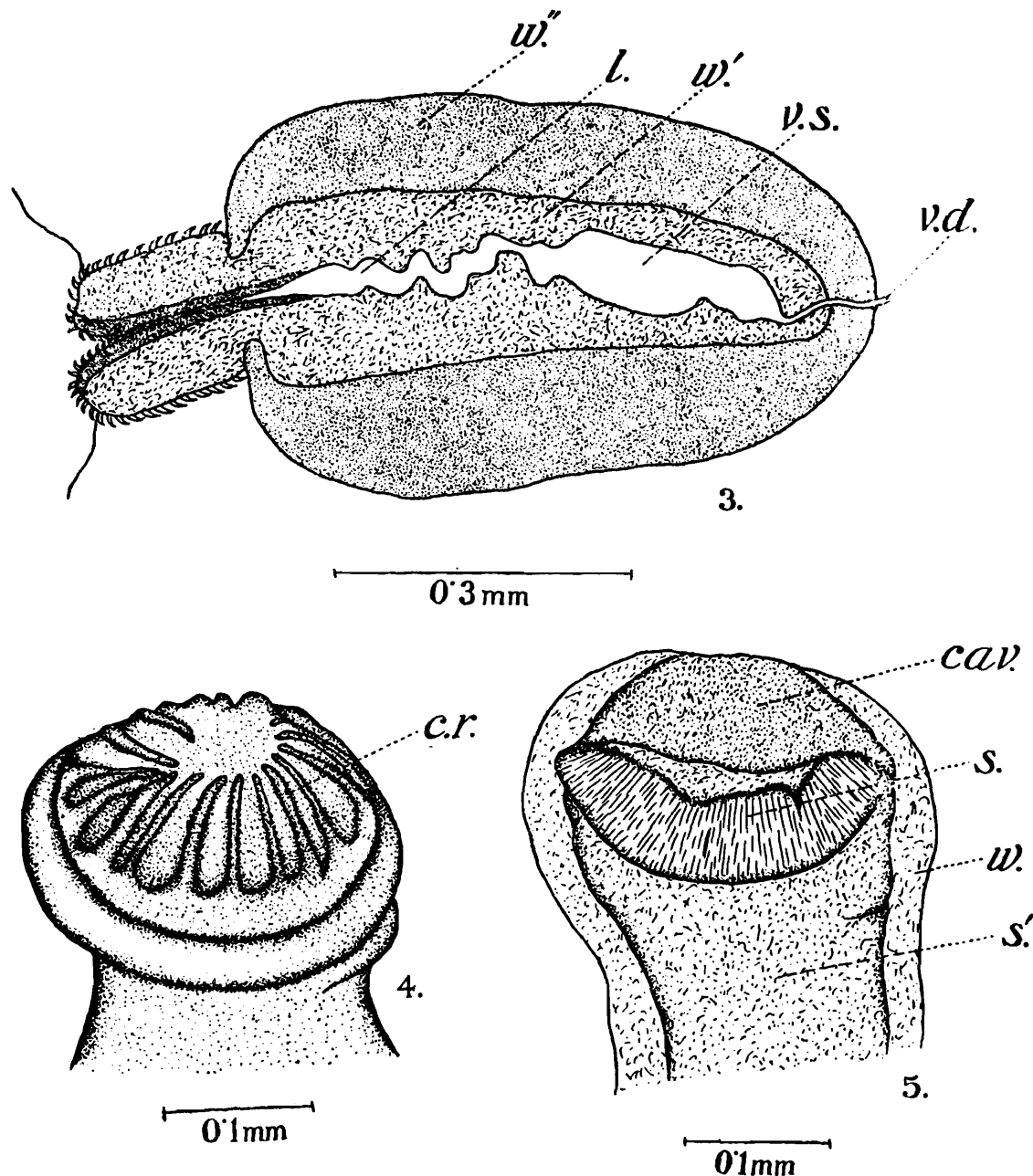
Two strobilae, one male and the other female.

Male.—Length 105, maximum breadth 3. Rostellum 0.264 dia., consisting of an apical portion externally surrounded with apparent bars, 0.09 long $\times$ 0.01 wide. At apex an opening, 0.072 dia., leading into a chamber at bottom of which is a large sucker, 0.148 dia., on the end of a muscular column inside the rostellar sheath. Rostellar hooks absent. Genital pore approximately at centre of proglottis margin. Two cirrus-sacs in each proglottis, each 0.75—0.85 $\times$ 0.48—0.55, extending past excretory vessels and consisting of a smooth sheath, 0.145—0.17 thick, inside which a muscular tube, 0.19—0.21 dia., with a lumen of 0.008—0.02, ends internally in an elongated vesicula seminalis, 0.07 dia., and externally in a cirrus. Cirrus 0.13—0.15 dia., armed with spines 0.01 long at apex, 0.012 in centre, and 0.018 at base. Testes in a single group, too indistinct and numerous to count.

Female.—Length 76, maximum breadth 5. Scolex 0.86 dia., of the same type as that of the male, *i.e.*, with small flattened suckers on anterior end. Rostellum also of same type as male, 0.288 dia., 0.86 long. Rostellar sheath 0.89 long. Internal sucker 0.34 dia. Bars thinner than those of male. Ovary and vitelline gland slightly aporal, the former a compact crescent, the latter an unbroken disc. Vagina wide from ovary to excretory vessels, then narrowing considerably, opening into a narrow elongated receptaculum seminis, narrowing again, and finally ending in a funnel-shaped opening to the exterior. Uterus a much divided sac, extending laterally to excretory vessels. Mature eggs absent.

The present species can be distinguished from all others by the peculiar structure of its rostellum: in addition, from *D. acotylus* Fuhrmann 1904 by the absence of coils in the cirrus-sac, from *D. aspera* (Mehlis 1831)

and *D. paronai* Fuhrmann 1900 by the actual and relative lengths of the cirrus-sac, from *D. novae-guinæe* Fuhrmann 1914 (Southwell 1930,



Dioicocestus fevita, n. sp.

TEXT-FIG. 3.—Cirrus-sac.

TEXT-FIG. 4.—External view of male scolex.

TEXT-FIG. 5.—Optical section of female scolex.

p. 202) by the armed cirrus. A description of *D. novae-hollandiae* (Krefft 1871) is not available in Rangoon.

Family HYMENOLEPIDIDAE Railliet and Henry 1909.

Subfamily DILEPIDINAE Fuhrmann 1907

Bancroftiella Johnston 1911.

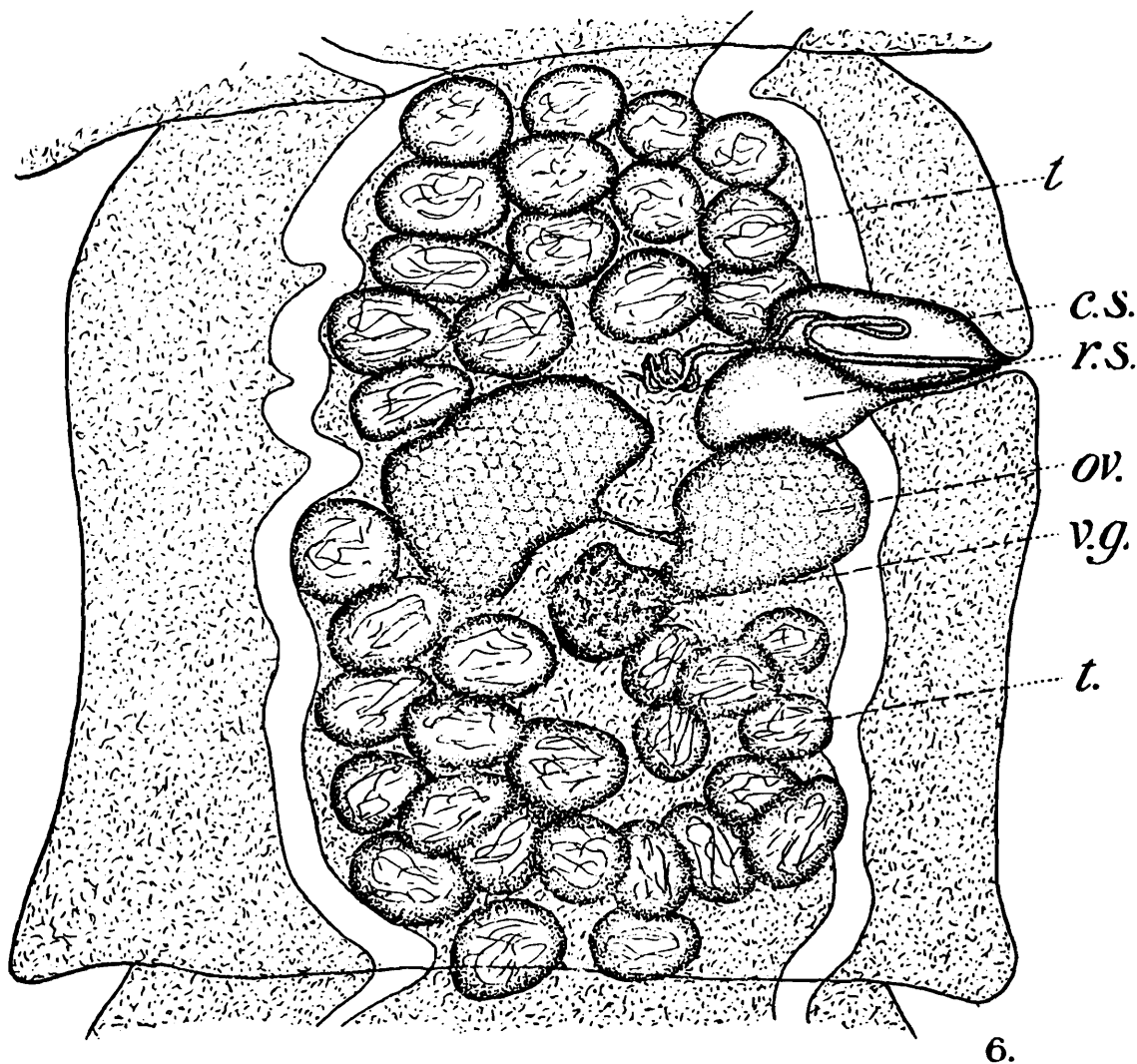
Bancroftiella forna, sp. nov.

(Figs. 6, 7.)

Host.—*Tringa hypoleucos* L. 1758. (Charadriiformes.)

Length 10–18, maximum breadth 0.53. Scolex 0.2–0.25 dia. Rostellum 0.05–0.06 dia.: rostellar hooks 14–16, 0.016–0.02 long.

Genital pore irregularly alternates, mostly on one side of the strobilus : in young proglottides at anterior third of proglottis margin but in gravid



6.

0.1mm

TEXT-FIG. 6.—*Bancroftiella forna*, sp. nov, Mature proglottis.

ones at the centre. Cirrus-sac in mature proglottides $0.136-0.152 \times 0.064-0.07$, in gravid ones $0.132-0.158 \times 0.068-0.072$, extending past ventral excretory vessels. Testes $0.056-0.07 \times 0.052-0.064$, in two groups, anteriorly and posteriorly, separated by the female glands, 14-16 anteriorly, 19-22 posteriorly, total 34-35. Receptaculum seminis



0.01mm

TEXT-FIG. 7.—*Bancroftiella forna*, sp. nov. Rostellar hooks.

very large, in mature proglottides $0.142-0.19 \times 0.122-0.146$, in gravid ones $0.16-0.168 \times 0.102-0.112$.

The descriptions of two of the three species of this genus are not available in Rangoon. *B. tenuis* Johnston 1911 is from a marsupial and therefore not likely to be the same as the present form: *B. ardeae* Johnston 1913 is from *Nycticorax* and may be the same. The shape of the hooks sufficiently separates the third species, *B. glandularis* (Fuhrmann 1905). The first record of this genus from Charadriiformes.

Choanotaenia Railliet 1896.

Choanotaenia infundibulum (Bloch 1779).

Host.—*Francolinus pintdeanus phayrei* (Blyth 1843). (Galliformes.)
The first record of a *Choanotaenia* from this genus of host.

Choanotaenia mutabilis (Linton 1927).

Host.—*Nycticorax nycticorax* (L. 1758). (Ardeiformes.)

Several strobilae but none with female organs. Maximum length 11. Scolex 0.18—0.2 dia. Rostellum 0.036 dia., armed with 10 hooks, 0.3—0.32 long: rostellar sac 0.05 dia., extending past posterior margin of suckers. Genital pore irregularly alternates, mostly on one side of the strobilae, at anterior corner of proglottis. Cirrus-sac 0.17—0.21 × 0.05—0.06, extending half-way across proglottis or even to aporal margin, containing a thickly armed cirrus and several coils of the vas deferens. Testes 10—13, 0.032—0.038 × 0.024—0.03, occupying the greater part of the proglottis but mostly aporal. A small receptaculum seminis.

The above description differs from that of *Valipora mutabilis* Linton (1927, 53), from the night heron, Wood's Hole, in the disposition of the genital pore and the extent of the cirrus-sac. With regard to the second point, the outlines of the sac are very indistinct: in most proglottides it appears as figured by Linton, with the internal coils of the vas deferens appearing as though external. With regard to the first, unless a large extent of strobilus be taken, indubitably the genital pores will appear unilateral. In view of the close correspondence in number and size of hooks, number of testes, diameter of scolex, etc., it is preferable to regard the points discussed as errors in the former description rather than to create a new species. The genus *Valipora* thus becomes a synonym of *Choanotaenia*: should the original description be correct as regards the genital pore, then the genus becomes a synonym of *Dendrouterina*.

Cyclorchida Fuhrmann 1907

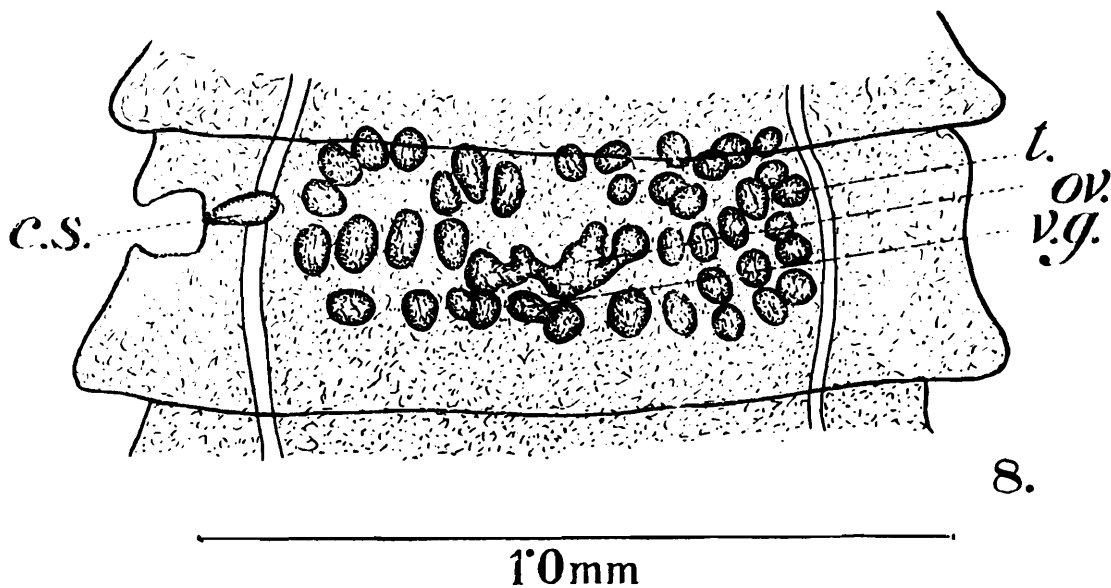
Cyclorchida foteria, sp. nov.

(Fig. 8.)

Host.—*Geocichla citrina* (Latham 1790). (Passeriformes.)

A single specimen. Length 59, maximum breadth 2. Scolex 0.43 dia. Rostellum 0.14 dia., devoid of hooks, enclosed within a sheath 0.18 dia., extending to posterior limit of suckers. Genital pore at centre of proglottis margin. Cirrus-sac in mature proglottides 0.094—0.098

$\times 0.049-0.053$, in gravid ones $0.142-0.145 \times 0.403-0.053$, not—or only just—extending to excretory vessels, opening into a deep genital cloaca. Testes 30—40, surrounding female glands. Uterus an elongated sac with



TEXT-FIG. 8.—*Cyclorchida foteria*, sp. nov. Mature proglottis.

anterior outgrowths, finally reticulate, filling the proglottis and extending laterally to excretory vessels. Onchospheres $0.034-0.045$ dia., shells $0.047-0.063$ dia. The above characters sufficiently separate the present form from all others of this genus. The first record of this genus from Passeriformes.

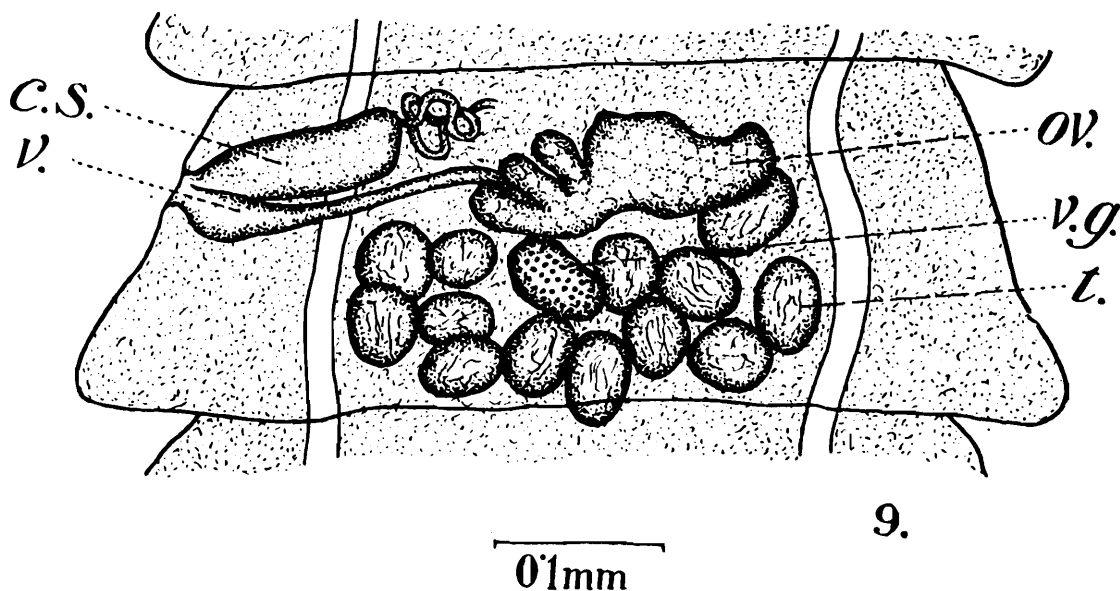
Dendrouterina Fuhrmann 1912.

Dendrouterina fovea, sp. nov.

(Figs. 9, 10.)

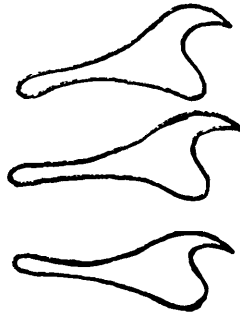
Host.—*Dendrocitta rufa* (Latham 1790). (Passeriformes).

Length 35—45, maximum breadth 1. Scolex $0.2-0.3$ dia. Rostellar sac $0.1-0.15$ dia., extending to anterior margin of suckers, with muscular



TEXT-FIG. 9.—*Dendrouterina fovea*, sp. nov. Mature proglottis.

base. Rostellum 0.1—0.13 dia.: rostellar hooks 70, 0.018—0.021 long, in two rows. Genital pore approximately at centre of proglottis margin. Cirrus-sac in mature proglottides 0.14—0.15×0.056—0.06, with thick muscular walls, extending to or just past excretory vessels. Testes 11—15, mostly posterior to female glands but occasionally lateral to them. Uterus a branched sac, not extending laterally to excretory vessels.



0.01mm

TEXT-FIG. 10.—*Dendrouterina fovea*, sp. nov. Rostellar hooks.

The above characters differentiate this species from all others of the same genus.

The first record of this genus from Passeriformes.

Subfamily FIMBRIARIINAE Meggitt 1924.

Fimbriaria Frölich 1802.

Fimbriaria fasciolaris (Pallas 1781).

Hosts.—*Anas poecilorhyncha* Forster 1781, *Casarca ferruginea* (Pallas 1764), *Francolinus pintdeanus phayrei* (Blyth 1843). (Anseriformes, Galiformes.)

Fimbriaria intermedia Fuhrmann 1914.

Host.—*Cereopsis novae-hollandiae* Latham 1801. (Anseriformes.)

Testes all poral. First record of a cestode from this genus.

Subfamily HYMENOLEPIDINAE Ransom 1909.

Aploparaksis Clerc 1903.

Aploparaksis sp.

Host.—*Anas poecilorhyncha* Forster 1781. (Anseriformes.)

Length 78, maximum breadth 2. Complete strobilae absent. Scolex disc-shaped, 1.5 dia. Rostellum 0.14 dia.; the presence or absence of rostellar hooks could not be ascertained without destroying the scolex. Cirrus-sac 0.36—0.39×0.05—0.06, extending to or just past longitudinal excretory vessels. Testis 0.14—0.17×0.11—0.13, poral. Ovary near aporal excretory vessel.

The above form differs from all others of the same genus by the combination of 8 longitudinal muscle bands, 4 each side, and a cirrus-sac only just reaching the excretory vessels. By reason of the incomplete description and of the lack of material it is best left unnamed. The first record of an *Aploparaksis* from this host.

Diorchis Clerc 1903.

Diorchis inflata (Rudolphi 1819).

Host.—*Fulica atra* (L. 1758). (Ralliformes.)

Diorchis sp.

Host.—*Anas poecilorhyncha* Forster 1781. (Anseriformes.)

A single fragment. Testes two, close together. Cirrus-sac in proglottides without ovary 0.2×0.035 , extending half-way across proglottis. In the absence of a scolex it is impossible to separate the present form from *D. acuminata* (Clerc 1902), *D. acuminata* Linton 1927—both different species—*D. flavescens* (Krefft 1871), *D. bulbodes* Mayhew 1929, and *D. microcirrosa* Mayhew 1929, all from Anseriformes. First record of a *Diorchis* from this host.

Hymenolepis Weinland 1858.

Hymenolepis brevis Fuhrmann 1906.

Host.—*Copsychus saularis* (L. 1766). (Passeriformes.)

Rostellar hooks $0.032-0.037$ instead of 0.04 . Cirrus-sac extending half-way across proglottis. Testes of the *Weinlandia* type. First record from this host.

Hymenolepis collaris (Batsch 1786).

Host.—*Anas poecilorhyncha* Forster 1781. (Anseriformes.)

First record from this host.

Hymenolepis echinocotyle Fuhrmann 1907

Host.—*Casarca ferruginea* (Pallas 1764). (Anseriformes.)

Rostellar hooks $0.024-0.028$ (Fuhrmann 0.03). Cirrus-sac $0.16-0.21 \times 0.034-0.04$ (Fuhrmann 0.16×0.012) in young proglottides, extending to excretory vessels. Otherwise agreeing with the original description (Fuhrmann 1907, 532). First record from this host.

Hymenolepis farciminosa (Goeze 1782).

Hosts.—*Gracupica nigricollis* (Paykull 1807): *Sturnia malabarica* (Gmelin 1789). (Passeriformes.)

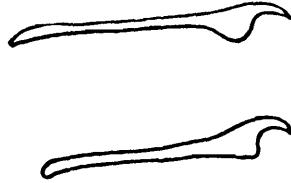
The first cestodes to be recorded from these hosts.

Hymenolepis filta, sp. nov.

(Fig. 11.)

Host.—*Bubulcus coromandus* (Boddaert 1783). (Ardeiformes.)

Length 12—20, maximum breadth 0.23. Scolex 0.12—0.13 dia. Rostellum 0.04—0.05 dia., rostellar hooks 8, 0.03—0.034 long. Genital pore at centre of proglottis margin. Sacculus accessorius absent. Cirrus-



0.01mm

TEXT-FIG. 11.—*Hymenolepis filta*, sp. nov. Rostellar hooks.

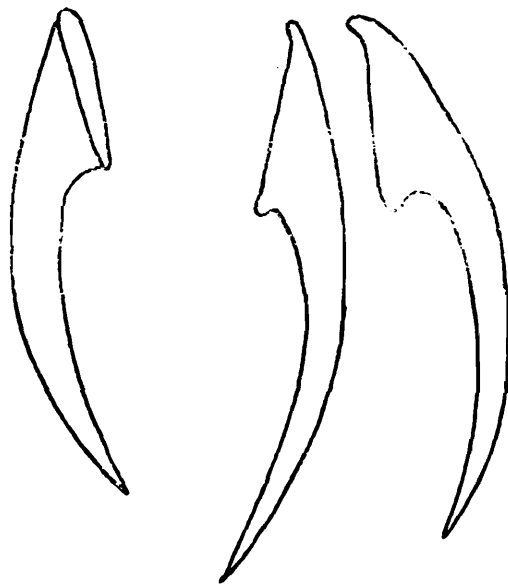
sac in proglottides with fully developed genital organs 0.1×0.008 , extending half-way across proglottis. Testes 0.03—0.035 dia., arranged either in the *Hymenolepis* or in the *Weinlandia* type, usually the former. The present species is distinguished from all others of the same genus by the shape and size of the rostellar hooks. First record of any cestode from this genus of host.

Hymenolepis fimula, sp. nov.

(Fig. 12.)

Host.—*Nyroca ferina* (L. 1758). (Anseriformes.)

Length 30—40, maximum breadth 1.0. Scolex 0.065—0.155. Rostellum 0.07—0.08 dia., rostellar hooks 8, 0.102—0.110 long, in shape



0.01 mm

TEXT-FIG. 12.—*Hymenolepis fimula*, sp. nov. Rostellar hooks.

like those of *H. gracilis* (Zeder 1803). Cirrus-sac $0.156-0.158 \times 0.026-0.03$, extending half-way across proglottis. Testes of the *Weinlandia* type. The present form most resembles *H. gracilis* but differs from it in the absence of a sacculus accessorius and in the larger size of the rostellar hooks.

***Hymenolepis finta*, sp. inq.**

Host.—*Ketupa zeylonensis* (Gmelin 1788). (Strigiformes.)

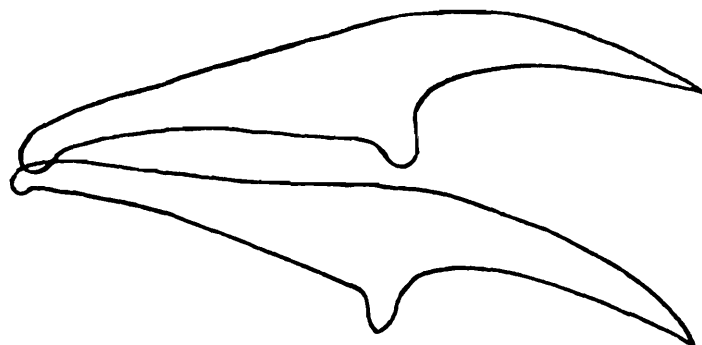
Length 10—25, breadth 0.6—0.8. Scolex absent. Genital pore at centre of proglottis margin. Cirrus-sac $0.16-0.2 \times 0.025-0.03$, extending half-way across proglottis in mature segments but less in younger ones. Sacculus accessorius absent. Testes of the *Weinlandia* type. No species of this genus have been recorded from Strigiformes. In view of the absence of a scolex a definite identification is impossible. A fragment of a *Hymenolepis* without scolex or genitalia has been found in *Tyto alba javanica* in Burma.

***Hymenolepis fista*, sp. nov.**

(Fig. 13.)

Host.—*Nettapus coromandelianus* (Gmelin 1789). (Anseriformes.)

Length 15—30, maximum breadth 1. Scolex $0.098-0.2$. Rostellar sac $0.048-0.052$, extending to or past posterior margin of suckers. Rostellum $0.04-0.064$ dia., rostellar hooks 8, $0.057-0.067$ long. Genital pore approximately at centre of proglottis margin: normally unilateral



0.01mm

TEXT-FIG. 13.—*Hymenolepis fista*, sp. nov. Rostellar hooks.

but in a few cases alternating. Cirrus-sac in proglottides with mature ovaries $0.39-0.42 \times 0.065$, in proglottides with uterus $0.65-0.66 \times 0.106-0.12$, extending half-way across proglottis or to aporal excretory vessel. Sacculus accessorius absent. Receptaculum seminis large. Uterus developing very quickly: in one proglottis no trace of it, in the next fully developed.

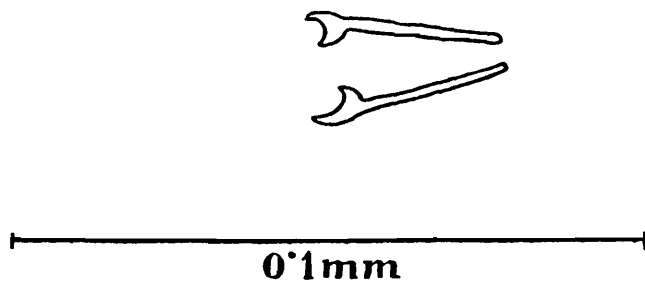
Hymenolepis fola, sp. nov.

(Fig. 14.)

Host.—*Rostratula benghalensis* (L. 1758). (Charadriiformes.)

Length 8—20, maximum breadth 0.8. Scolex 0.18—0.19 dia. Rostellar sheath 0.048—0.07 dia.: rostellum 0.04—0.05 dia.: rostellar hooks 10, 0.032—0.034 long. Genital pore at anterior third of proglottis margin. Cirrus-sac 0.33—0.4 × 0.035—0.04, extending half-way across proglottis. Sacculus accessorius absent. Testes of the *Weinlandia* type.

None of the species of this genus recorded from Charadriiformes agrees

TEXT-FIG. 14.—*Hymenolepis fola*, sp. nov. Rostellar hooks.

with the above form. Of the others, the shape of the hooks and their length, the arrangement of the testes, and the length of the cirrus-sac distinguish it from all except those mentioned under the succeeding species, the descriptions of which are not available in Rangoon, and the following: *H. armata* Fuhrmann 1906, *H. zosteropsis* Fuhrmann 1918 which are distinguished by the absolute and relative lengths of the cirrus-sac, *H. corvi* (Mayhew 1925) by the relative length of the cirrus-sac, *H. phalacrocorax* (Woodland 1929) by the position in that species of the testes external to the excretory vessels, *H. brevicirrosa* Fuhrmann 1913, *H. fringillarum* (Rudolphi 1810), *H. voluta* (Linstow 1904), and *H. dahurica* (Linstow 1903) of which the descriptions are incomplete. In view of these facts and of the different order of the host it appears necessary to create a new species. First record of a *Hymenolepis* from this genus of host.

Hymenolepis fona, sp. nov.

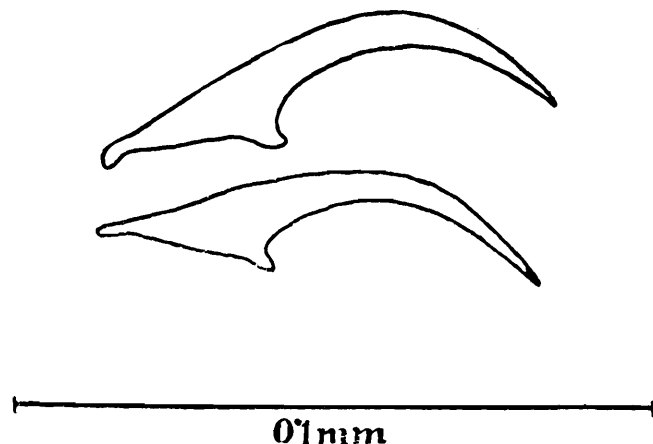
(Fig. 15.)

Host.—*Cygnus olor* (Gmelin 1789). (Anseriformes.)

Length 1.5, breadth 0.3. Scolex 0.18 dia. Rostellum 0.053 dia., extending to centre of suckers: rostellar hooks 10, 0.07—0.074 long. Genital pore in anterior portion of proglottis margin. Cirrus-sac 0.19—0.2 × 0.023—0.03, extending two-thirds of the way across the proglottis.

The characters above given separate the present form from all others of the same genus except the following: *H. anatis* (Müller 1780), *H. carenula* Skrjabin 1926, *H. filamentosa* (Goeze 1782), *H. ovoides* Galli-Valerio 1929, *H. passeris* (Gmelin 1790), *H. sphaerophora* (Rudolphi 1810) of which no valid descriptions exist: *H. mesacantha* (Daday 1900), *H. sibirica* (Linstow 1905)—Anseriformes—*H. sinuata* Rosseter 1909—

Anseriformes,—*H. taeniata* Skrjabin 1914—Anseriformes,—*H. vallei* (Stossich 1902), *H. villosoides* Solowiow 1911—Anseriformes,—of which



TEXT-FIG. 15.—*Hymenolepis fona*, sp. nov. Rostellar hooks.

the descriptions are either incomplete or not available in Rangoon: *H. breviannulata* Fuhrmann 1906 is separated by its considerably shorter cirrus-sac.

***Hymenolepis foveata*, sp. nov.**

Host.—*Anas poecilorhyncha* Forster 1781. (Anseriformes.)

Length 23, maximum breadth 1. Scolex 0.176 dia., without rostellum. Genital pore very anterior. Sacculus accessorius absent. Cirrus-sac in proglottides with mature testes but immature ovary 0.7×0.088 . Testes $0.19-0.27 \times 0.12-0.16$, arranged in the *Weinlandia* type. The complete absence of a rostellum separates this form from all species of *Hymenolepis* and may, if proved to be absent in other species, be the basis for the foundation of a new genus.

***Hymenolepis introversa* (Mayhew 1925).**

Host.—*Anas poecilorhyncha* Forster 1781. (Anseriformes.)

***Hymenolepis longicirrosa* Fuhrmann 1906.**

Host.—*Anas crecca* L. 1758. (Anseriformes.)

Genital pore slightly anterior. Genital cloaca small, genital sphincter not seen. Cirrus-sac in mature proglottides $0.4-0.47 \times 0.024-0.036$, opening nearer the margin of the proglottis than shown by Fuhrmann (1906, fig. 17), Chitinous lining of cirrus extending to aporal excretory vessel and capable of evagination as shown by Clerc (1906, fig. 4—*L'aiguille chitineuse*) for *H. rugosa*. External vesicula seminalis large, $0.17-0.18 \times 0.12-0.126$, in the anterior and aporal portion of proglottis. Testes $0.108-0.132 \times 0.078-0.102$, in young proglottides disposed as in *Weinlandia* but in mature ones filling practically all the proglottis and being in the same straight line. Testes often with lobes, connected with the main portion only by a narrow isthmus. Sacculus accessorius

conspicuous. Vaginal opening anterior, posterior or ventral to cirrus-sac. Receptaculum seminis large, $0.116-0.118 \times 0.086-0.096$, spherical, transversely across proglottis, approximately central. The above account differs in details from that of Fuhrmann but not sufficiently to justify the separation of the two forms.

Hymenolepis setigera (Frölich 1789).

Host.—*Nyroca ferina* (L. 1758). (Anseriformes.)

Differs from the usual form in that the rostellar hooks are $0.046-0.05$ long instead of $0.035-0.044$.

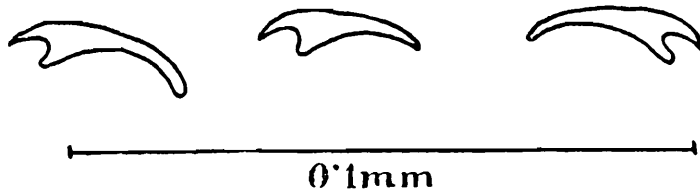
Hymenolepis sp.

(Fig. 16.)

Host.—*Coccothraustes coccothraustes* (L. 1758). (Passeriformes.)

Length 4, maximum breadth 0.25. Scolex 0.1—0.15. Rostellum 0.03—0.04: rostellar hooks 12, $0.025-0.03$ long. Genital pore unilateral. Genital organs immature.

The size and shape of the hooks agree with those of *Diorchis acuminata* (Clerc 1902), and approximately with those of *Hymenolepis echinocoyle*



TEXT-FIG. 16.—*Hymenolepis* sp. Rostellar hooks.

Fuhrmann 1907, *H. longistylota* Tscheng 1932, *H. magniovata* Fuhrmann 1918, *H. serpentulus* (Schränk 1788) and *H. ambiguus* Clerc 1906. The only cestodes recorded from this genus of host are *Taenia coccothraustis* Rudolphi 1819, *T. nasigera* Creplin 1849, the latter of which is regarded as invalid by Fuhrmann (1908, 96). In the circumstances it is best to leave the form unnamed.

Hymenolepis sp.

Host.—*Spinus ictericus* (Lichtenstein 1823). (Passeriformes.)

A single specimen, 35 long $\times$ 2 broad. Scolex 0.24 dia. Rostellar sac 0.08 dia. Rostellum 0.06 dia. rostellar hooks absent. Genital pore anterior. Cirrus-sac 0.07×0.15 , not reaching excretory vessels. Testes arranged in the *Weinlandia* type.

In the absence of rostellar hooks this form cannot be definitely identified. *H. fringillarum* (Rudolphi 1809) has been recorded from *Spinus spinus* (L. 1758) but in the absence of internal characters cannot be compared.

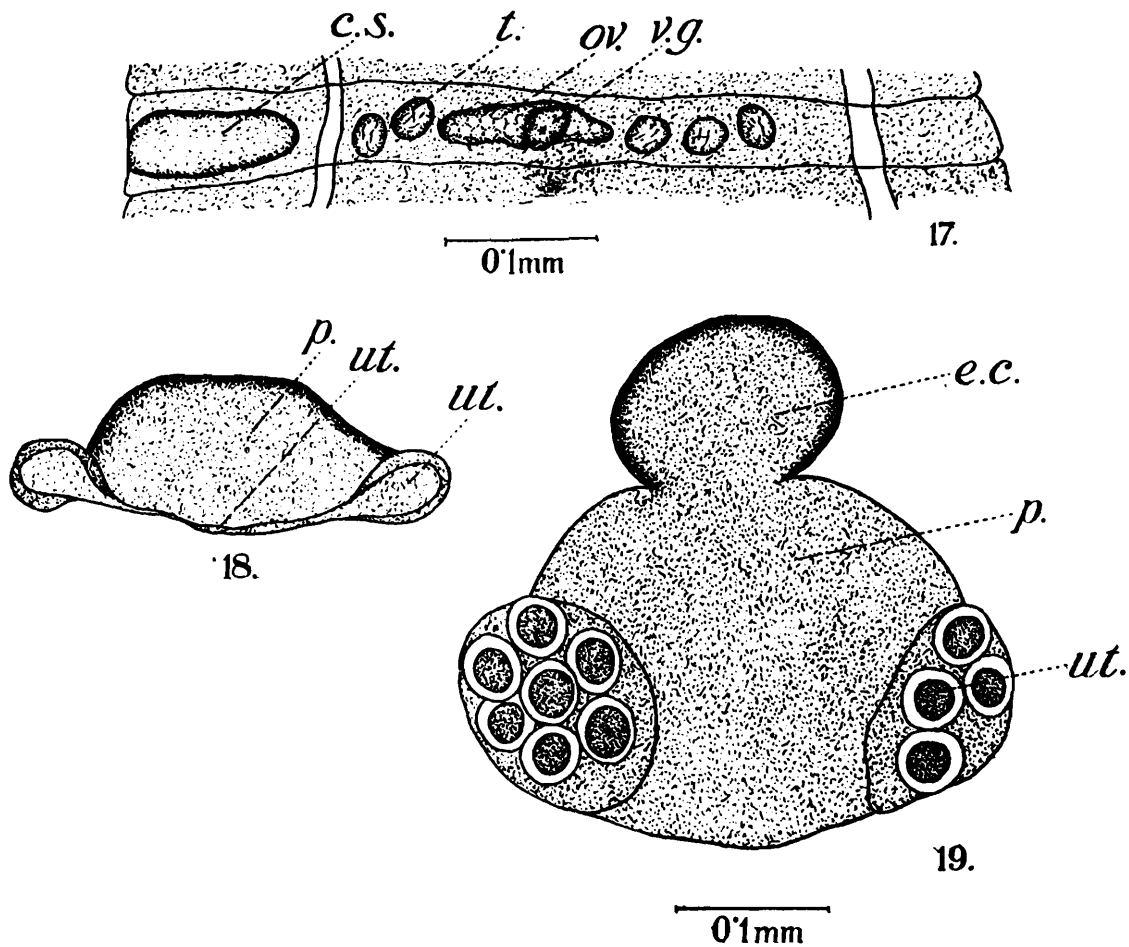
Subfamily PARUTERININAE Ransom 1909.

Metroliaestes Ransom 1900.**Metroliaestes fulvida**, sp. nov.

(Figs. 17, 18, 19.)

Host.—*Oriolus chinensis indicus* Jerdon 1847. (Passeriformes.)

Length 35—40, maximum breadth 8. Scolex 0.35—0.4 dia., without rostellum or hooks. All proglottides, but more especially the anterior, much broader than long. Genital ducts pass between excretory vessels. Genital pore slightly anterior to centre of proglottis margin. Cirrus-sac in proglottides with testes but without fully developed female glands 0.12—0.124 × 0.046—0.052, not passing excretory vessels and tapering towards the interior. Testes 6—10, lateral to female glands. Ovary slightly poral. Vitelline gland ventral and slightly aporal. Uterus develops as an aporal outgrowth of the female ducts leading from the

*Metroliaestes fulvida* n. sp.

TEXT-FIG. 17.—Mature proglottis.

TEXT-FIG. 18.—Young uterus and peruterine organ.

TEXT-FIG. 19.—Mature stage of preceding figure.

ovary, increases in size so as to form a narrow sac occupying the central third of the proglottis, then separates into two portions. These are at first linked together by a narrowing isthmus which becomes a thin strand and finally disappears entirely, leaving two completely separate portions of the uterus. Anterior to uterus a paruterine organ develops, enveloping the inner and anterior ends of the two uterine portions and developing

at its anterior end a small egg-capsule into which the eggs finally pass. It is noteworthy that the eggs remain most of the time in the uterus and do not pass into the paruterine organ until late, immediately afterwards entering the egg-capsule.

The definition of the genus requires alteration so as to allow of the inclusion of the present form. "Testes 20—30" should be omitted, while "two spherical sacs touching in the median line and more or less fused with one another" should be altered to "two spherical sacs either fused or separate". This is the first record of a *Metroliastes* from Passeriformes.

Family TAENIIDAE Ludwig 1886.

Cladotaenia Cohn 1901.

The genus *Cladotaenia* was created by Cohn for the reception of *Taenia globifera* Batsch 1786. Most authorities have subsequently agreed that this species is synonymous with *T. cylindracea* Bloch 1782. The material in four tubes of the collection obviously belonged to this genus but the different tubes showed more differences than could be accounted for by individual variation. In attempting to decide which conformed most closely with the original description it was found that many of the points investigated had been ignored by previous workers. The type is therefore regarded as the form from *Falco*, that being the host most closely related to the original: moreover the presence of rostellar hooks enables a closer inspection to be made.

Cladotaenia cylindracea (Bloch 1782).

Host.—*Falco tinnunculus* L. 1758. (Accipitriformes.)

Mature proglottides approximately 0.96 long $\times$ 0.68 broad. Scolex 0.27 dia. Rostellum 0.096 dia., rostellar hooks in two rows, approximately 28 in each, 0.02—0.025 long. Genital pore very anterior in young proglottides, more central in mature ones. A deep genital cloaca present. Cirrus-sac 0.14—0.15 $\times$ 0.059—0.069 in mature proglottides, extending to excretory vessels. Testes 0.046—0.067 dia., in number 37—38 aporal, 28—33 poral, total 64—67, extending posteriorly to ovary. Uterus with 11—14 lateral branches each side, but as no fully gravid proglottis was seen this number is not necessarily accurate: not extending more than slightly anteriorly to genital pore.

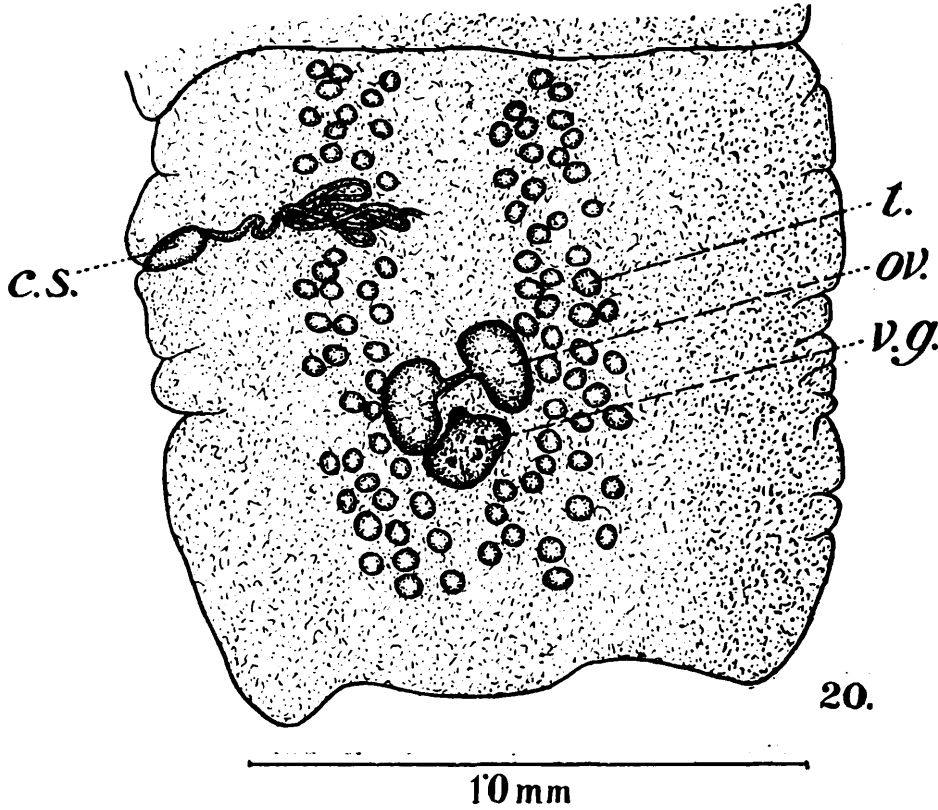
Cladotaenia feuta, sp. nov.

(Fig. 20.)

Host.—*Circus assimilis* Jardine and Selby 1828. (Accipitriformes.)

Scolex 0.19. Rostellum 0.13 dia.: rostellar hooks absent. Mature proglottides 1.25—1.45 long $\times$ 0.82—1 wide. Genital pore at anterior

quarter of proglottis margin. Cirrus-sac $0.12-0.16 \times 0.05-0.07$, not extending to longitudinal excretory vessel. Testes $85-97$, extending



TEXT-FIG. 20.—*Cladotaenia feuta*, sp. nov. Mature proglottis.

posteriorly to ovary. Uterus with $17-21$ lateral branches each side, not extending more than slightly anterior to genital pore. The following table gives the differences between the three forms.

<i>Cladotaenia.</i>	Length of mature proglottis.	Breadth of mature proglottis.	Extent of cirrus-sac.	Length of cirrus-sac.	Breadth of cirrus-sac.	Number of testes.	Position of testes.	Extent of uterus.	Uterine diverticulae.
<i>cylindracea</i> (Bloch 1782).	0.96	0.68	to excretory vessels.	0.14-0.15	0.059-0.069	64-67	extending posteriorly anterior to ovary.	not to genital pore.	11-14
<i>fania</i> sp. nov.	1.36	0.9	not	0.11-0.164	0.072-0.1	73-94	not	all proglottis.	12-13
<i>feuta</i> sp. nov.	1.25-1.45	0.82-1.0	not	0.12-0.16	0.05-0.07	85-97	posteriorly	not	17-21

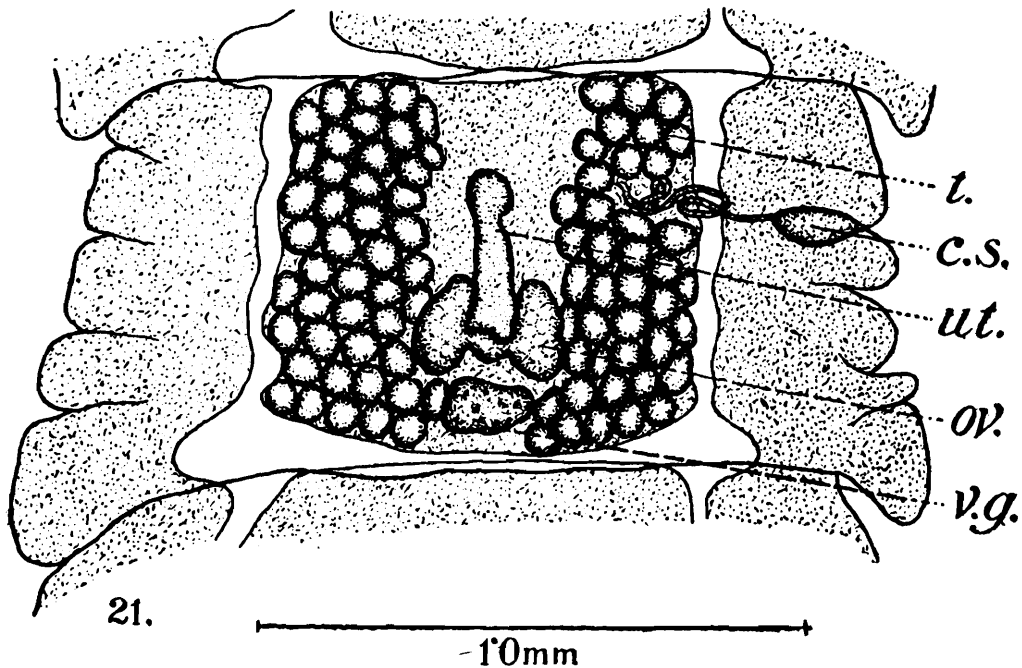
Cladotaenia fania, sp. nov.

(Fig. 21.)

Host.—*Hieraaëtus pennatus* (Gmelin 1782). (Accipitriformes.)
Choriotis kori (Burchell 1822). (Charadriiformes.)

Scolex 0.21. Rostellum 0.065 dia.: rostellar hooks $20, 0.006-0.007$ long. Mature proglottides 0.9 broad $\times 1.36$ long. Genital pore at anterior quarter or third of proglottis margin. Cirrus-sac spherical, $0.11-0.164 \times 0.072-0.1$, not extending to excretory vessels. Testes $39-41$ poral, $49-53$ aporal, total $73-94$, not extending posteriorly to ovary. Uterus with $12-13$ lateral diverticulae each side and occupying all the proglottis: again no fully gravid proglottides seen.

T. globifera is figured by Morell (1895, pl. 7, fig. 7) as having the testes absent from the region posteriorly to the ovary but with them in that



TEXT-FIG. 21.—*C. fania* sp. nov. Mature proglottis.

region by Cohn (1901, pl. 32, fig. 51). That name cannot be employed. This is the first record of a cestode from the genus *Hieraaëtus* and of a *Cladotaenia* from Charadriiformes. The latter form was in better condition than the former and no appreciable differences between them could be found: the form is therefore not a pseudoparasite.

Order PSEUDOPHYLLIDEA Carus 1863.

Family DIPHYLLOBOTHRIDAE Lühe 1911.

Subfamily DIPHYLLOBOTHRINAE Lühe 1910.

Bothridium Blainville 1824.

Bothridium pithonis Blainville 1824.

Host.—*Python molurus* (L. 1768).

Duthiersia Perrier 1873.

Duthiersia fimbriata (Diesing 1854).

Host.—*Varanus flavescens* (Gray 1831).

Order TETRAPHYLLIDEA Carus 1863.

Family PROTEOCEPHALIDAE La Rue 1911.

Crepidobothrium Monticelli 1899.

Crepidobothrium biroi (Ratz 1900).

Host.—*Varanus flavescens* (Gray 1831).

Complete strobilae absent. Scolex 0.17—0.19 dia. Apical sucker 0.05—0.06 dia. Cuticular spines absent, but material in bad condition.

Genital pore anterior to centre of proglottis margin, opening on a small genital papilla. Cirrus-sac $0.164-0.246 \times 0.08-0.142$, mostly crescent-shaped, extending past excretory vessels approximately $\frac{1}{4}$ to $\frac{1}{3}$ across proglottis. Vagina anterior or posterior to cirrus-sac. Testes 11—16 poral and anterior to genital pore, 8—13 posterior to it, 25—32 aporal, total 48—54: in size $0.056-0.086 \times 0.056-0.074$: in two irregular groups, but with a tendency to fuse at anterior end of proglottis. Fully gravid proglottides absent. In the most gravid ones available, the uterus swells at places so as to fill the whole width of the proglottis in the form of a local sac: in addition to these swellings were approximately 20 diverticulae each side.

The descriptions of the forms with cuticular spines belonging to this genus are mostly incomplete and inadequate, and the old genus *Acanthotaenia* is in need of a thorough revision. In placing the present form great difficulty was experienced in separating the allied species (*e.g.*, *C. shipleyi*, *C. articulatum* etc.) and the final result is more of an approximation than an identification.

***Crepidobothrium fima* Meggitt 1927.**

Host.—*Natrix stolatus* (L. 1758).

Cirrus-sac $0.21-0.25 \times 0.05$. Testes 91—95. Uterine diverticulae 19—30 each side. The present form being intermediate between *C. fixa* and *C. fima*, the former species becomes a synonym of the latter.

***Crepidobothrium* sp.**

Host.—*Hyalobates hoolock* (Harlan 1834).

A single scolex with a few fragments. Scolex 0.33 dia., devoid of any terminal sucker. Maximum breadth of strobilus 0.8. Genital pore at centre of proglottis margin. Cirrus-sac and vagina alternating: the former extending well past excretory vessels and approximately $\frac{1}{5}$ of proglottis width. Testes in two distinct groups. No proglottis sufficiently mature to count the testes or measure the cirrus-sac. Only one species of this family, *C. punica* (Cholodkovsky 1908) has been recorded from mammals.

UNIDENTIFIED SPECIES.

***Cestode* sp.**

Host.—*Garrulax leucolophus* (Hardwick 1815). (Passeriformes.)

A single strobilus. Length 18, breadth 1.33. Scolex of the same diameter as the strobilus. Rostellum absent. Genital pore irregularly alternating. Genitalia not developed. All proglottides much broader than long.

***Cestode* sp.**

Host.—*Perdicula argoondah* (Sykes 1832). (Galliformes.)

A few isolated fragments in a bad state of preservation. Genital pore irregularly alternating, in anterior portion of proglottis margin. Cirrus-sac not quite reaching excretory vessels. Ovary towards anterior border of proglottis. All proglottides very immature.

Cestode sp.

Host.—*Rostratula benghalensis* (L. 1758). (Charadriiformes.)

A single strobilus, 12×0.5 . Scolex absent. Genital pore very anterior, almost at anterior corner of proglottis. Cirrus-sac 0.27×0.042 , extending just past longitudinal excretory vessels. Testes 30—34, posterior and lateral to female organs. Gravid proglottides absent. The only cestodes recorded from this host are *Hymenolepis spinosa*, Linstow 1906 and *Monopylidium macracanthum* Fuhrmann 1907. The latter form differs from the present one in the slightly smaller number of testes, smaller size of the cirrus-sac, relative smaller extent of that organ, and position of the genital pore. In the absence of scolex and gravid proglottides a definite identification is impossible.

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THE PEARL OYSTERS OF INDIAN WATERS.

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The present paper on the true pearl-oysters of the genus *Pinctada* Röding found in the Indian waters is based on a prolonged study of the extensive collections of these shells in the Indian Museum. The senior author has also had the advantage of examining the extensive collections of these forms in the British Museum (Natural History), South Kensington, London, the "Siboga" collections and a very rich collection from the Philippine waters which was sent to him for identification by the authorities of the United States National Museum, Washington, D. C.

The species of the genus *Pinctada* are very variable and it is almost impossible to find any well-marked characters for the identification of the various species. In the following pages we have given detailed notes on the species which we recognise as valid, and have also tried as far as possible, to clear up the very confused synonymies of the different species.

We are able to recognize the following species from the Indian waters—

1. *Pinctada margaritifera* (Linn.).
2. *Pinctada vulgaris* (Schumacher).
3. *Pinctada chemnitzii* (Philippi).
4. *Pinctada anomioides* (Reeve).
5. *Pinctada atropurpurea* (Dunker).

Genus **Pinctada** Röding.

1798. *Pinctada* (ex parte), Röding, *Mus. Boltenianum*, p. 166.

1931. *Pinctada*, Grant and Gale, *Mem. San Diego Nat. Hist.*, I, p. 147.

1932. *Pinctada*, Prashad, "Siboga" *Exped.*, LIIIc, *Pelecypoda*, p. 97.

The pearl oysters were for a long time given the generic name *Margaritifera*, but this name is pre-Linnaean and as has been shown by Iredale¹, Grant and Gale and Prashad, the correct name for the genus is *Pinctada* Röding. The genus is well defined by Adams², Fischer³, Jameson⁴ and lately by Grant and Gale; the latter authors, however, consider it to be a subgenus of *Pteria* Scopoli, a view to which we are unable to subscribe.

Jameson in his revision of the Pearl Oysters remarked that "the species of *Margaritifera* are difficult to separate from one another by hard and fast lines, owing to the absence of well-marked diagnostic characters, and to the extraordinary amount of geographical and casual variation." We have after an examination of large series of specimens

¹ Iredale, T.—*Proc. Malacol. Soc. London*, XI, p. 305 (1915).

² Adams, H. and A.—*Gen. Rec. Moll.*, II, p. 525 (1857).

³ Fischer, P.—*Man. Conchyliol.*, p. 952 (1886).

⁴ Jameson, H. L.—*Proc. Zool. Soc. London*, I, p. 372 (1901).

found his remarks to be fully justified. In the following account we have in addition to giving the diagnostic characters of the various species included measurements of a number of shells from various localities to show the range of variability in shape and size of the species.

Jameson's divisions and subsections based mainly on the form of shells and the presence or absence of a hinge tooth are, in our opinion, very artificial, and we have, as indicated above, failed to find any other characters on which the division of the various species into groups or subgroups could be based. It may also be noted that the presence or absence of scales on the external surface of the valves and the differences in colour of the valves, on which the earlier authors relied for the distinction of several species, are of no value whatsoever. Fresh and young shells usually have scales and concentric imbricated laminae on the external surface of the valves but the imbrications wear out with age and in full grown shells traces of imbrications or scales are only rarely to be found. The thickness of the hinge-line, the development of the anterior and posterior auricles and the extent of the internal nacreous layer also exhibit a considerable amount of variation in shells of different ages of the same species. Further, most species of this genus have a very wide range of distribution, and shells from different localities and even from the same area often vary in form, outline, thickness of valves, colour, etc.

***Pinctada margaritifera* (Linn.).**

1758. *Mytilus margaritiferus*, Linnaeus, *Syst. Nat.* (ed. X), p. 704.

1931. *Pinctada margaritifera*, Faustino, *Philippine Journ. Sci.*, XLV, p. 328, pl. ii.

1932. *Pinctada margaritifera*, Prashad, "Siboga" *Exped.* LIIIc, *Pelecypoda*, p. 98.

As remarked in Prashad's work, cited above, there has been a great deal of confusion regarding the Linnaean species *Mytilus margaritiferus*. A detailed synonymy of the species is published in the work cited, but it may be noted that on examination of the material from the Mergui Archipelago referred to this species by von Martens¹ we find that all the specimens are true *P. vulgaris* (Schumacher).

In the Indian Museum *P. margaritifera* is represented by a fair series of shells of various ages from a number of localities in the Indian Ocean. After a careful examination of these shells we are of opinion that they must all be referred to Jameson's var. "*typica*"². Some of the shells from the Andamans and Nicobars resemble var. *zanzibarensis* Jameson in the colour of the nacre, but we are unable to separate them from other shells of the var. *typica* from the same locality or from other areas.

Jameson and Faustino have described the species in detail and notes on the form of the muscle-scar of this species will be found in Odhner's work.³

The large series of shells in the Indian Museum collection from the Andamans shows a variation in form and outline similar to that noticed by Prashad in the case of the "Siboga" material.

¹ von Martens, E.—*Journ. Linn. Soc. London*, (Zool.), XXI, p. 202 (1887).

² Jameson, H. L.—*Proc. Zool. Soc. London*, I, p. 374 (1901).

³ Odhner, N. Hj.—*Kungl. Svensk. Vet. Handl.*, LII, no. 16, p. 16 (1917).

The chief characters on which we have relied for the identification of the species are the convexity of the valves, the hinge-margin being only slightly more than half the length of the nacreous area of the valves in the antero-posterior direction, the entire absence of *teeth* and the colour of the shells. The external colour, as noted by Jameson, is very variable, the ground colour being "pale yellowish brown, green olive, reddish grey, dark brown or black. It is characteristically marked with about 10 to 18 radial rows of white or yellow spots, running from the umbo to the margin." The margin of the nacre is usually dark or smoky and often radiating from it are a series of dark bands alternating with narrower bands of light yellowish colour.

Measurements (in millimetres).

	1	2	3	4	5	6	7	8	9	10	11	12
Maximum length	61	12.7	35	112	60	61	63	68	74	117	95	173
Height	60	12	31	118	64	77	90	77	88	111	64	152
Maximum thickness	17	4	10	44	20	21	22	20	29	33	30	51
Hinge-line (including the auricle).	42	12	25.4	71	51	51	50	40	44.8	63	57	115

Specimen 1 is from Mauritius, 2-4 from Ceylon, 5-9 from the Andaman Islands, 10 from the Nicobars, 11 from the Mergui Archipelago, and 12 from the Persian Gulf.

Distribution.—*P. margaritifera* and its varieties are widely distributed in the Indo-Pacific area. The var. *typica* is represented in the Indian Museum collection from Mauritius, the Persian Gulf, the Mergui Archipelago, the Andaman and Nicobar Islands.

Remarks.—As noted above, we are rather sceptical about the validity of Jameson's var. *zanzibarensis*. From the Persian Gulf we have seen a single large shell labelled var. *persica* Jameson, but this shell, except for its large size, so closely resembles the typical form that we are inclined to doubt the validity of Jameson's variety from the Persian Gulf. The measurements of this shell are given in the above table under No. 12.

***Pinctada vulgaris* (Schumacher).**

1817. *Perlamter vulgaris*, Schumacher, *Essai Nouv. Syst.*, p. 108, pl. xx, figs. 3a, b.

1929. *Pinctada* (*P.*) *vulgaris* and *P.* (*P.*) *lentiginosa*, Lamy, *Bull. Mus. d'Hist. Nat. Paris*, (2) I, pp. 114, 115.

1932. *Pinctada vulgaris*, Prashad, "*Siboga*" *Exped.*, LIIIc, *Pelecypoda*, p. 99.

Pinctada vulgaris is, as one of us has pointed out in the paper cited above, a very variable species, and several variations of it have been described as distinct species under the names *albina* Lam., *fucata* Gould, *perviridis* Reeve, *occa* Reeve, *aerata* Reeve, and *varia* Dunker. There is also reason to doubt the validity of such species as *imbricata* Reeve and *nebulosa* Conrad, but with the material before us we do not feel justified in relegating these forms to the synonymy of *P. vulgaris*. The case of *P. lentiginosa* Reeve¹ is, however, different. Cooke² included

¹ Reeve, L.—*Conch. Icon.*, X, *Avicula*, pl. vi, fig. 13 (1857).

² Cooke, A. H.—*Ann. Mag. Nat. Hist.*, (5), XVII, p. 137 (1886).

it in the synonymy of *P. vulgaris*, but Jameson¹ considered it distinct and remarked that it differs "mainly from *M. vulgaris* in being larger, somewhat flatter, and of a greyish external colour." We also were originally inclined to treat it as a distinct species, but after an examination of a large series of fresh young shells from the Ceylon beds (*vide infra*) we are of opinion that Reeve's *lentiginosa* is based on slightly variable shells of *P. vulgaris*. The characters, noted by Jameson, are not constant, and the only important difference is the marked development of a posterior auricle of a triangular shape in some shells; this distinction also is purely arbitrary, as in a large series of shells we found that whereas some are provided with a well developed posterior auricle in others there is no indication of this structure. A few photographs of shells showing the variability of this character were published by Herdman and Hornell² in their paper on the anatomy of *P. vulgaris*. In view of the above remarks we consider that *lentiginosa* Reeve can definitely be assigned to the synonymy of *P. vulgaris*.

From an examination of specimens of *P. martensi* (Dunker) from the Japanese waters we agree with Jameson (*loc. cit.*, p. 386) that this species is probably nothing more than a geographical variety of the wide-spread *P. vulgaris*.

P. vulgaris is the common Indian pearl oyster found in abundance on the Pearl Banks round Tuticorin in the Gulf of Manaar and round Ceylon. Both the valves of this species are convex, the left being more so than the right. The species is of a moderate size with a triangular anterior auricle and often with a small or even well developed posterior auricle. The hinge-area is moderately broad, and a small tooth or a thickening of the hinge-line is usually present in front of the ligament. The surface of the valves in most of the old specimens is generally smooth, but in fresh and young shells imbricate scales arranged in radial rows are present. The nacre is fairly thick, of a whitish shining mother-of-pearl colour, with iridescent areas of various hues along the border. The non-nacreous margin shows alternate dark and light bands in most of the shells before us.

Young shells of *P. vulgaris* collected from the Ceylon Pearl Banks and varying in size from 14 to 24 mm. along the hinge line are subquadrate in outline. The right valve is only slightly convex but the left is greatly excavated for the soft parts. The ground colour of shells preserved in spirit is creamy white and a number of brownish red radiating rays are prominently marked. In other cases, the radiating rays may be darker, almost black or green. The posterior auricle, which is distinctly marked in most young shells, is also of a brownish red colour. The surface of the shells is covered by concentric imbricating laminae, with, in most, cases a large number of short scale-like spines, or "long ribbon-like spines," such as are shown in the figure of *Avicula hystrix* Reeve (*Conch. Icon.*, X, *Avicula*, pl. viii, fig. 18) arising from the margin of the laminae. Some of the shells bear rays of a light shining greenish colour.

¹ Jameson, H. L.—*Proc. Zool. Soc. London*, I, p. 387 (1901).

² Herdman, W. A. and Hornell, J.—*Report Ceylon Pearl Oyster Fisheries*, II, pl. i, figs. 1-4 (1904).

Measurements (in millimetres).

	1	2	3	4	5	6	7	8	9	10
Maximum length	51	17.7	40.2	41.8	45	43	46	37.5	45	72
Height	52.2	24.5	43.1	43	48	46	49	38	43	81
Maximum thickness	18.4	8	20	12	20	13	17.4	12.5	16	36.7
Hinge-line (including the auricle).	47	25	45	33	41.5	40	43.7	31.2	42	63.2

Specimens 1 and 2 are from Baluchistan, 3 from Aden, 4 from the Andamans, 5 from the Nicobars, 6 from the Mergui Archipelago, 7 from Penang, 8 from Singapore, 9 from Annesley Bay and 10 from Ceylon.

Distribution.—*P. vulgaris* is a widely distributed species; it has been recorded from the Red Sea, the Persian Gulf, all over the Indian Ocean and in the Pacific Ocean from round Australia to north of the Philippines. For a detailed list of localities of this species reference may be made to Jameson's paper.

In the Indian Museum collection the species is represented by a good series of shells from Aden, Henjam (Persian Gulf), Baluchistan, Trincomali (Ceylon), Vizagapatam, Arakan, the Mergui Archipelago, the Andamans and Nicobars, Penang, Singapore, the East Indies and Annesley Bay.

***Pinctada chemnitzii* (Philippi).**

1785. *Concha margaritifera laevis* etc., Chemnitz, *Conch.-Cab.*, VIII, pl. lxxx, fig. 720.
 1849. *Avicula Chemnitzii*, Philippi, *Zeitschr. Malakozool.*, VI, p. 19.
 1857. *Avicula praetexta*, Reeve, *Conch. Icon.*, X, *Avicula*, pl. vii, fig. 15.
 1872. *Avicula (Meleagrina) Chemnitzii* and *A. (M.) praetexta*, Dunker, in *Martini Chemn. Conch.-Cab.*, (N. F.), VII (3), *Avicula*, p. 15, pl. iii, fig. 5, p. 38, pl. xii, fig. 1.
 1901. *Margaritifera praetexta* and *M. chemnitzii*, Jameson, *Proc. Zool. Soc. London*, I, pp. 387, 388.

Chemnitz described and figured a shell from the Tranquebar Coast as "*Concha margaritifera laevis, tenuis, ex subalbido radiata*," this form and some shells from the China Sea were later described under the name *Avicula Chemnitzii* by Philippi in the paper cited above. After a careful comparison of the description and figures of this species we are convinced that *Avicula praetexta* Reeve from the Island of Corrigidor, Philippines, is synonymous with Philippi's species. We cannot, however, agree with Dunker's suggestion that Reeve's *lentiginosa* is probably a synonym of *P. chemnitzii*, for as has been remarked above (pp. 169, 170) Reeve's *lentiginosa* is a synonym of *P. vulgaris*. Jameson in his revision included Reeve's *praetexta* as a separate species but suggested that probably this species and Philippi's *chemnitzii* are both synonymous with *P. vulgaris*.

The shells which we identify as *P. chemnitzii* are suborbicular, not very convex, somewhat inequivalve, with a moderately developed triangular anterior auricle and a well marked, rather broad and elongated posterior auricle. The posterior auricle is distinctly marked off by a broad sinus from the posterior margin of the valves and though lined by a thin nacreous layer has a narrow non-nacreous margin. The hinge-line is moderately broad, usually with a distinct tooth anterior to the ligament. The nacreous portion is not very extensive and is bordered

by a fairly broad darker non-nacreous region. The muscle scar is rather long with a comparatively broad upper portion. The external surface of the valves is of a horny colour with a few deep brownish bands radiating from the umbones. The marginal part of the external surface of the valves, and the posterior wing bear broad concentric rows of scaly imbrications with a few distinctly marked scales arising from the lower margin.

Measurements (in millimetres).

	1	2	3	4	5	6	7	8
Maximum length	44.5	51	56	35	49	55	58.4	28.5
Height	47.2	52	57	34.6	56.2	60	60	29.6
Maximum thickness	15.6	16	17	10	19.8	19	18	13
Hinge-line (including the auricle)	57	64	66	41	54	65.4	58	40

Specimens 1-3 from the Tavoy Sea Coast, 4 from Hongkong, 5 from Penang, 6 from the Mergui Archipelago, 7 from Trincomali (Ceylon), and 8 from Aden.

Distribution.—*P. chemnitzii* is represented in the Indian Museum collection from Aden, Ceylon, Balassore Bay (Orissa Coast), the Mergui Archipelago, Penang and Hongkong.

Remarks.—The less convex valves and the well-developed elongated, tongue-like posterior auricle, usually separated off by a broad notch from the rest of the shell make it possible to distinguish *P. chemnitzii* from *P. vulgaris*.

***Pinctada anomioides* (Reeve).**

1857. *Avicula Anomioides*, Reeve, *Conch. Icon.*, X, *Avicula*, pl. ix, fig. 26.

1932. *Pinctada anomioides*, Prashad, "*Siboga*" *Exped.*, LIIIc, *Pelecypoda*, p. 100, pl. iii, figs. 5-8.

For other references to *P. anomioides* the work of Prashad, cited above, may be referred to. In the Indian Museum collection this species is represented by a good series of shells, and it is, therefore, possible to discuss it in some detail.

The shells before us vary from almost white, yellow, light brown to green in colour; they often have a number of rays of a lighter colour radiating from the umbonal area to the margins. Most of the shells are smooth and do not show any scales, but in a number of cases distinct radially arranged imbricated scales are present. The right valve is almost flat, and the left is only moderately convex. The narrow hinge-line is almost straight, without or with only a trace of a tooth anterior to the ligament in the right valve. There is a well marked anterior auricle separated by a deep byssal notch from the rest of the shell; in the left valve the anterior margin extends in a straight line outside the nacreous area. The posterior nacreous border forms almost a right angle with the nacreous part of the hinge-line.

In fresh shells from the Mergui Archipelago there are rather low and hardly prominent scaly imbrications of a light brownish colour along the lower margin.

Measurements (in millimetres).

	1	2	3	4	5	6	7	8	9	10	11
Length (including the auricle)	29	33	37.5	41	30	34	31	32	17.5	40	31
Height	25	31.5	39	46	29	28	39	27	20	38	21
Maximum thickness	6	8.9	10	12	8	7.5	10	7	5	9	6

Specimens 1-4 are from the Andaman Islands, 5 and 6 from Trincomali, 7 and 8 from Bombay, 9 and 10 from Baluchistan and 11 from the Tavoy Coast.

A shell from the Andaman Islands, the measurements of which are 48 mm. $\times$ 40 mm. $\times$ 8 mm. agrees almost exactly with Reeve's descriptions and figure both in outline and form of the valves, but the "rudely jagged" lamination along the margin mentioned by Reeve, is not so marked; other shells from the same locality, however, show a distinct lamination along the margins.

We also refer, with some hesitation, a very large shell from the Andamans to this species. The measurements of this shell are 13.2 cm. $\times$ 12.2 cm. $\times$ 2.5 cm., the valves are over 2 mm. thick, but even with this thickness the shell is translucent. It is of a dirty yellowish brown colour with a moderately developed pearly nacreous layer, and a band of a greenish yellow colour along the border. The outer surface of the right valve is laminated, while there are traces of scales along the almost concentric laminae of the left valve. The hinge-line is straight, moderately thick and without any trace of a tooth. The general outline of the shell is similar to that of the younger shells.

Distribution.—The types of *P. anomioides* were without any definite locality, but as noted in Prashad's work there are shells of this species in the British Museum collection from Bazaranto Islands and some shells from Nangamessi Sumba from the "Siboga" Expedition were also, referred to this species. In the Indian Museum there is a good series of shells of this species from Aden, Baluchistan, Bombay, Trincomali (Ceylon), the Tavoy Sea-Coast, the Mergui Archipelago and the Andaman Islands.

Remarks.—We cannot agree with Cooke¹ that *P. anomioides* is synonymous with *P. vulgaris* (Schumacher); the general facies and the form of the shell are quite different. We have examined a very larger series of shells of *P. vulgaris* but have never come across a single specimen in which the shell is so thin, flat or rayed as in *P. anomioides*. Further the valves of *P. vulgaris* are always more convex and exhibit a distinct sinus in the posterior margin. In *P. anomioides* the hinge-line is relatively much narrower, and the upper part of the muscular scar is very narrow and generally less than $\frac{1}{3}$ the total length of the scar.

***Pinctada atropurpurea* (Dunker).**

1852. *Avicula* (*Meleagrina*) *atro-purpurea*, Dunker, *Zeitschr. Malakozool.*, IX, p. 76.

1872. *Avicula* (*Meleagrina*) *atropurpurea*, Dunker, in *Martini Chemn. Conch.-Cab.*, (N. F.), VII (3), *Avicula*, p. 14, pl. iii, fig. 3.

1877. *Avicula atropurpurea*, von Martens, *Journ. Linn. Soc. London*, (Zool.), XXI, p. 203.

1901. *Margaritifera atropurpurea*, Jameson, *Proc. Zool. Soc. London*, I, p. 384.

¹ Cooke, A. H.—*Ann. Mag. Nat. Hist.*, (5) XVII, p. 137 (1886).

Dunker described a shell of unknown habitat from Scheepmaker's collection under the name *Avicula atropurpurea* and the species remained as doubtful till von Martens referred a young shell from the Mergui Archipelago to it. Jameson apparently did not have any shells of the species for his revision of the pearl oysters, but included the species in his *section b.* (*loc. cit.*, p. 380). In the Indian Museum collection are the Mergui specimen referred to this species by von Martens, a shell from Trincomali, Ceylon, and two fresh shells from the Andamans. The following notes on these shells should prove useful for future reference.

Shell rotundate-ovate, with the rather narrow hinge-margin almost straight; valves very thin, translucent, of a deep copper-red colour with a few lighter rays radiating from the umbonal area to the lower margin. Right valve only slightly convex, left with a moderately deep cavity in the umbonal region; nacre very thin, of a bluish white colour extending over the greater part of the shell and bordered by a dark coppery non-nacreous margin; the nacreous part of the hinge-line forms an acute angle with the posterior margin of the nacreous area; the rostrum is short, of a triangular lappet-shaped form, separated laterally from the main part of the shell by a shallow ridge and in the byssal region by a deep notch. There is a slight trace of a tooth in front of the ligament in the Trincomali and Andaman specimens.

In a young fresh shell from the Andamans there are a few radially arranged scales of a creamy colour arising from low concentric laminations.

Measurements (in millimetres).

	Trincomali shell.	Mergui shell.	Fresh Andaman shells.	
			1	2
Length (including the auricle)	39.8	22	33.2	38.2
Height	38.3	18.5	36.8	38.2
Maximum thickness	9.2	4.5	10	9

Distribution.—The specimens in the Indian Museum, which we assign to *P. atropurpurea*, are from Pilai Bay (Mergui Archipelago), Trincomali, and the Andamans. We have also seen a shell of this species from the Philippine waters.

Remarks.—*P. atropurpurea* is closely allied to *P. anomoides* (Reeve) but differs in its peculiar colouration, much thinner and more translucent shell and in the nacre along the posterior margin meeting the hinge-line in a more acute angle.

A REVISION OF THE GENUS *OROLESTES* (ORDER ODONATA).

By F. C. FRASER, *Lt.-Col., I.M.S.*

(Plate IV.)

The genus *Orolestes* was erected in the year 1895 by the late Mr. MacLachlan to accommodate a single species which he named *O. selysi* after the distinguished odontologist Baron de Selys Longchamps. Since then four other species have been added to the genus including one new species which is here described for the first time. The genotype was discovered in the N. E. Himalayas but the distribution of the genus is now known to extend as far east as Borneo, as Kirby's *Lestes wallacei*, from Sarawak, has since been transferred to *Orolestes*.

MacLachlan's original diagnosis of the genus was founded on the characteristics of *O. selysi* which has broadly coloured wings, but the discovery of two species in which the wings are completely hyaline has necessitated some modifications in this diagnosis. Laidlaw has also pointed out a grave error in the original description of the genus, that is, the dimensions of the discoidal cells, MacLachlan having given the length of the lower side as twice the length of the inner. The upper side was obviously intended and that this was so, was fully established by an examination of the genotype made by myself a few years ago.

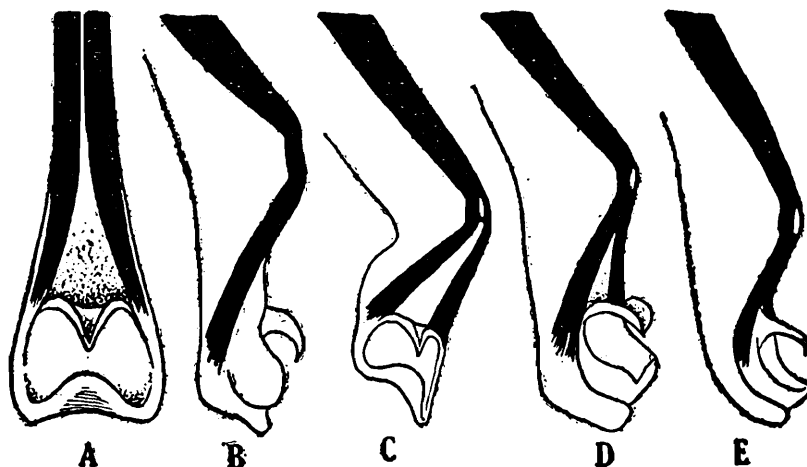
Employing the Tillyard notation, the diagnosis of the genus as revised, may now be given as follows :—

Zygopterous dragonflies of small, medium or of comparatively large size, with slender abdomen, narrow wings, a partially metallic green thorax and forcipated superior anal appendages. Wings hyaline or marked with spots, bands or fasciae of dark blackish brown; petiolation extending as far as the nervure *AC*, which latter lies distinctly nearer the distal antenodal nervure; discoidal cells equal in size and of the same shape in fore- and hind-wings, the posterior border nearly double the length of the costal and about three times the length of the basal, acutely pointed distally; *Riii* arising $5\frac{1}{2}$ to 8 cells distad the node in the fore-wings, *IRii* 4 cells beyond *Riii*; *Riv+v* and *IRiii* arising far proximal of the node; none of the sectors zigzagged except *MA* and *IA* at their distal ends; pterostigma of great length, covering from 4 to 7 cells poorly braced, slightly dilated at its middle; intercalated rudimentary sectors present between *MA* and *Riv+v* and between the latter and *IRiii*, and others at the apical portion of wings. Legs slim, hind femora extending slightly beyond the posterior end of thorax; middle and hind femora with a row of rather widely spaced spines; tibial spines short, numerous.

Anal appendages long and forcipate, with an expansion on the inner border of superiors which ends in a robust acute spine; inferior appendages shortly conical, inclined to be rudimentary; penis with blunt apex which may project or be curled up at its middle part, cupped above and armed here with a short foliate spine. Vulvar scales robust, extending

to end of abdomen and armed below with several robust imbricated spines.

Habitat.—So far as at present known, the genus has a broken distribution from the N. E. Himalayas through Siam, Cambodia, and Tonkin to Borneo and Sumatra. Needham has described a larva which he opines belongs to *Orolestes* and if this is so, then, from the larval characters, the genus is undoubtedly a Synlestine. When however we come to examine the penile organs of the five species we find that they are closely similar to the same organ in *Austrolestes* and I am inclined to consider *Orolestes*, on this evidence, as a modern product of that genus. Needham's larva is more probably a *Megalestes* which genus is closely related to the Synlestinae and probably a genus of that subfamily.



TEXT-FIG. 1.—Penile organs of *A. Orolestes excelsa*, *sp. nov.*, dorsal view. *B.* The same seen in profile. *C.* *Orolestes selysi* MacL. semi-dorsal view. *D.* *Orolestes wallacei* (Kirby) semi-lateral view. *E.* *Austrolestes cingulatus* (Burm) seen in profile. (Contrast the latter with figure *B.*)

Needham's genus *Sinolestes* bears a remarkably close superficial resemblance to those species of *Orolestes* which have coloured wings, but the more proximal origins of *Riii* and *IRii* as well as the greater petiolation of the wings is sufficient to separate the two genera. *Orolestes* is separated from *Lestes*, *Austrolestes* and *Megalestes* by the more distal origin of *IRii* and *Riii* and by its greater petiolation.

Key to Species of *Orolestes*.

- | | | |
|----|--|-------------------------------------|
| 1. | { Wings of male broadly marked with blackish brown | 2. |
| | { Wings of male hyaline | 3. |
| | { Wings of male with a broad unbroken fascia extending from proximad the node as far as the pterostigma | <i>O. selysi</i> MacLach. |
| 2. | { Wings of male with a large spot beneath the pterostigma and a broad fascia just distad the level of node | <i>O. octomaculata</i> Mart. |
| | { Wings of male with similar markings to the last but the preapical spot extending right across the wings and broadly confluent with the subbasal fascia. A much larger species than the last, abdomen 60 mm. compared to 52 | <i>O. excelsa</i> , <i>sp. nov.</i> |
| | { Ground-colour of prothorax and thorax light reddish brown; inferior anal appendages separated | <i>O. udeana</i> (Krug). |
| 3. | { Ground-colour of prothorax and thorax pale bluish green or blue; inferior anal appendages closely apposed | <i>O. wallacei</i> (Kirby). |

Orolestes wallacei (Kirby).

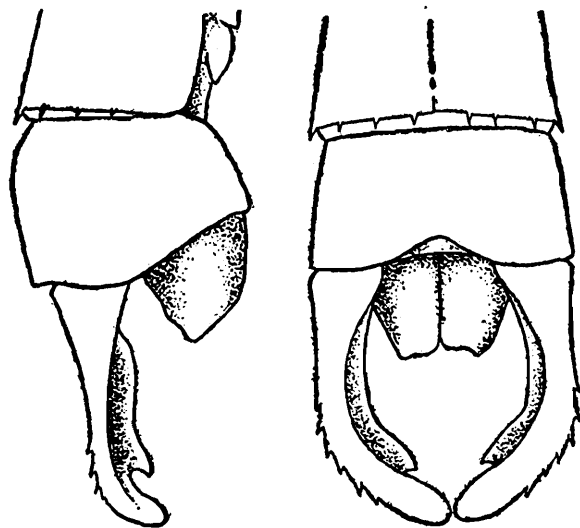
(Plate IV, fig. 1.)

Lestes wallacei Kirby, *Proc. Zool. Soc. Lond.* p. 302 (1889); *id. Cat. Odon.* p. 162 (1890); Laid. *Proc. Zool. Soc. London*, pp. 340, 341 (1920).*Lestes ridleyi* Laid. *Proc. Zool. Soc. London*, p. 92 (1902).*Orolestes wallacei* Laid. *Rec. Ind. Mus.* XIX, text-fig. 1 (1920); Ris., *Zool. Mededeel. S'Rijks Mus. Nat. Hist. Leiden*, X, Af, I, p. 13 (1927), Laid. *Proc. Zool. Soc. Lond.* pp. 134, 135 (1928); *id. Journ. F. M. S. Mus.* XVI, p. 184 (1930); *id. ibid* p. 246 (1930).

Male. Abdomen 48 mm. Hindwing 28 mm.

Head: labium dirty white; labrum, bases of mandibles and genae pale azure blue; rest of head including antennae blackish brown, the occiput streaked obliquely with ochreous behind and entirely so below; eyes dark brown, probably dark blue during life.*Prothorax*: pale olivaceous, the posterior lobe and a broad middorsal area on the middle lobe reddish brown.*Thorax*: coppery metallic green on dorsum, the middorsal carina broadly black, a narrow bluish green antehumeral stripe separating the metallic area from the humeral suture, after which is a broad reddish brown stripe covering the anterior half of the metepimeron, the upper half of this stripe golden or coppery metallic; rest of sides and beneath, uniform pale blue.*Legs*: reddish brown, flexor surfaces of femora blackish brown.*Wings*: hyaline, apices of all and costal space as far as from node to pterostigma palely enfumed; pterostigma dark reddish brown, covering $3\frac{1}{2}$ to $4\frac{1}{2}$ cells, braced; 19 to 20 postnodal nervures to forewings, 17 to 18 to the hind; *Riii* arising from $6\frac{1}{2}$ to 7 cells distad the node, *IRii* 3 to 4 cells beyond *Riii*.

Abdomen very long and slender, pale blue or greenish blue on segment 1 and sides of segments 2 to 5, the dorsum black from segment 2 to 7; narrow pale blue basal annules on segments 3 to 7 which are confluent with the blue on the sides of the anterior segments; segments 8 to 10 entirely azure blue.

TEXT-FIG. 2.—Anal appendages of *Orolestes wallacei* (Kirby) ♂ right lateral and dorsal views.*Anal appendages* black; superiors nearly twice the length of segment 10, the distal halves curved strongly in so that the apices meet in the

middle line, the middle two fourths expanded on the inner side, deeply concave and ending in a robust subapical inner spine; apices moderately acute, the outer border spined; inferiors nearly half as long as the superiors, closely apposed, blunt conical processes. Penis with a broad apex which projects as a short process as seen in profile, cupped above, the cup with a shallow collar anteriorly and with a broad short spine at its posterior part, the apex of which curls strongly forward; closely similar to the penis found in the genus *Austrolestes*. Female unknown.

Habitat.—Sarawak, Borneo; Bettotan, Borneo from July to August. Differs like *O. udeana* (Krug.) from other species of the genus in having the wings unmarked with dark spots or bands. For the differences between it and the latter species see below under the description of *O. udeana*.

***Orolestes udeana* (Kruger).**

Lestes udeana Kruger, *Stett. Ent. Zeit.* LIX, pp. 130, 131 (1898).

Orolestes udeana Ris., *Zool. Mededeel. Zool. Rijk's Mus. Nat. Hist. Leiden*, X, pp. 11-15, text-fig. 4 to 6 (1927).

Male. Abdomen 47 mm. Hindwing 30 mm.

A clear-winged species like the last and distinguished by the following characters. The ground colour a pale reddish brown instead of pale blue or bluish green; the occiput clouded with white instead of blackish brown streaked with ochreous. (The author does not give the colour of the labrum, bases of mandibles or genae so presumably these are included in the reddish brown of upper surface of head.) There is a zigzagged green metallic transverse stripe above the frons of *O. udeana* which is absent in *O. wallacei*; the thorax apart from the ground colour is very similar in the two insects; the legs are paler in *O. udeana*. The abdomen is similarly marked but the colour of the end segments 8 to 10 is given as dull dark brown for *O. udeana* with a note appended suggesting that they are paler in the living state; I think that there can be no doubt but that they are pale blue in this state and the dark colouring in the type is due to the effects of decomposition. Lastly the apices of the inferior anal appendages of *O. udeana* are well separated and less than half the length of the superiors, whereas they are closely apposed and at least half the length of the superiors in *O. wallacei*.

This species is the only one in which the female has been described, the vulvar scales possessing a row of robust imbricated ventral spines.

Habitat.—Sumatra. Type, allotype female and paratypes all in the Leiden Museum.

***Orolestes selysi* MacLachlan.**

(Plate IV, fig. 2.)

Orolestes selysi MacL. *Ann. Mag. Nat. Hist.* (6) XVI, pp. 21-23 (1895); Mart. *Mission Pavie* (sep) p. 18 (1904); Laid. *Rec. Ind. Mus.* XIX, pp. 148-150 (1920); *id.* *Proc. Zool. Soc. Lond.* Pt. I, pp. 134, 135 (1928); *Fras. Journ. Bombay Nat. Hist.* XXXIII, pp. 838, 839 (1929); (Larva ?) Needham, *Ent. News*, XXII, pp. 342-344, pl. XI, figs. i to iv. (1911).

Male. Abdomen 57—60 mm. Hindwing 36—42 mm.

Head: labium sulphur yellow; labrum and bases of mandibles turquoise blue; rest of head black marked with a narrow reddish brown interrupted stripe at level of posterior ocelli and streaked with dull

ochreous on the occiput; the inner and posterior parts adjacent to the posterior ocelli metallic emerald green; beneath head pale ochreous; eyes brown but probably blue during life.

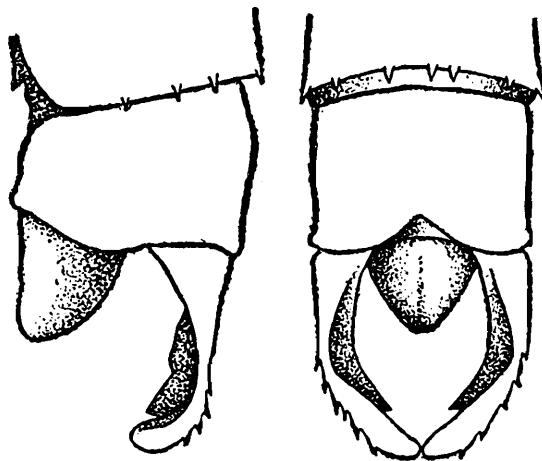
Prothorax: bluish green heavily pruinose white on the sides; posterior lobe large and broadly arched.

Thorax: olivaceous on dorsum marked with a broad metallic emerald green antehumeral stripe on each side which extends from the antealar sinus to the lower part of dorsum; antealar sinus also marked with bright green; laterally pale olivaceous with two broad oblique bright sulphur yellow stripes, one on the antero-lateral suture and the other running along the ventral border of thorax; beneath yellowish white.

Wings: hyaline at apices and extreme base, blackish brown in between these areas, the dark area ending outwardly at the proximal end of pterostigma or one to two cells proximal or one to two cells distal of that level, the outer margin somewhat irregular, slightly crenate in the type, ragged and sinuous in a specimen from Siam and deeply concave in Dr. Schmidt's specimen, the inner end oblique and extending variably nearly up to or actually over the discoidal cells and sending a prolongation in the subcostal space which may extend nearly to base of wings; the cell middles and borders over some parts of this dark area paler so that each cell appears to include a broad diffuse dark ring; origin of *Riii* somewhat variable, from 7 to 8 cells distad the node in forewings and from $5\frac{1}{2}$ to $6\frac{1}{2}$ in the hind. *IRii* arising 3 to 4 cells after *Riii*; discoidal cells as for genus (In the type these cells are distinctly longer and more narrow than in my specimen from Siam). Pterostigma very long and markedly dilated at the middle, dark brown enclosed in thick black nervures, poorly or not braced; below this organ the hyaline portion of wing bears a cloud of opalescence which is much broader and far more conspicuous in the Siam specimen than in the type; this cloud shows in the figure on Plate IV as a dark diffuse cloud; 21—24 postnodals in forewings, 20 in the hind.

Legs: blackish brown; coxae and trochanters bright yellow.

Abdomen: segment 1 bluish green with a middorsal patch of metallic emerald green; segment 2 broadly bluish green on the sides, the middorsal



TEXT-FIG. 3.—Anal appendages of *Orolestes selysi* MacL. ♂ left lateral and dorsal views.

carina narrowly ochreous and with a very broad metallic emerald green stripe on each side of it which broadens apically and becomes confluent

at extreme apex of segment; segment 3 very similar but the blue on the sides extending up over dorsum narrowly at base to form a basal annule; segment 4 similar but the middorsal carina marked with ochreous only on its basal portion which also bears a basal blue annule; segments 5 to 7 dark cupreous blackish brown; 8 to 10 black (but with irregular paler areas showing up in the specimen from Siam so that one gets the impression that these segments are actually pale blue during life).

Anal appendages: superiors blackish brown, curved regularly towards each other so that the apices meet; about half as long again as segment 10, spined on the outer side and with a broad deeply cupped expansion at the middle two fourths of inner side; apices bluntly pointed. Penile organ rounded and very broad at apex, the central portion of this border curled up and back; a prominent curling dorsal spine above. Female unknown.

Habitat.—The type comes from Darjeeling, Bengal, but Martin has reported the species from Tonkin and I have a specimen taken by Dr. Kerr in Siam. I have no data as to where Dr. Schmidt obtained his example. The Siamese specimen is considerably larger than the type and presents some differences in markings which I think are due to the effects of decomposition in the latter but if not, then it is probably not more than a local race differing by the broader extent of the dark areas of wings and by the metallic green antehumeral stripes on thorax and similar markings on the basal abdominal segments and dorsum of head. All these markings are definitely brilliant metallic as contrasted with the "bronzey green" of the type. The less extent of the dark area in Dr. Schmidt's example, this area also deeply concave outwardly, suggests that a number of varieties exist.

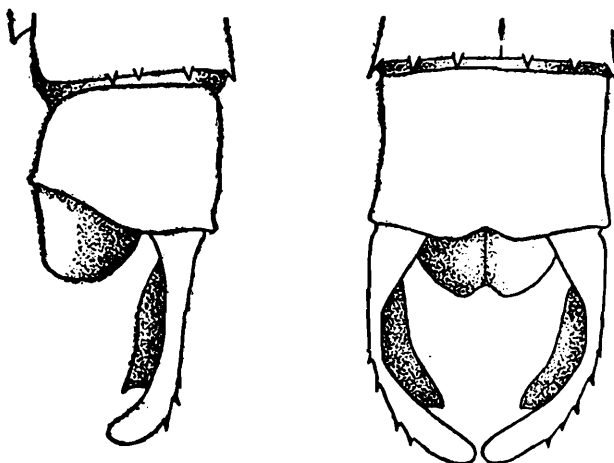
Orolestes octomaculata Martin.

(Plate IV, fig. 4.)

Orolestes octomaculata Mart. *Mission Pavie* (sep.) p. 19 (1904); Laid. *roc. Zool. Soc. London*, Part I, p. 135 (1928); *Fras. Journ. Siam Soc. (Nat. Hist. Suppl.)* VIII, No. 4, pp. 293, 294 (1932).

This species was described from an unique specimen from Cambodia and now in the Museum, Jardines des Plantes, Paris. After remaining the sole specimen known for over forty years it was rediscovered by Dr. A. F. Kerr in Lower Siam, another single male being taken, which is at present in my collection. The new specimen shows a number of minor differences in the extent of the blackish brown markings of the wings and the venation. *Riii* arises only 6 cells distad the node in the forewings as against $7\frac{1}{2}$ in the type and $5\frac{1}{2}$ cells in the hindwings of both; *IRii* begins 5 cells after *Riii* in the forewings, but only $2\frac{1}{2}$ in the hind; *AC* is situated exactly midway between the two antenodal nervures in forewings, but nearer the distal antenodal in the hind; the discoidal cells are similar to those of *O. selysi*. The apical spots begin well before the pterostigma and extend outwards to slightly beyond the middle of that organ. The colouring and markings are an extraordinary close

repliqua of those of *O. selysi* but the green metallic areas on head, thorax and abdomen are more of the nature of golden coppery metallic ; the



TEXT-FIG. 4.—Anal appendages of *Orolestes octomaculata* Mart. ♂ left lateral and dorsal views.

labrum and bases of mandibles are turquoise blue. In size the species is comparable to *O. wallacei* and much smaller than *O. selysi* or *excelsa*.

***Orolestes excelsa*, sp. nov.**

(Plate IV, fig. 3).

Male. Abdomen 60 mm. Hindwing 39 mm.

Head : labium pale yellow ; labrum, genae and anteclypeus dull turquoise blue ; rest of head dark reddish-brown ; the occiput spotted and, behind the eyes, striped with ochreous.

Prothorax : olivaceous, the middorsum from the posterior to anterior lobe paler, a diffuse bronzed black spot on either side of dorsum of middle lobe and some irregular reddish-brown clouding on the posterior part of same and on the posterior lobe.

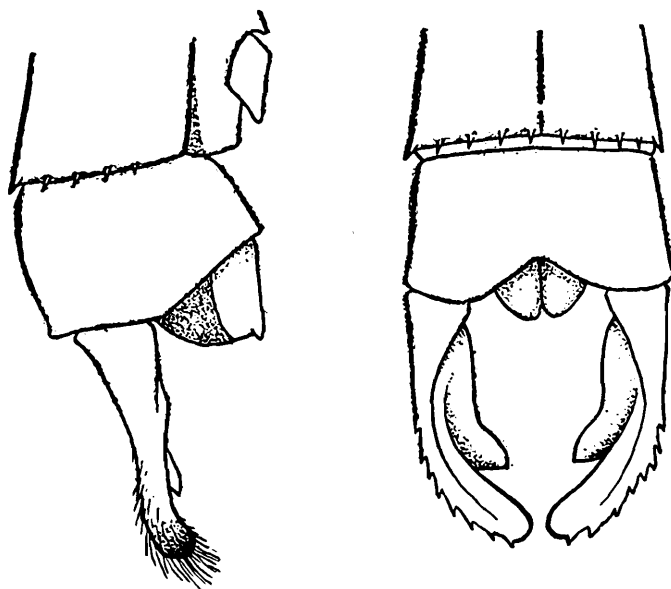
Thorax : with middorsum broadly dark reddish-brown, on each side of which area a broad metallic green band extends from the antealar sinus to the anterior border of thorax followed or bordered outwardly by an equally broad dark olivaceous brown band which extends laterally nearly to the antero-lateral suture ; laterally pale bluish green thinly pruinose posteriorly and below ; beneath thorax snowy white with pruinescence.

Legs : warm reddish-brown with numerous robust, rather long and gradually lengthening spines on the two hind pairs of femora.

Wings : partly hyaline, each with a broad blackish brown fascia shaped like a broad mark of exclamation lying on its side, the head of the marking situated near apex of wings and its base extending to slightly proximal the level of node and covering the whole of the surface of the wings as far out as slightly distal the pterostigma except for a large, triangular hyaline area on the posterior border of wings with its centre slightly distal the centre of wings and extending as far forwards as *IRiii*. The costal space opposite this and as far out as the pterostigma hyaline so that the marking is greatly constricted at this point. Pterostigma very long, expanded at its middle (5 mm.), unbraced, covering about

6 cells, dark reddish-brown between thick black nervures ; 19 postnodal nervures in forewings, 16-17 in the hind ; *Ac* lying nearer the distal antenodal nervure ; discoidal cells of about the same size and shape in all wings ; *Riii* arising about the level of the 6th or 7th postnodal nervures, and much nearer the node than to pterostigma.

Abdomen : very long and slender, its surface finely rugose, uniform dark brown changing to black on the end segments ; segments 1 and 2 bluish at the sides, the latter segment with a fine longitudinal pale olivaceous middorsal stripe.



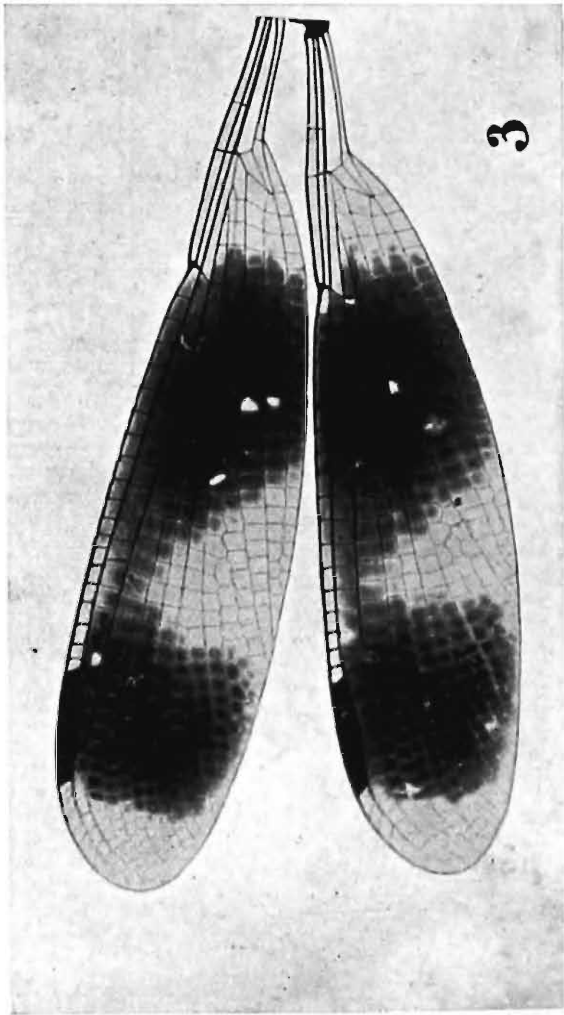
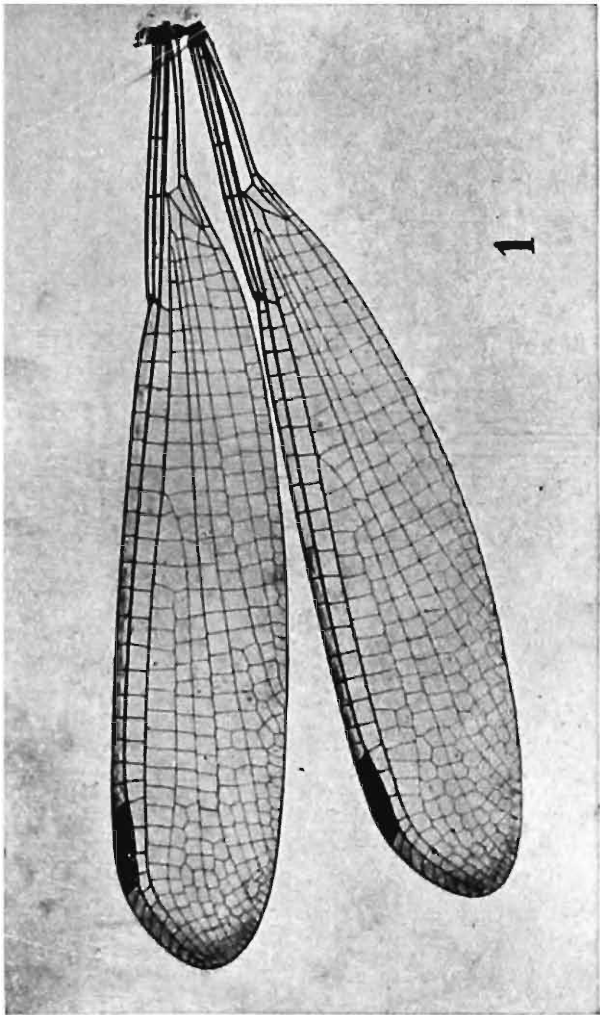
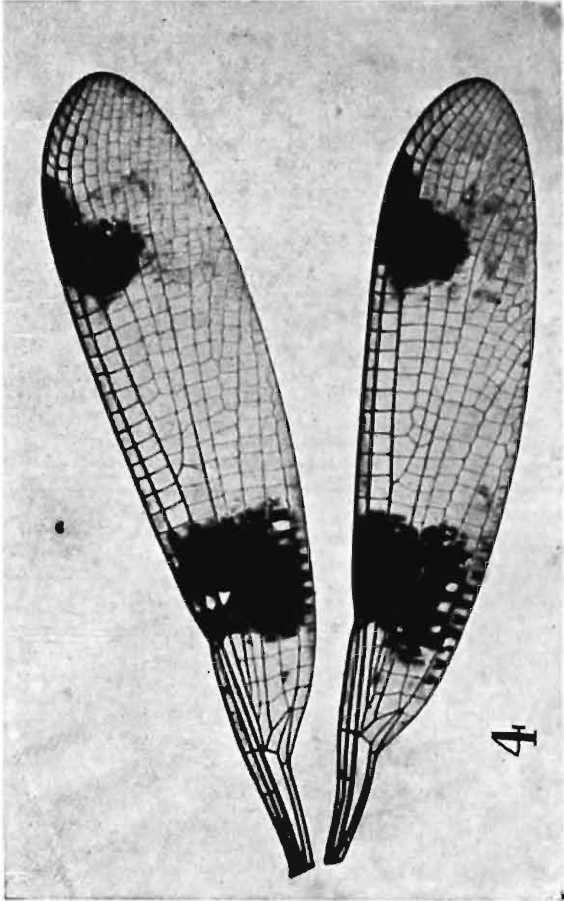
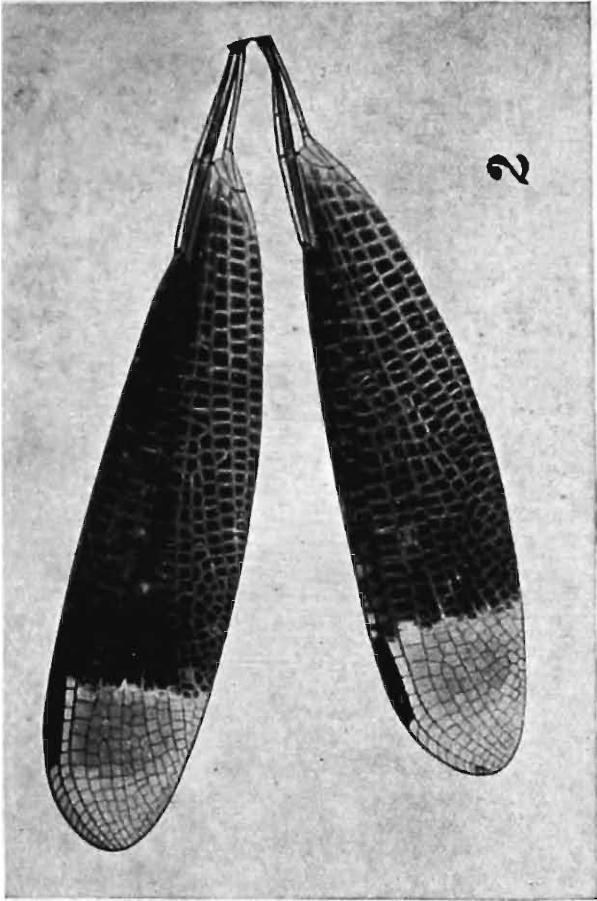
TEXT-FIG. 5.—Anal appendages of *Orolestes excelsa*, sp. nov. ♂ left lateral and dorsal views.

Anal appendages : black ; superiors nearly half as long again as segment 10, narrow, forcipate, coarsely spined outwardly and with a narrow shell-like expansion occupying the middle two fourths of its inner border and ending in a robust incurved spine ; inferior appendages stout, conical, closely apposed processes about one third the length of superiors.

Habitat.—Chaiyabari, N. E. Siam. A single male taken by Dr. A. Kerr, 3rd May 1932, in scrub beside a river, resting with its wings slightly raised and spread out at an angle of about 10—15 degrees from the horizontal. Closely allied to *O. selysi* and *O. octomaculata* but a larger insect and with the wings quite differently marked.

EXPLANATION OF PLATE IV.

- FIG. 1.—Wing of *Orolestes wallacei* (Kirby) ♂.
FIG. 2.—Wing of *Orolestes selysi* MacL. ♂.
FIG. 3.—Wing of *Orolestes excelsa*, sp. nov. ♂.
FIG. 4.—Wing of *Orolestes octomaculata* Mart ♂.



Wings of *Orolestes* (Insecta: Odonata).

NOTES ON FISHES IN THE INDIAN MUSEUM.

XX. LOACHES OF THE GENUS *NEMACHILUS* FROM BALUCHISTAN.

By SUNDER LAL HORA, D.Sc., F.R.S.E., F.A.S.B., Assistant Superintendent, Zoological Survey of India, Calcutta.

(Plate V.)

Griffith¹ in his "remarks on the fishes he met with in Afghanistan and adjoining provinces" records the occurrence of a species of loach at Quetta, which he stated to be "fairly within Afghanistan, and the waters of which no longer run into the Indus, but are either lost in detail, or make their way to the tributaries of the Helmand." No specimen of this loach appears to have been examined by McClelland² who reported on the collection made by Griffith. Day³ in his account of the fishes of Afghanistan records a species of *Nemachilus* from the hills near Kelat and Quetta, and in doing so remarks that, "Dr. Duke has sent several young examples of a species of this genus; but they are too small and in too bad a state of preservation to render it safe to describe them, though they appear to me to be of a species not as yet described, so far as I am aware. It is probably identical with the form obtained by Griffith from the same locality. It is banded with transverse bars of yellow rather wider than the ground-colour, these bars taking on a somewhat angular form near the tail. Col. Miles sent me several small ones of the same species from the river near Gwadar." It was, however, left for Günther⁴ to describe this loach as new—*N. kessleri*—in 1889, when writing an account of fishes collected by Dr. J. E. T. Aitchison, a member of the Afghan Delimitation Commission. His description was based on eight specimens collected at Nushki, not very far from Quetta, of which the largest was "only twenty-eight lines long." Zugmayer⁵ in his travels along the Mekran Coast and in the interior of Baluchistan discovered two new species of *Nemachilus*, one at Kalat and the other at Panjgur. The late Dr. N. Annandale and Dr. S. W. Kemp found a species of *Nemachilus* most abundant in the small streams of the Quetta and Pishin districts of northern Baluchistan at altitudes between 5,000 and 6,000 feet. Annandale and I⁶ considered it to be *N. montanus* (McClelland), but a further examination of this and the allied material has shown that it is *N. kessleri* Günther, which is quite distinct from *N. montanus* of the Simla Hills. Annandale and Kemp also collected specimens of *N. brahui* Zugmayer at Quetta.

¹ Griffith, *Calcutta Journ. Nat. Hist. Soc.* II, p. 563 (1842).

² McClelland, *ibid.*, pp. 575-586 (1842).

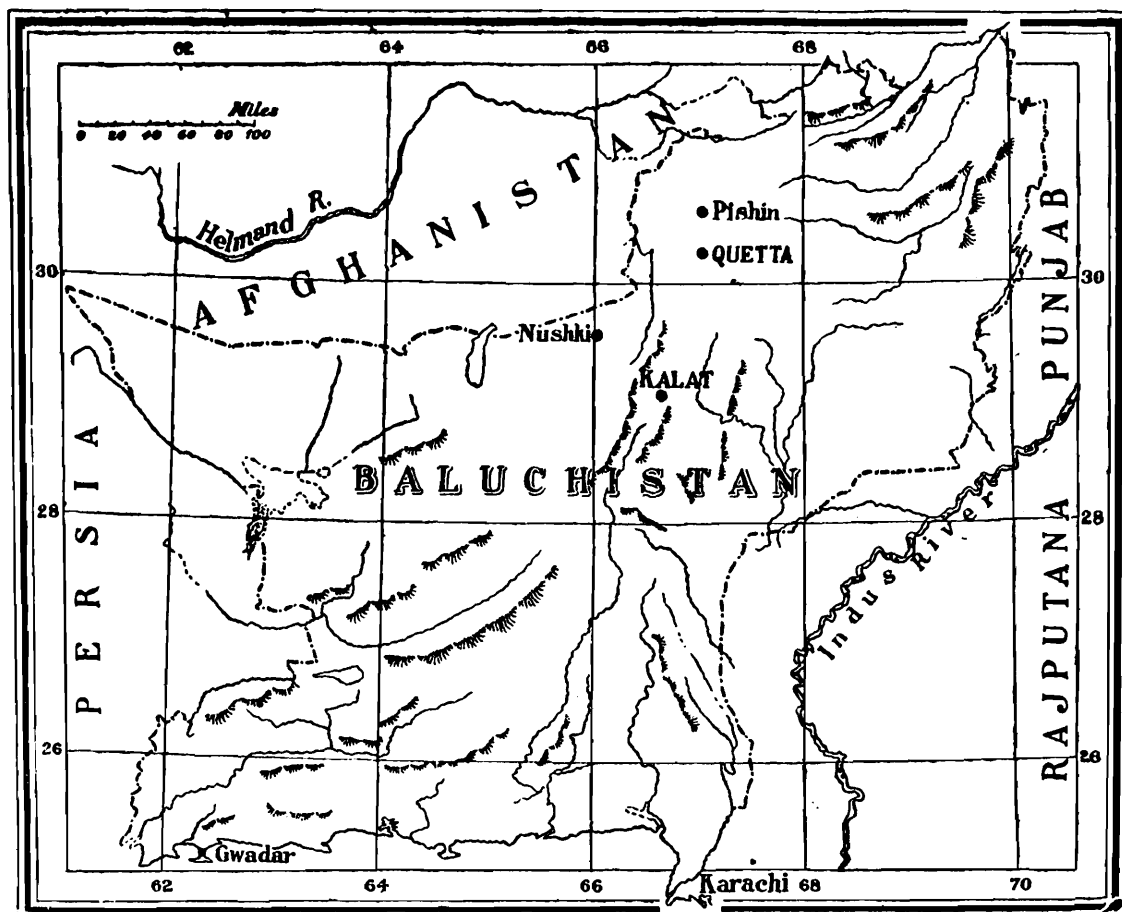
³ Day, *Proc. Zool. Soc. London*, p. 229 (1880).

⁴ Günther, *Trans. Linn. Soc. London (Zoology)* Ser. 2, V, p. 109 (1889).

⁵ Zugmayer, *Ann. Mag. Nat. Hist.* (8) X, pp. 598, 599 (1912); *Abk. K. Bayerischen Ak. Wiss. (Math.-phys. Klasse)* XXVI, pp. 31, 32 (1913).

⁶ Annandale and Hora, *Rec. Ind. Mus.* XVIII, p. 167 (1920).

It is thus seen that only three species of *Nemachilus* are known from Baluchistan. Of these two—*N kessleri* and *N brahui*—are found in the north-eastern portion of the country in the districts of Nushki, Kalat, Quetta and Pishin. The remaining species, *N baluchiorum* Zugmayer, is found on the west side almost in the middle of the country. The loach obtained by Col. Miles “from a river about twenty miles inland from Gwadar, on the Mekran Coast,” and considered by Day as identical with the Quetta form remains still to be determined. Very little is known about the ichthyology of Baluchistan, and, consequently, the



TEXT-FIG. 1.—A sketch-map of Baluchistan showing the localities in which *Nemachilus* have been collected.

distribution of the various species cannot be assigned properly. The affinities of these species are of special interest. *N kessleri* is closely allied to the Indian species of the genus in general facies, though it has developed certain special features. *N brahui* is allied to the Central Asiatic forms and closely resembles *N griffithii* Günther and certain specimens recently collected at Paghman in Afghanistan. *N baluchiorum* has its affinities with Persian forms¹ such as *N sargadensis* Nikolski and *N bampurensis* Nikolski. The three species from Baluchistan, indicate in a way the affinities of the entire fish-fauna of the country.

¹ Nikolsky, *Ann. Mus. Zool. Acad. Imp. Sci. St. Peters.* IV, pp. 414-417 (1899).

Mr. L. Bogdanov has helped me with the Russian text of Nikolsky's paper and for this my sincerest thanks are due to him.

In the collection of the Zoological Survey of India the three species are well represented and they may be distinguished from one another by the following key :—

- A. Body covered with small, but very conspicuous scales . *N. baluchiorum.*
- B. Body naked
 - a. Anal fin extending considerably beyond anal opening *N. brahui.*
 - b. Anal fin not extending as far as or just reaching anal-opening *N. kessleri.*

***Nemachilus baluchiorum* Zugmayer.**

(Plate V, figs. 6 and 7.)

1912. *Nemachilus baluchiorum*, Zugmayer, *Ann. Mag. Nat. Hist.* (8) X, p. 599.

1913. *Nemachilus baluchiorum*, Zugmayer, *Abh. K. Bayerischen Ak. Wiss. (Math.-phys. Klasse)* XXVI, p. 31.

Nemachilus baluchiorum is a small, cylindrical and elongated species in which the body is scaly and marked with a large number of bands. The species is represented by two specimens in the collection of the Zoological Survey; these were obtained in exchange from the Quetta Museum and are stated to have been collected in the type-locality. Of these specimens, one is a mature male with the secondary sexual characters well developed, while the other is a female full of eggs. The male is infected with trematode parasites, which are noticeable as black cysts on the hinder part of the body and the fins. The lips are thick and plicated; the lower lip is interrupted in the middle.

According to Zugmayer *N. baluchiorum* is similar to *N. kessleri* in colouration "but the presence of scales and the size of the orbit make it quite distinct; from the similarly coloured species *N. bampurensis*, Nik., and *N. sargadensis*, Nik., it is easily distinguished by its much greater depth of body." From *N. brahui* "it differs in colour, as well as in the presence of scales, the proportions of the caudal peduncle, and the length of the ventral fin."

Locality :—Panjgur, whence thirteen specimens of the species were collected by Zugmayer.

Measurements in millimetres.

Total length including caudal	67.0
Length of caudal	12.0
Length of head	12.5
Depth of body	9.5
Length of snout	6.6
Interorbital distance	2.5
Length of caudal peduncle	7.2
Least height of caudal peduncle	7.3
Longest ray of dorsal	10.5
Length of pectoral	10.8
Length of ventral	9.2
Longest ray of anal	7.0
Distance between tip of snout and commencement of dorsal	28.6
Distance between commencement of pectoral and that of ventral	18.2
Distance between tip of snout and anal-opening	42.2

Nemachilus brahui Zugmayer.

(Plate V, figs. 4 and 5.)

1912. *Nemachilus brahui*, Zugmayer, *Ann. Mag. Nat. Hist.* (8) X, p. 598, 5991913. *Nemachilus brahui*, Zugmayer, *Abh. K. Bayerischen Ak. Wiss. (Math.-phys. Klasse)* XXVI, p. 32.

Nemachilus brahui is represented by seven specimens in the collection of the Zoological Survey of India. Of these, five were collected by Dr. N. Annandale and Dr. S. W. Kemp at Quetta, while the remaining two were received from Major G. E. F. Stammers from the same locality.

The secondary sexual characters are not well defined. In the male there is a shallow groove running forwards and downwards from the middle of the eye, the pectoral fins are provided with cutaneous flaps on their dorsal surface, and the general colouration is much lighter. The females appear to be more conspicuously coloured.

The alimentary canal possesses three loops in its entire course. A mature egg is slightly greater than a millimetre in diameter.

According to Zugmayer the colouration is "Greyish green, with irregular transverse bars and blotches; fins dirty orange, D. and C. speckled with black." The specimens before me indicate that the colouration varies both with age and locality. In the young specimens there is a distinct moniliform band along the lateral line and there are indications of short, saddle-shaped bands along the dorsal surface. The dorsal surface of the head and body are speckled with minute dots. A male specimen about 77 mm. in length without the caudal and collected in the Residency Garden at Quetta is pale olivaceous except for a few inconspicuous marking on the dorsal surface of the head and body. The dorsal and the caudal fins are spotted with rows of dots.

Zugmayer compared this species with *N. rhadinaeus* Regan¹ and *N. macmahoni* Chaudhuri.² Both of these Seistan species were referred to the genus *Adiposia* by Annandale and myself.³ *N. brahui* does not possess an adipose fin. In general facies and colouration it bears a close resemblance to *N. griffithii* Günther,⁴ but can be distinguished from it by the possession of a much longer head (five in total length) and a deeper caudal peduncle (half as high as long). Moreover, in *N. brahui* the ventrals extend considerably beyond the anal-opening.

Localities :—Zugmayer collected 24 specimens at Kalat, while the specimens in the Zoological Survey were obtained from Quetta.

Measurements in millimetres.

Total length including caudal	96.8	89.0	91.5
Length of caudal .	15.5	12.0	13.8
Length of head	20.0	19.6	18.2
Depth of body .	12.5	12.5	14.8
Length of snout .	8.0	7.9	8.0
Interorbital distance	4.2	4.2	4.0

¹ Regan, *Journ. As. Soc. Bengal* (N. S.) II, p. 8 (1906).² Chaudhuri, *Rec. Ind. Mus.* III, p. 341 (1909).³ Annandale and Hora, *Rec. Ind. Mus.* XVIII, p. 182 (1920).⁴ Hora, *Journ. As. Soc. Bengal* (N. S.) XXIV, pp. 482, 483 (1929).

Measurements in millimetres—contd.

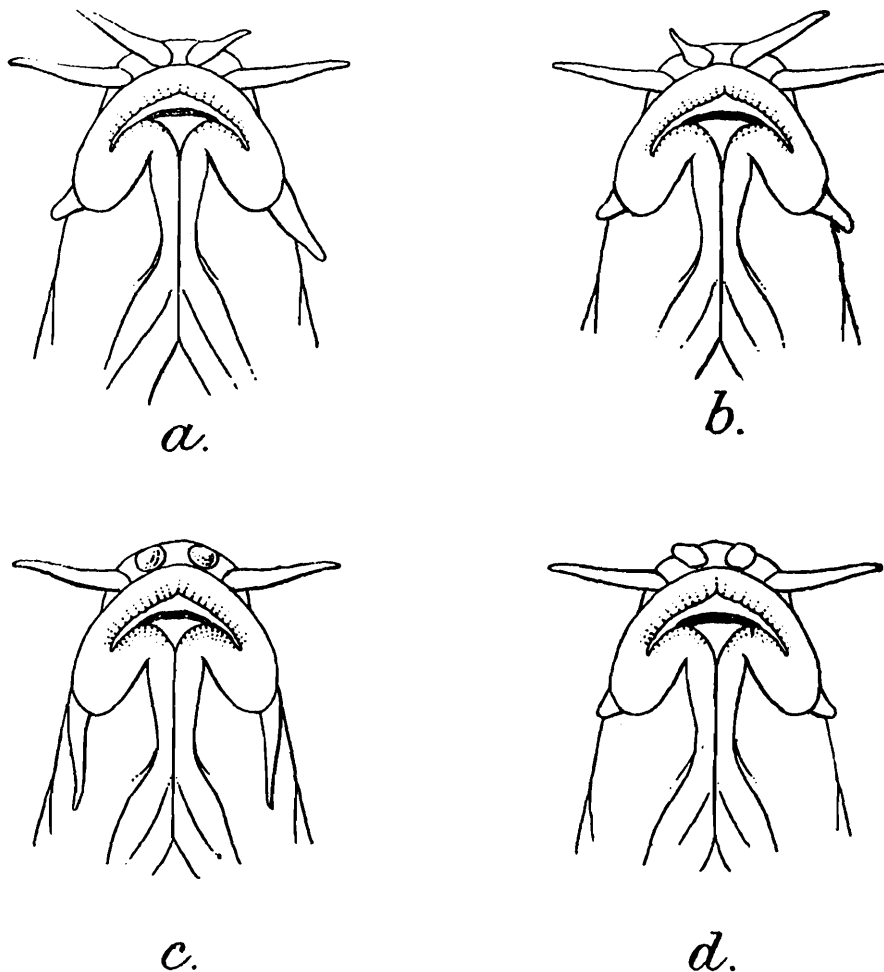
Length of caudal peduncle	15.8	14.5	16.5
Least height of caudal peduncle	7.5	7.2	8.8
Longest ray of dorsal	11.5	12.5	13.7
Length of pectoral .	14.2	13.8	14.0
Length of ventral	10.5	11.5	12.0
Longest ray of anal .	10.7	11.0	11.5
Distance between tip of snout and commencement of dorsal .	43.3	41.8	41.0
Distance between commencement of pectoral and that of ventral	28.5	24.2	24.3
Distance between tip of snout and anal-opening	56.5	54.4	51.3

***Nemachilus kessleri* Günther.**

(Plate V, fig. 3.)

1889. *Nemachilus kessleri*, Günther, *Trans. Linn. Soc. London* (Zoology) 2nd Ser., V, p. 109.1929. *Nemachilus kessleri*, Hora, *Rec. Ind. Mus.* XXXI, p. 313.

Nemachilus kessleri is represented by a large series of specimens in the collection of the Zoological Survey of India. Of these, four examples



TEXT-FIG. 2.—Ventral surface of head of 4 specimens (a—d) of *Nemachilus kessleri* Günther showing defective barbels. (From *Rec. Ind. Mus.* XXXI, p. 313, 1929).

were collected by Dr. J. E. T. Aitchison of the Afghan Delimitation Commission and are probably from the type-series, while the others were obtained by Dr. N. Annandale, Dr. S. W. Kemp and Major G. E. F.

Stammers in the Quetta and Pishin districts of Baluchistan. It seems to be a very common species in the neighbourhood of Quetta, and it is likely that the earlier references regarding the occurrence of a loach at Quetta both by Griffith¹ and Day² refer to this species.

In young specimens about 12 mm. in length without the caudal, the dorsal and the ventral fin-folds are present in front of the base of the caudal fin. The caudal fin is forked, emarginate or obliquely truncate. "The markings of the body are rather indistinct, and concentrated on the back into twelve somewhat irregular cross bands. A deep black spot on the base of the three anterior dorsal rays, the upper part of the fin ornamented with one or two series of black specks running parallel to the upper margin of the fin. Caudal fin with a narrow blackish cross bands on the root and with two more or less indistinct, oblique, series of black specks."

I have referred elsewhere³ to the variability and deformities of the barbels in this species. From the study of a large number of abnormal specimens it is seen that the outer rostral barbels are a constant feature of the fish and do not appear to be subject to any variation. The inner rostral barbels vary considerably, and in one specimen they are so small and rudimentary that the fish appears to possess only four barbels. In the accompanying figure four types of abnormalities are represented.

Localities :—Nushki, Quetta and Pishin Districts in Northern Baluchistan.

Remarks.—Nikolsky⁴ records this species from "Keljate-Marg in terra Zirekuch" in Persia and points out that his specimens agree with Günther's description of the species in every respect. If further researches show that this observation is correct, then the range of distribution of *N. kessleri* will have to be considerably extended.

Measurements in millimetres.

Total length including caudal	46.3	47.3	50.0	58.6
Length of caudal	9.1	8.8	9.5	9.5
Length of head	8.2	8.5	9.6	10.2
Depth of body	4.6	5.0	6.0	6.1
Length of snout	3.6	3.3	4.2	4.5
Interorbital distance	1.5	1.5	2.2	2.3
Length of caudal peduncle	5.8	7.0	8.0	7.8
Least height of caudal peduncle	3.2	3.5	3.5	4.2
Longest ray of dorsal	6.0	5.8	7.2	7.8
Length of pectoral	7.3	7.7	8.0	8.2
Length of ventral	5.8	6.5	6.6	7.4
Longest ray of anal	5.2	6.7	6.0	6.3
Distance between tip of snout and commencement of dorsal	20.3	20.4	22.2	26.0
Distance between commencement of pectoral and that of ventral	12.0	11.8	12.5	16.0
Distance between tip of snout and anal-opening	28.2	28.0	30.0	35.3

¹ Griffith, *Calcutta Journ. Nat. Hist. Soc.* II, p. 563 (1842).

² Day, *Proc. Zool. Soc. London*, p. 229 (1880).

Hora, *Rec. Ind. Mus.* XXXI, p. 313 (1929).

⁴ Nikolski, *Ann. Mus. Zool. Acad. Imp. Sci. St. Peters.* IV, p. 414 (1899).

XXI. ON A NEW SPECIES OF *NEMACHILUS* FROM KOHAT, N. W. F. PROVINCE.

So far as I am aware no species of *Nemachilus* has up till now been recorded from the N. W. F. Province. In 1919, at my request, Mr. Prashar Bhatia made a small collection of fish near the cities of Bannu and Kohat, and obtained several specimens of *Nemachilus*. From Bannu he sent to me 4 examples of *N. corica* (H. B.), while in a spring about 300 yards north of Kohat city he discovered a new loach, of which he collected a large number of specimens. The new species resembles *N. kessleri* very closely, but is of a stouter build and of a different type of facies. I have great pleasure in associating this fish with the name of my friend, Mr. Prashar Bhatia, in recognition of the interest he took in making a collection of fishes for me.

Early in 1929, my colleague Dr. B. N. Chopra, while touring in the Peshawar District, collected a few specimens of *Nemachilus* in the Kabul River at Naushahra and in the Kalpani stream near Risalpur. With the exception of a damaged specimen of what appears to be *N. botia* (H.B.), the others belong to the new species obtained by Mr. Bhatia at Kohat. Attention may be directed here to a young specimen of *N. gracilis* Day from the Chel stream about 8 miles from Attock. This is a small stream with clear and slow-flowing water and a sandy bottom ; it joins the Indus a little above Attock, where the Kabul River also joins the Indus. *N. gracilis* was described from Basgo on the head waters of the Indus,¹ but I² have recorded this fish from the Lukong River, the Yasin River and from a lake about 4 miles from Sonmarg in Kashmir. It is interesting, therefore, to note that a representative of Central Asiatic loaches extends as far down in the Indus as Attock. In my account of the 'Fish of Afghanistan,'³ I have shown that the Central Asiatic element of the fish-fauna of the Kabul River extends as far as Attock. It seems likely, therefore, that the waters and the bed of the Indus River below Attock are not suitable for the abode of the Central Asiatic species of fish.

It is well known that the majority of the fishes of the N. W. F. Province are widely distributed in the plains of India. Of the four species of *Nemachilus* referred to above, two—*N. corica* and *N. botia*—are extensively found in the north-eastern parts of India, *N. gracilis* has its original home in the head waters of the Indus and *N. prashari*, the new species, has strong affinities with the Indian members of the genus.

***Nemachilus prashari*, sp. nov.**

(Plate V, figs. 1 and 2.)

D. 2/7 ; P 9 ; V 7 ; A. 2/5, C. 18.

Nemachilus prashari is a small and subcylindrical fish in which both the dorsal and the ventral profiles are slightly arched. The ventral

¹ Day, *Proc. Zool. Soc. London*, p. 798 (1876).

² Hora, *Rec. Ind. Mus.* XXIV, p. 74 (1922).

³ An account of the "Fish of Afghanistan" will be published in the volume for 1933 of the *Journal of the Bombay Natural History Society*.

surface of the head and to a certain extent of the body in front of the ventral fins is flattened. The head is small and broadly pointed anteriorly ; its length is contained 5.3 to 5.7 times in the total length and 4.4 to 4.8 times in the length without the caudal. The height of head at the occiput is equal to the width of the head about the middle of the eyes ; its greatest width is equal to the length of the head behind the nostrils. The snout is almost as long as the postorbital part of the head. The eyes are small and are situated in the middle of the length of the head ; they are dorso-lateral in position and are not visible from the ventral surface. The mouth is small and crescentic, and is bordered by fleshy lips ; the anterior lip is indistinctly fimbriated while the posterior lip is rugose and interrupted in the middle. There are 6 short barbels, 4 rostral and 2 maxillary ; the maxillary barbels are slightly longer than the rostral barbels. The greatest depth of the body lies just below the commencement of the dorsal ; it is contained 6.8 to 8.1 times in the total length and 5.4 to 6.8 times in the length without the caudal.

The commencement of the dorsal is almost opposite to that of the ventral, and is nearer to the base of the caudal than to the tip of the snout. The pectorals are shorter than the head and are separated from the ventrals by a considerable distance. The ventral fins are similar to the pectorals, and are almost as long ; they do not extend as far as the anal-opening. The caudal fin is deeply emarginate ; the upper lobe is slightly longer than the lower.

The head and body are smooth and devoid of scales. The lateral line is well marked anteriorly, becomes indistinct gradually and finally disappears above the base of the ventral fin. The caudal peduncle is well developed ; its least height is contained 1.4 to 1.6 times in its length. The eggs are large and a mature ovum is as much as 1 mm. in diameter.

In spirit specimens the general colouration is pale-yellow. The dorsal surface of the head is greyish, while the cheeks and the opercular regions are yellowish. The body is marked with 15-17 cross bars of dark olive colour ; these descend from the dorsal surface to the sides, but do not extend as far as the ventral surface. There is usually an interrupted band of somewhat darker colour at the base of the caudal fin. A prominent black spot is present at the base of the three anterior dorsal rays and an oblique band in the middle of the dorsal fin. The caudal fin possesses two dark wavy bands in its distal half. The pupil is dark, and the iris is white. The pectoral, ventral and anal fins are pale yellow.

Type-specimen.—F 10719/1, *Zoological Survey of India (Ind. Mus.)*.

Locality.—A spring 300 yards north of Kohat City (N. W. F. Province).

Remarks.—As has been indicated above *N. prashari* is very similar to a number of Himalayan forms. It is also related to *N. kessleri* known from Baluchistan. In *N. kessleri* the greatest depth of the body is contained 8 times in the length without the caudal, whereas in *N. prashari* it is contained 5.4 to 6.8 times in the same dimensions.

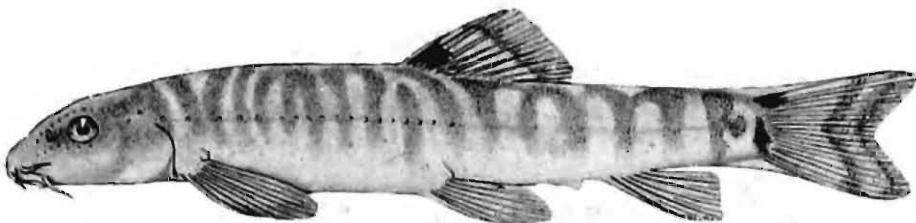
Measurements in millimetres.

Total length including caudal	49.5	44.3	43.2	42.7
Length of caudal	8.8	6.9	7.2	7.3
Length of head	8.8	7.8	7.5	8.0
Depth of body	7.0	6.0	5.3	6.5
Length of snout	3.7	3.0	3.3	3.3
Interorbital distance	2.0	1.5	1.5	1.7
Length of caudal peduncle	6.0	4.8	5.5	4.8
Least height of caudal peduncle	3.6	3.0	3.6	3.4
Longest ray of dorsal	7.2	7.0	5.9	6.0
Length of pectoral	7.8	7.0	6.0	7.0
Length of ventral	7.5	6.0	6.0	6.2
Longest ray of anal	5.7	5.2	4.9	5.0
Distance between tip of snout and commencement of dorsal	22.0	19.8	19.4	19.8
Distance between commencement of pectoral and that of ventral	14.5	12.8	12.0	11.2
Distance between tip of snout and anal opening	30.0	27.6	27.2	26.8

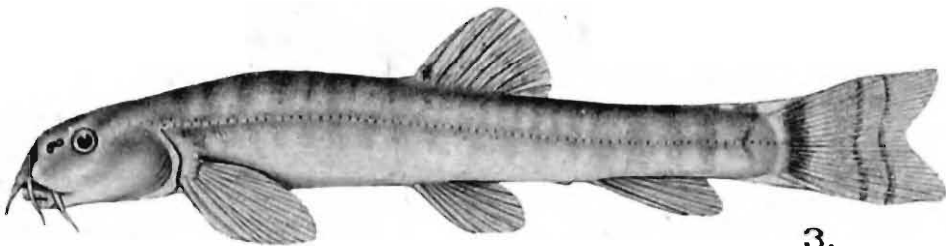
EXPLANATION OF PLATE V.

Nemachilus from Baluchistan and N. W. F. Province.

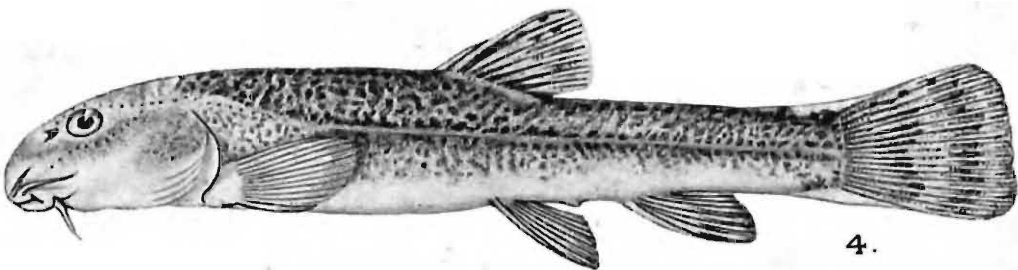
- FIG. 1.—Lateral view of *Nemachilus prashari*, sp. nov. $\times 2$.
FIG. 2.—Ventral surface of head and anterior part of body of same. $\times 3$.
FIG. 3.—Lateral view of *Nemachilus kessleri* Günther. $\times 2$.
FIG. 4.—Lateral view of *Nemachilus brahui* Zugmayer. Nat. Size.
FIG. 5.—Ventral surface of head and anterior part of body of same. $\times 2$.
FIG. 6.—Lateral view of *Nemachilus baluchiorum* Zugmayer. $\times 1\frac{1}{2}$.
FIG. 7.—Ventral surface of head and anterior part of body of same. $\times 1\frac{1}{2}$.



1.



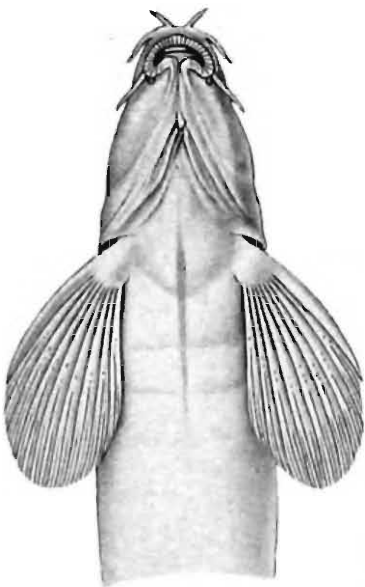
3.



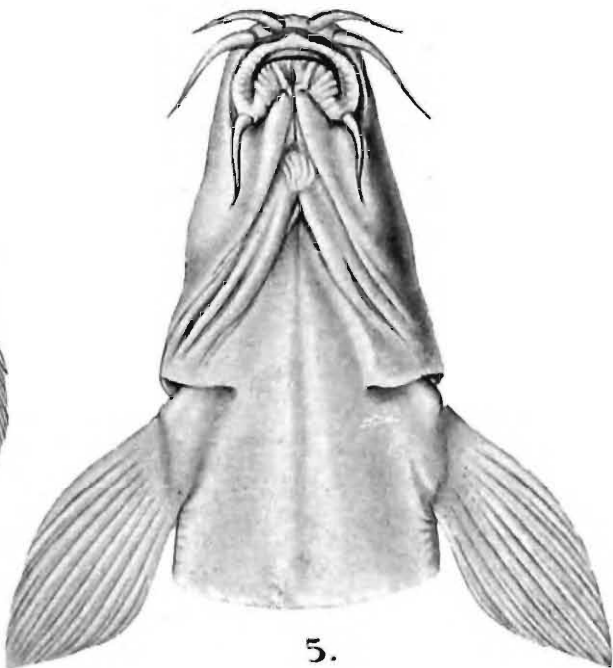
4.



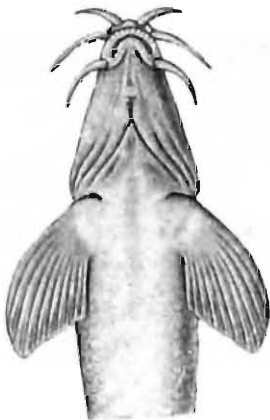
6.



2.



5.



7.

NOTE ON *CIRRHINA AFGHANA* GÜNTHER.

(Pisces-Cyprinidae).

By LEO S. BERG.

In his report on the fishes brought by the Afghan Delimitation Commission Günther¹ described a new Cyprinoid fish under the name *Cirrhina afghana*. Numerous specimens of this fish were collected "at Nushki, N. Baluchistan, and in the small river at Kushk, Badghis, N. W. Afghanistan."

The occurrence of the Indian genus *Cirrhina* as far north as in the drainage system of the Murghab, Transcaspia, is very interesting, if Günther's determination be correct.

According to the description the formula of *C. afghana* is as follows : *D.* 13-14, *A.* 10, *ll* 40, pharyngeal teeth 4·3·2 2·3·4 or 5·3·2—2·3·5. One pair of barbels only at the angles of the mouth. Intestinal caecal with numerous convolutions. Peritoneum deep black. Lower lip transverse, generally covered with a horny substance which forms a sharp edge. Last single ray of the dorsal fin distinctly serrated along its basal portion.

Günther was not quite sure that the above named species belonged to the genus *Cirrhina*. He remarks : "This species differs in several points from the typical *Cirrhina*. In the latter the snout is more depressed, and the covering of the lower jaw by horny substance is the exception ; of the barbels the upper ones are more frequently developed than the lower ; the anal fin has a ray or two less than in the present species, and finally the nakedness of the abdomen is a character by which our species seems to differ from all the others."

N. Zarudny brought in 1898 to the Museum of Zoology, Academy of Sciences, St. Petersburg, numerous specimens of *Cirrhina afghana* from South Persia (Basman, No. 11710 ; Bampur, No. 11711) which allow us to decide the question as to the generic position of this species.

The type of *Cirrhinus* or *Cirrhina* Cuvier 1817 is *Cyprinus cirrhosus* Bloch 1795, from the Malabar coast ; this species has no osseous ray in the dorsal, *D.* III—IV 14—15, *A.* III 5, *ll* 42-44, barbels 4, a tubercle at the symphysis of the lower jaw, peritoneum light, intestine short, no scaleless furrow in front of the dorsal. Scales distinctly elongate. It is obvious, therefore, that *Cirrhina afghana* does not belong to the genus *Cirrhina*.²

¹ Günther, *Trans. Linn. Soc. London*, Zoology V, p. 106, pl. xii, fig. c (1889).

² Day (*Fishes of India*, 1878, p. 547) enumerates in the genus *Cirrhina* the following species from India :—

C. cirrhosa (Bloch).

C. mrigala (H. B.).

C. latia (H. B.).

C. reba (H. B.).

C. fulungee (Sykes).

Of these five species I have seen all but the last. *C. cirrhosa*, *C. mrigala* and *C. reba* belong to the genus *Cirrhina*, as defined above. *C. fulungee*, to judge from Day's

The proper place of *Cirrhina afghana* is in the genus *Cyprinion* Heckel 1843 (type: *C. macrostomus* Heckel) which is allied to *Varicorhinus* Rüppell 1835 (type: *V. beso* Rüppell)=*Capoeta* Valenciennes 1842 (type: *C. fundulus* Val.=*C. capoeta* Güldenstadt)=*Scaphiodon* Heckel 1843 (type: *Sc. perergrinorum* Heckel=*V. damascinus* (Val.)), but differs in having seven branched rays in the anal fin (instead of five or, rarely, six), and a more or less developed scaleless furrow from the occiput to the origin of the dorsal. Dorsal with an osseous ray serrated behind and with from 9 to 16 branched rays. Scales subcircular. Barbels 2, angular. Intestinal canal very long, with many convolutions. The posterior chamber of the air-bladder long and narrow (in *C. microphthalmum*), longer than in *Crossochilus latius*.

The very characteristic genus *Cyprinion* includes some species inhabiting Syria, Mesopotamia, Southern Persia, Baluchistan, Sind and Punjab (Salt Range). These species are: *C. macrostomus* Heckel, *C. tenuiradius* Heckel and some species grouped about *C. watsoni* (Day). The species of the last group have been referred to most diverse genera: *Scaphiodon*, *Cirrhina*, *Barbus* etc. The section *C. watsoni* contains small forms with (9) 10-11, mostly 10 branched rays in the dorsal. The species belonging to this group are common in Southern Persia, Baluchistan, Sind and Salt Range, chiefly in tributaries to the Indian Ocean, but in some of the inland basins of Southern Persia and Baluchistan also, for instance, at Nushki, Quetta, Panjgur, and in the system of Hamun Lake.

Cyprinion is absent from central and northern Persia. Therefore it is quite improbable that *Cirrhina afghana* should be met with at Kashk, in the drainage system of the Murghab (Transcaspia).

I give here a preliminary list of all the species of *Cyprinion* belonging to the *watsoni* group. Although I have in my hands rather considerable materials from Persia collected by N. Zarudny in 1898-1901 and 1904, I do not regard them sufficient to warrant a definitive system of this very variable group.

1. *Cyprinion watsoni* (Day), Syn.: *Scaphiodon watsoni* Day 1872, Sind.

2. *C. watsoni belensis* (Zugmayer). Syn.: *Scaphiodon watsoni* var. *belensis* Zugmayer 1912. Las Belas in Baluchistan. Sarbas R. in S. E. Persia.

3. *C. irregulare* (Day). Syn.: *Scaphiodon irregularis* Day 1872 *Scaphiodon readingi* Hora 1923.—Sind, Salt Range, Quetta, Persian Baluchistan, S. Waziristan (Indus system).

4. *C. microphthalmum* (Day). Syn.: *Scaphiodon microphthalmus* Day 1880, Quetta; *Cirrhina afghana* Günther 1889, Nushki; *Scaphiodon*

description and figure, belongs to *Cirrhina* also. *C. latia* (H. B.) belongs to the genus *Crossocheilus* Hasselt 1823 (type *C. oblongus* Hasselt). *C. latius* (H. B.) [*Cyprinus Garra*] *latius* H. B. 1822, Tista R., Ganges, *Barbus diplochilus* 1838 and *Tylognathus barbatulus* Heckel 1844, Kashmir; I have seen three specimens from Kashmir No. 5311 and six from Simla No. 8296] has the anal opening in adults far apart from the origin of the anal fin, peritoneum black, intestinal canal long, upper lip distinctly fringed the posterior chamber of the air-bladder, as shown by Hora (*Rec. Ind. Mus.* XXII, 1921, pp. 646, 647, fig. II), long and narrow.

macmahoni Regan 1906, delta of Helmand; *Scaphiodon baluchiorum* Jenkins 1910, S. Baluchistan.—S. Persia (Kirman), Seistan, Baluchistan.

C. microphthalmum subsp. *nikolskii* (Berg) 1905. Syn.: *Scaphiodon aculeatus* Day, Gwadar, Quetta; *Cirrhina afghana* var. *nikolskii* Berg 1905, Bampur R.; *Scaphiodon aculeatus* (non Val.) Zugmyer, 1913, Gwadar, S. Persia (Bampur R., Gwadar R.), probably also Baluchistan (Quetta).

5. *C. milesi* (Day) 1880. Syn.: *Barbus milesi* Day 1880, Quetta; *B. milesi* var. Day 1880, Gwadar; *Barbus bampurensis* Nikolsky 1899, Bampur R.; *Scaphiodon daukesi* Zugmayer 1912, Baluchistan; *Barbus baschakirdi* Holly 1929, Gaz R. in Biaban, S. Persia.—Southern Persia and Baluchistan in rivers emptying into the Indian Ocean. Quetta.

Full descriptions and figures will be found in my paper on the fishes of Persia, Mesopotamia and Syria, now in preparation.

It has been indicated above that in the case of "*Cirrhina afghana*" there is a probability that some labels may have been transposed. This seems to have happened also in the case of certain other species brought by the Afghan Delimitation Commission. I give here a list of all the species mentioned by Günther (1889) with notes on their synonymy and true geographical distribution.

1. *Cirrhina afghana* Günther. "Nushki, Kushk" (Günther). = *Cyprinion microphthalmum* (Day) 1880.—South Persia as far north as Seistan. Baluchistan.

2. *Discognathus lamta* (H. B.) "Helmand R., Kushk." Boulenger¹ referred these specimens (in the British Museum) to *Discognathus variabilis* (non Heckel). Formerly (Fische von Turkestan, 1905, p. 51) I believed that Boulenger was mistaken in his determination, but as Hora² referred the examples in the Indian Museum, brought by Aitchison (Afghan Delimitation Commission), to *Garra rossicus*, I do not doubt that Günther's identification was wrong.

The proper name of *Discognathus variabilis* Boulenger (non Heckel) is *Discognathichthys rossicus* (Nikolsky) 1900 (type from the Tedshen R., Transcaspia). Specimens from Eastern Persia, Kirman, with naked belly, breast and back before the dorsal were separated by me in 1905 as *Discognathus rossicus* var. *nudiventris*.³ Later on the same variety was described from Seistan by Annandale⁴ as *Discognathus phryne*; it occurs also in Quetta and Pishin Districts (Baluchistan).

All the specimens from the Murghab and Tedshen in the collections of the Zool. Mus., Academy of Sciences, have the chest and back scaled. As Hora (*loc. cit.*) refers Aitchison's specimens to *D. rossicus* = *phryne* Ann. (*i.e.*, to the form with naked chest and back, = *nudiventris* Berg) I suppose that they were collected not in "Helmand and Kushk," but in the Helmand and at Nushki.

3. *Capoeta steindachneri* (Kessler). "Nushki, Kushk." = *Varicorhinus heratensis* (Keyserling) 1861.—Rivers of Transcaspia (Germab,

¹ Boulenger, *Proc. Zool. Soc. London* II, p. 160 (1901).

² Hora, *Rec. Ind. Mus.* XXII, p. 683 (1921).

³ Berg, *Fische von Turkestan*, p. 54 (1905); *Faune de la Russie*, Poissons III, livr. 2, p. 526 (1914). The type-specimen of the species came from Shivar, north of Nikh or Neh, N. E. Kirman, basin of Hamun lake.

⁴ Annandale, *Rec. Ind. Mus.* XVII, p. 76 (1919).

Tedshen, Murghab) ; eastward replaced by subsp. *steindachneri* (Kessler) 1872. The genus *Varicorhinus* is absent from Baluchistan and it is quite improbable that it should be met with at Nushki.

4. *Schizothorax intermedius* McClell. "Kushk." I have never seen specimens of *Sch. intermedius* from the Murghab drainage system. I believe that Günther's specimens came from the Helmand and represent what is known as *Sch. zarudnyi* (Nikolsky) 1897=*Barbus microlepis* Keyserling 1861 (*nomen praeoccupatum*), both described from the Hamun Lake drainage.

5. *Schizothorax raulinsii* Günther. "Hari-rud near Khusan" ; Bezg on the Jam R., a tributary of the Hari-rud in Khorasan,"=*Sch. pelzami* Kessler 1870.—Northern Persia. Transcaspia (Hari-rud, or Tedshen, and others).

6. *Gobio gobio* (L.). "Kushk."=*Bungia nigrescens* Keyserling 1861, Hari-rud at Herat=*G. gobio lepidolaemus* Kessler 1872, Zaravshan.—Transcaspia (Tedshen or Hari-rud, Murghab), Zaravshan, Syr-daria.

7. *Nemachilus kessleri* Günther. "Nushki."—Baluchistan. N. Zarudny brought this species (No. 11701) from Kelate-marg in the territory Neh-i-Bandan, Eastern Persia, South of Zirkuh, and not in Zirkuh as stated by Nikolsky.

COMPARATIVE MORPHOLOGY OF THE MALE GENITALIA IN LEPIDOPTERA.

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INTRODUCTION.

In the domains of both Morphology and Taxonomy the study of Insect genitalia has evoked considerable interest during the past half century. Zander (1900, 1901, 1903) suggested a common structural plan for the genitalia in various orders of insects. This work stimulated further research and his conclusions were amplified by Crampton (1920) who homologized the different parts in the genitalia of Hymenoptera, Mecoptera, Neuroptera, Diptera, Trichoptera Lepidoptera, Hemiptera and Strepsiptera with those of more generalized insects like the Ephemeroptera and Thysanura. During this time the use of genitalic characters for taxonomic purposes was also realized particularly in cases where the other imaginal characters had failed to serve. In this connection may be mentioned the work of Buchanan White (1876), Gosse (1883), Bethune Baker (1914), Pierce (1909, 1914, 1922) and others. Also, a comparative account of the genitalia, as a basis for the phylogenetic study of different insect orders, was employed by Walker (1919), Sharp and Muir (1912), Singh-Pruthi (1925) and Cole (1927), in Orthoptera, Coleoptera, Hemiptera and the Diptera respectively. It is surprising, work of this nature having been found so useful in these groups, that an important order like the Lepidoptera should have escaped careful analysis at the hands of the morphologists. Bethune Baker (1914) emphasized the taxonomic importance of the genitalia in Lepidoptera but his observations were too restricted. Eyer (1924) has attempted to work out the natural relationships of the primitive Lepidoptera and the allied insect groups and in a later contribution (1926), he has established characters of family and superfamily significance in the male genitalia of Microlepidoptera. A strict perusal of the rather enormous literature on the genitalia of Lepidoptera (which has been

¹ For explanation of lettering of text-figures see bottom of p. 208.

supplemented from time to time) convinces one of the scantiness of information regarding the phylogeny of this group. The truth is that we have no work dealing with the morphology of the whole order in a comprehensive manner.

Several attempts have been made to work out the true phylogenetic relationships of Lepidoptera based on characters of the egg, caterpillar, pupa and the imago, with the result that many divergent views have been expressed. It would, therefore, seem perfectly justifiable to look for another set of stable characters in the adult which could, at least, without being unnecessarily speculative be a useful aid in a natural classification of the Lepidoptera. With this end in view, I have attempted to give a comparative morphological account of the male genitalia in this order and to trace as far as is practicable the different lines of structural variation in the phylogeny of Lepidoptera. It must be admitted that no single structure can form the basis of a classification. Phylogenetic speculation, therefore, has only been indulged in after due cognizance has been taken of characters other than genitalia.

The nomenclature on the male genitalia of Lepidoptera is very complicated. An endeavour has been made in this paper to apply the names correctly to the various parts of the male genitalia as determined strictly by the laws of priority. In this way much of the confusion which is usually experienced in a study of this nature has been eliminated.

As in all systematic work, much difficulty has been found in grouping the different families in a regular order. I have mainly restricted myself to Meyrick's arrangement of the British Lepidoptera (1927) and in some cases as in Imms's 'General Textbook of Entomology' (1929). For the superfamily Noctuina, reference is made to Hampson's catalogue of the Lepidoptera Phalaenae in the British Museum (1898-1926).

The nomenclatorial accuracy of the specimens has been checked by Mr. W. H. T. Tams and Capt. N. D. Riley of the British Museum (Natural History), London.

All the drawings have been made by the Camera lucida. In most cases the ventral aspect was found most convenient to examine but in certain forms, *e.g.*, Papilionina, lateral views were found more convenient.

This problem was suggested to me by Mr. L. E. S. Eastham (my supervisor of research studies), whom I take this opportunity of thanking for his sympathetic interest and able guidance. His enthusiasm for this problem has been a great stimulus to me. To Professor J. Stanley Gardiner, I am much indebted for providing me with every facility for work in the Zoological Laboratory, Cambridge.

Much of the material for this investigation was obtained from the British Museum (Natural History), London, with the kind permission of the Trustees. I wish to express my sincere thanks to Sir Guy Marshall and Major E. E. Austen, for permission to work in the Natural History Museum, and to Mr. W. H. T. Tams and Capt. N. D. Riley for several courtesies enjoyed at their hands during the course of this investigation.

Lastly, I wish gratefully to acknowledge to the Government of the Punjab the grant of a University scholarship which I held during the progress of this research.

HISTORICAL REVIEW.

Early record of the male genitalia in Lepidoptera may be discovered in the works of Malpighi (1669) Kirby and Spence (1828), Burmeister (1832) and Siebold and Stannius (1848). These authors used the term 'Valvae' or the 'Valves' for the lateral outer appendages.

In 1842, De Haan fully described the male genital armature in the Papilionidae and employed the term 'Klappen' for the valvae and 'Zijdelingsche aanhangsels' for the two lateral appendages concealed in them. His account of the rest of the parts as translated by Gosse (1883) is reproduced below.¹ "The truncated and sometimes even hollow end of the hinder part of the body, which lies within these valves, bears upon the upper edge a pointed spine bent downwards, with the two lateral plates (Zijdelings plaatjes) which lie close to it. From the middle of the hinder part of the body the penis (roede) is exposed, which is gristly (Kraakbeenig), straight, blunt, and shorter than the lateral valves."

In discussing the asymmetry of parts in the male genital armature of *Nisoniades tristis* Boisd.; Scudder and Burgess (1870) used the term "Clasp" for the valvae and the "Upper organ" for the dorsal portion of the genitalia. The terms "Main body" and the "Dorsal crest" were used to describe the proximal portion of the upper organ. A pair of lateral arms which arise from the upper organ and extend ventrally were termed the "Inferior armature". These authors were the first to emphasize the usefulness of genitalic characters for the differentiation of closely related species.

Mc'Lachlan (1872) described the genitalia of *Acentropus* and applied the terms "Appendices inferiores", "Boat-shaped lobes", "Superior processes", and "Penis" for the different parts, which had been previously used for the description of similar organs in the Trichoptera.

Buchanan White (1876) gave a clearer account of the male genital armature in the European Rhopalocera. He replaced the term "Upper organ" of Scudder and Burgess by "Tegumen" which signified both the tergal and sternal parts of the terminal segment. The term "Harpagones" was used for the lateral valves.

Gosse (1881, 1883) introduced a new nomenclatorial scheme for the description of copulatory organs. The term "Valvae" was retained and he introduced the term "Harpe" for a peculiar prehensile organ found on the inner surface of each valve. He compared these to the 'lateral appendages' ('Zijdelingsche aanhangsels') of the Papilionidae, previously described by De Haan (1842). The term 'tegumen' adopted by Buchanan White (1876) was found hardly appropriate for the apical spinose, often wiry point and so he called it the "Uncus" (drag hook). Arising from the base of the uncus, he noticed a mass of shining white tissue occupying the chief place in the genital cavity and owing to its resemblance to a boat, he termed it the "Scaphium". The term "Penis" was employed for the central intromittent organ and its inner soft white tissue was left unnamed.

¹ Cited from Gosse, *Trans. Ent. Soc. London* (1883).

Various articles were published in the ensuing period and the chief contributions were made by Cholodkovsky (1884, 1885), Hofman (1895), Smith (1889, 1898), Jackson (1889), Peytoureau (1895), Stichel (1889) and Peterson (1900), on the morphology of the male genitalia in Lepidoptera.

In 1900, Stitz, using Gosse's nomenclature gave a comprehensive account of the genital armature in some families of this order. His work is usually discredited since he erroneously employed the term 'scaphium' for the uncus and represented the latter as a sub-anal structure.

Poljanec (1902) referred to the modifications in the eighth abdominal sternite and used the term "Rami" for the distal processes of the post-segmental margin.

Zander (1903) published a very comprehensive account of the genital armature in the Lepidoptera. He partly accepted Gosse's terminology and referred the tegumen to the ninth segment and the uncus and scaphium as dorsal and ventral processes respectively of the tenth segment, which is membranous and lies concealed below the tegumen. Like several others, he too was mistaken in representing the scaphium as sub-anal. The penis and its development were fully worked out and he suggested the term "Ringwall" for its ventral supporting structure. His work has dual importance since he also studied the development of these organs to pick up their real morphological significance.

The value of genitalic characters for taxonomic purposes was also realized and Rothschild and Jordan (1903) and Pierce (1909) described the male genitalia in the Sphingidae and the Noctuidae respectively.

In 1911, McDunnough worked out a nomenclatorial scheme out of the existing literature on the subject. He also erroneously described the scaphium as sub-anal.

Bethune Baker (1914) gave a comparative account of the copulatory organs in the Lepidoptera and emphasized their systematic importance. In this connection he modified the existing nomenclature and invented a terminology which was not universally accepted.

The warm reception of his publication on the male genitalia of the British Noctuidae encouraged Pierce to describe on similar lines the families Geometridae (1914) and Tortricidae (1922). At this stage he revised the nomenclature and invented new names for the different elements in these two families. The terminology adopted by this author is usually employed in all modern descriptions of the genitalia in the Lepidoptera.

Busck and Heinrich (1921) revised the nomenclature in the light of Pierce's work and emphasized the taxonomic value of the genital armature.

In the recent years considerable attention has been focussed on the taxonomic use of the genitalia. In this connection Burrows (1924), Eyer (1924, 1926) and Philpott (1923, 1927) published general accounts of the copulatory organs in different groups of Lepidoptera.

Eyer (1924) and Philpott (1923, 1926, 1927) described these organs in the primitive Lepidoptera, and their conclusions furnish additional evidence regarding the phylogeny of Homoneura. Skinner and Williams

(1924), Roswell and Williams (1927), Warren (1926) and Nakahara (1927) have been able successfully to utilize the genitalic characters for the discrimination of closely allied genera and species in the Hesperoidea and the Papilio-machaon groups of the Papilionina respectively.

TECHNIQUE.

For the preparation of genitalia, the methods suggested by Tams (1926) have been successfully employed. In the case of large forms such as the Sphingidae, wood naphtha is applied to the terminal segments of the abdomen, these being subsequently treated with potash. With smaller forms following method was adopted.

The entire abdomen is dipped in 90 per cent. alcohol. The alcohol penetrates the entire specimen rapidly with the result that it readily absorbs water when later it is dropped in it. The specimens are then left from 10-24 hours in a solution of 10 per cent. KOH. In the case of very small insects like some of the Tineidae, Eriocraniidae, and Micropterygidae a solution of 3 per cent. KOH gave very satisfactory results. No boiling in potash is required unless the parts are too rigid to soften otherwise. After proper dehydration the genitalia are dissected in clove oil before mounting the specimens in Canada Balsam.

For minute forms like *Micropteryx aruncella* Scop, a blue stain considerably improves the preparation and brings out the sclerites and sutures between them. For this purpose I have used with advantage the stain Carbol Methylene Blue as recommended by Pierce (1909). It is usually sold prepared in the liquid state and a few drops put in the alcohol for dehydration are enough to give a deep blue stain which may be slowly differentiated in oil of cloves ; or clearing in xylol is also recommended.

Picric acid dissolved in oil of cloves stains the membranous parts. This has also been frequently used in my preparations.

NOMENCLATURE.

References to the nomenclature for describing the male genitalia have been made in the preceding pages. It is seen that the first serious attempt to organize such a scheme was made by Gosse in 1883. He was followed by Zander (1903) and Pierce (1909). The latter author introduced several new names to represent the complicated genitalia in the family Noctuidae. The existing terminology was found confusing in several respects and in 1911, McDunnough developed a more or less conciliatory system of nomenclature purely on the basis of priority. Bethune Baker (1914) started a new terminology for these structures but it was not universally accepted. The real contribution of some importance was made by Pierce (1914) who outlined the structural details in the genital armature of the families Geometridae and the Tortricidae. He invented several new terms for accessory structures developed in connection with the valvae and the tegumen. Later, in 1921, Busck and Heinrich presented another nomenclatorial scheme in the light of Pierce's work. They do not appear to have adopted all his terms.

The absence of a uniform nomenclature for genitalia in Lepidoptera has its origin in incomplete morphological study, homologies being impossible to determine. A comprehensive analysis of existing nomenclatorial systems is therefore desirable. To avoid confusion the law of priority must be adhered to as strictly as the special conditions allow.

The ninth and tenth abdominal segments in the adult Lepidopteron are involved to form the genitalia proper with occasional modifications of the eighth sternite. In the list of names reproduced below, a brief explanation is also appended to describe each structure. The segment to which each of them belongs is also referred to.

Seventh Abdominal Segment.

COREMATA. (Pierce, 1914).

In some of the Geometridae, an extensile bag clothed with hair and bearing a spiracle is developed on either side of the seventh segment. This seems to bear no particular relation to the copulatory organs (Text-fig. 82, *Cr.*)

Eighth Abdominal Segment.

RAMI. (Poljanec, 1902).

In several Lepidoptera, the eighth sternite consists of a large chitinous piece and is distally produced into long often asymmetrical arms "The Rami" (text-fig. 95). Pierce (1914) used the term "The Cerata" for similar structures in the Acidaliinae (Geometridae).

MAPPA. (Pierce, 1914).

Covering the 'cerata' (Pierce) is a loose semicircular flap clothed with long scales. This flap is termed "The Mappa" It is developed in connection with the eighth sternite.

ABDOMINAL PLATE. (Buchanan White, 1891).

This is a distinct ventral plate sometimes developed on the eighth sternite into which the genitalia are usually withdrawn. It has been noticed in the Eupitheciinae amongst the Geometridae, some of the Nymphalidae and in the Species *Perrisectis australasiae* Don., amongst the Hepialidae (Text-fig. 4, *Vp.*).

Ninth Abdominal Segment.

TEGUMEN. (Buchanan White, 1876).

This term is now employed to denote the dorsal part of the ninth segment. Buchanan White used this term in a collective sense to signify both the tergite and the sternite of the ninth segment.

PENICULUS. (Pierce, 1909).

A densely hairy lobiform basal process is situated on either side of the tegumen which in some of the Noctuidae attains the form of broad lateral expansions (Text-fig. 97, *Pn.*).

VINCULUM. (Pierce, 1909).

Saccus in part. (Bethune Baker, 1891).

This is a ventral chitinized band which represents the sternite of the ninth segment. Pierce (1914) discarded it in favour of the term "The Saccus" (B. Baker, 1891) which signified both the vinculum and the saccus. In this paper, the term 'vinculum' has been retained for the ninth sternite. The saccus in the family Tineidae and the Nymphalidae, is a conspicuous structure while it is hardly represented as such in several other families. I have, therefore, adopted this term 'saccus' for the prolongation of the vinculum which in some of the Nymphalidae (Papilionina) extends as far as the fifth abdominal somite (Text-fig. 103, S).

VALVAE. (Burmeister, 1832).

These are paired clasping organs which basally articulate with the vinculum. Pierce (1909, 1914) has given the most adequate description of these organs and I have adopted his terminology for the Noctuidae and the Geometridae. In such cases the valvae may be divided into three parts which are more or less fused together (Text-figs. 96, 97). To these parts he has given the names "The Costa", "The Valvula" and "The Sacculus". In his account of the Noctuidae the term "Cucullus" is used for the distal part of the valve while the basal half is called the "Sacculus". The upper edge of the cucullus is called "The Margin", to which is often attached a uniform row of incurved spines which he terms as "The Corona". Besides these, there are attached to the edge of the valvae long spines which he designates as the "Marginal Spines". The outer margin of the cucullus is termed the "Anal Margin" and where the division occurs the name "Anal Angle" has been given. The inner border of the valves is called the "Costal Margin".

The central area of the valvae is occupied by a complicated series of prehensile organs. Gosse (1883) used the term "Harpe" for similar structures in the Papilionidae. The position of the harpe is variable. Pierce (1909) divided the whole organ into "Clasper" and "Ampulla" two closely situated structures and sometimes with different appearance. The former term is confusing since it has been commonly applied to the valvae. The "Ampulla" is a process arising on the inner side of the central area. Like the harpe, this too is a variable organ and at times is hard to locate.

The sacculus is the proximal portion of the valvae. It also assumes a variety of form. A small organ called the "Clavus" (Pierce, 1909) is developed from the base of the sacculus on the costal margin (Text-fig. 97, *cl*). It is highly developed in the family Noctuidae. Sometimes the two sacculi may project centrally quite apart from the valvae and are even fused together. To the organ thus formed Pierce has given the name of "The Furca" (Text-fig. 25, *F*).

TRANSTILLA. (Pierce, 1914).

This is a cross-bar which arises from the costal margin of the valvae. It may assume variable shape and is particularly well developed in the Tortricidae (Text-fig. 33, *Ts*).

LABIDES. (Pierce, 1914).

This term denotes two long arms each bearing a soft hairy pad and united by a thin membrane. They arise from the points where the transtilla meets the sacculus on the costal margin. These are prominent organs in the family Geometridae (Text-fig. 79, *Lb*).

Tenth Abdominal Segment.

UNCUS. (Gosse, 1883).

The uncus forms a dorsal process of the tenth segment which remains membranous and retracted within the tegumen. The anal opening lies just below the uncus and sometimes projects some distance away from it.

SCAPHIUM. (Gosse, 1883).

Gosse (1883) applied this term to a mass of shining white tissue arising from the base of the uncus and occupying the chief place in the genital cavity. It has been erroneously described as sub-anal by several authors. In 1911, Chapman correctly located this organ after making a thorough comparison in different forms, and he came to the conclusion that it is situated dorsally to the anus. Pierce (1909) compared it to a similarly situated organ in the Noctuidae Catocalinae. In fact this supra-anal process in the family Noctuidae is not the "Scaphium of Gosse" The latter structure is only a chitinous shield usually attached to the dorsal surface of the anal tube, and is conspicuous in the Papilioninae and some members of the Heterocera. For this supra-anal process (Text-fig. 96, 'Sp. an. p.'), found in the Catocalinae (Noctuidae), Thyrididae and other groups of Lepidoptera, the term "Subuncus" has been proposed by Pierce (1909), but I have not adopted it.

SOEII. (Pierce, 1914).

These are paired hairy pads or lobiform processes which arise from the base of the uncus and lie on either side of the anal tube. The form assumed is variable in different families of the Lepidoptera (Text-fig. 35, *Si*).

SIDE LOBE. (Buchanan White, 1876).

On either side of the tegumen and near its apex, arises a slender, curved spine-like lobe which is termed the "Side lobe" It is variable in form and is a conspicuous organ in the Papilionina (Text-fig. 101, *Sl*).

GNATHOS. (Pierce, 1909).

This term indicates a sub-anal structure hinged to the base of the uncus. It has two arms or 'brachia' which meet medially at a point

often described as the central lip. The arms may be free, in the form of a loop (Text-fig. 82, *Gn*), or, may be fused to the tegumen. This organ has frequently been mistaken for the 'scaphium of Gosse' (Zander and others).

Sexual organs.

PENIS. (Gosse, 1883).

The Penis forms the central (*intromittent*) organ and it consists of a strong tube called the "*Aedæagus*" which is kept in position by a sleeve-shaped eversible membranous tube named "*Manica*" by Pierce (1914). The Penis encloses a membranous tube, the "*Ductus ejaculatorius*" which enters the central organ near its blind end or 'blindsack' (Zander, 1903). The extrusible part of this duct which comes in contact with the bursa of the female is termed "The *Vesica*" by Pierce (1909) (Text-fig. 91, *D Ej*). It is usually armed with small spines or denticles which he has termed the "*Cornuti*" (Text-fig. 91, *Cn*).

RINGWALL. (Zander, 1903).

Anellus and Juxta. (Pierce, 1909, 1914).

It is a cone-like tube or a small more or less triangular plate which is ventrally supported by the vinculum and on either side by the valvae. It is subject to great modification and may be extended into lateral processes, the "*Anellus lobes*" (Text-fig. 53, *An*) which in the Geometridae and some other Heterocera are sometimes united so as to produce a single arm called the "*Calcar*" (Text-fig. 82, *Cal*).

"The *Juxta*" is a shield or plate borne on the ventral surface of the anellus. It is often decorated on either side by a pad covered with hairs or scales which Pierce (1914) has termed "The *Cristae*" (Text-fig. 84, *C*).

TRULLEUM. (Philpott, 1927).

This is apically connected with the tegumen and is produced into lower processes. The organ is found only in the Hepialidae and is particularly well developed in *Perrisectis australasiae* Don. (Text-fig. 4, *Tr*).

Function.

On the function of copulatory organs in the Lepidoptera much attention has not been focussed. Apart from the biological significance of copulation, Muir (1928) has held that the consideration of this function is of value both to Taxonomy and Morphology. Only casual notes may be discovered in the literature more or less of the nature of assumptions regarding the actual use of the organs during coitus.

The process of paring consists essentially in the conjunction of the male and female tubes, and the relative station taken up by the individuals, just previous to pairing or the 'pose' (Lamb, 1922), is that in which the insects are collinear. This condition is described as the "Linear pose" by Lamb (1922) in which the moths copulate and lie tail to tail and the 'necessary reaction to the pairing forces is provided

for by the presence of a 'common platform' It is generally agreed that the genital armature of Lepidoptera has the function of a special prehensile apparatus during copulation. It is very complicated in more specialized families such as the Noctuidae, Geometridae and the Sphingidae. Gosse (1883) and others have shown that the valvae are the chief clasping organs and the accessory structures like the harpe, ampulla, etc., are calculated to increase their efficiency. Jordan (1896) observed the actual mating in *Papilio memnon* and he found that the male claspers seize the protruding vaginal bulbs, taking hold on chitinous folds and ridges. In this respect he contradicted Gosse (1883) who maintained that the terminal segments were grasped by the valvae during copulation.

Pierce (1909) could not assign any definite function to the uncus and he believed that it is used to grasp the female dorsally or perhaps it may be thrown back and act as a guide, sometimes fitting between the ovipositor lobes. Michael (1923) also held that in *Bombyx mori* Linn., the uncus formed a part of the prehensile apparatus. In the family Psychidae, Jones (1927) has attributed a peculiar function to this organ. The female in this family is enclosed in her case and the male alights on it and as a preliminary to coitus, seeks access into the interior by using the awl-like uncus.

The supra-anal process such as the scaphium, etc., and the sub-anal 'gnathos' or the sub-anal 'sub-scaphium' are merely chitinous pieces which form the armature of the anal tube and are also sometimes used for grasping the female.

The penis is the central intromittent organ and the ductus ejaculatorius with its vesica are extruded into the bursa of the female. Evidence of this has been secured by Chapman (1913) who discovered the shedding of cornuti in the bursa of the female Pyralids, and Jones (1927) dissected the mated pairs of Psychids to ascertain the actual length of the extruded seminal duct.

It is supposed by Pierce (1909) that the densely hairy lobiform 'peniculus' in the Noctuidae appears to act as brush for the penis.

The juxta forms a ventral support for the penis and according to Pierce (1914), it may possibly act as a guide to this organ when it is produced centrally in the form of a long lip or spout.

The genitalia are usually covered all over the surface with hairs which probably have a sensory or tactile function.

Comparative Morphology.

The abdomen, in the male adult Lepidopteron, is composed of ten distinct somites, the last two being involved in the formation of the genitalia, with occasional modifications of the eighth sternite. There is no indication of the existence of an eleventh abdominal segment though some workers have described it.

The first abdominal segment bears no sternite and the tergite is closely applied to the thorax. The spiracles are usually borne on somites 1-7 and in the Hepialidae a distinct spiracle is also present on the eighth segment.

In some of the Hepialidae, there occur a number of unchitinized areas or fossae on the 3-8 somites and on the fifth sternite in the Eriocraniidae. The seventh segment is highly developed in some of the Geometridae, being produced on either side to form the extensile pouch clothed with hair, the 'Coremata' (Pierce, 1914). These are also found in connection with the ninth somite in some of the Eupitheciinae. The eighth segment shows occasional modifications, being produced distally into paired, elongated sometimes curved arms or "Rami" (Poljanec, 1902), and in some Bombycidae such processes arise proximally as well and are directed anteriorly (Text-fig. 95). The details of such structural variation in the eighth, ninth and the tenth abdominal segments have been incorporated in the ensuing systematic account.

Order LEPIDOPTERA.

Sub-Order HOMONEURA.

This is an archaic group comprising the families Micropterygidae, Mnesarchaeidae, Hepialidae, Prototheoridae, and Eriocraniidae. Their inter-relationships based on characters of the male genitalia have been extensively described by Eyer (1924) and Philpott (1923). In this study material for the families Mnesarchaeidae and Prototheoridae was not available, consequently I have depended on the observations of these authors.

Family MICROPTERYGIDAE.

The eighth sternite is very much reduced.

Valvae simple, elongate, costal margin convex, apex broad, lobiform, sparsely spinose. Between the valvae and the ninth sternite lies a small sclerite termed the "Horizontal Plate" ('H', fig. 1) by Philpott (1923).

The ninth sternite is broad, well developed and fused with the tegumen by a distinct suture. Philpott (1923) failed to observe any indication of such a line of fusion between the tegumen and the ninth sternite in *Micropteryx aruncella* Scop., and inferred that 'the tergite has disappeared entirely, its place being taken and its functions carried out by outgrowths from the sternite.' The tegumen is a short piece and is continued dorsally into an erect process, the uncus. Ventrally it is produced into a pair of lateral plates which are curved upwards apically to a point. From the base on each of these arises a short blunt process with hair on the apex. Philpott regarded them as 'surgonopods' or 'surstyli'.

Penis long. Cornuti distinct.

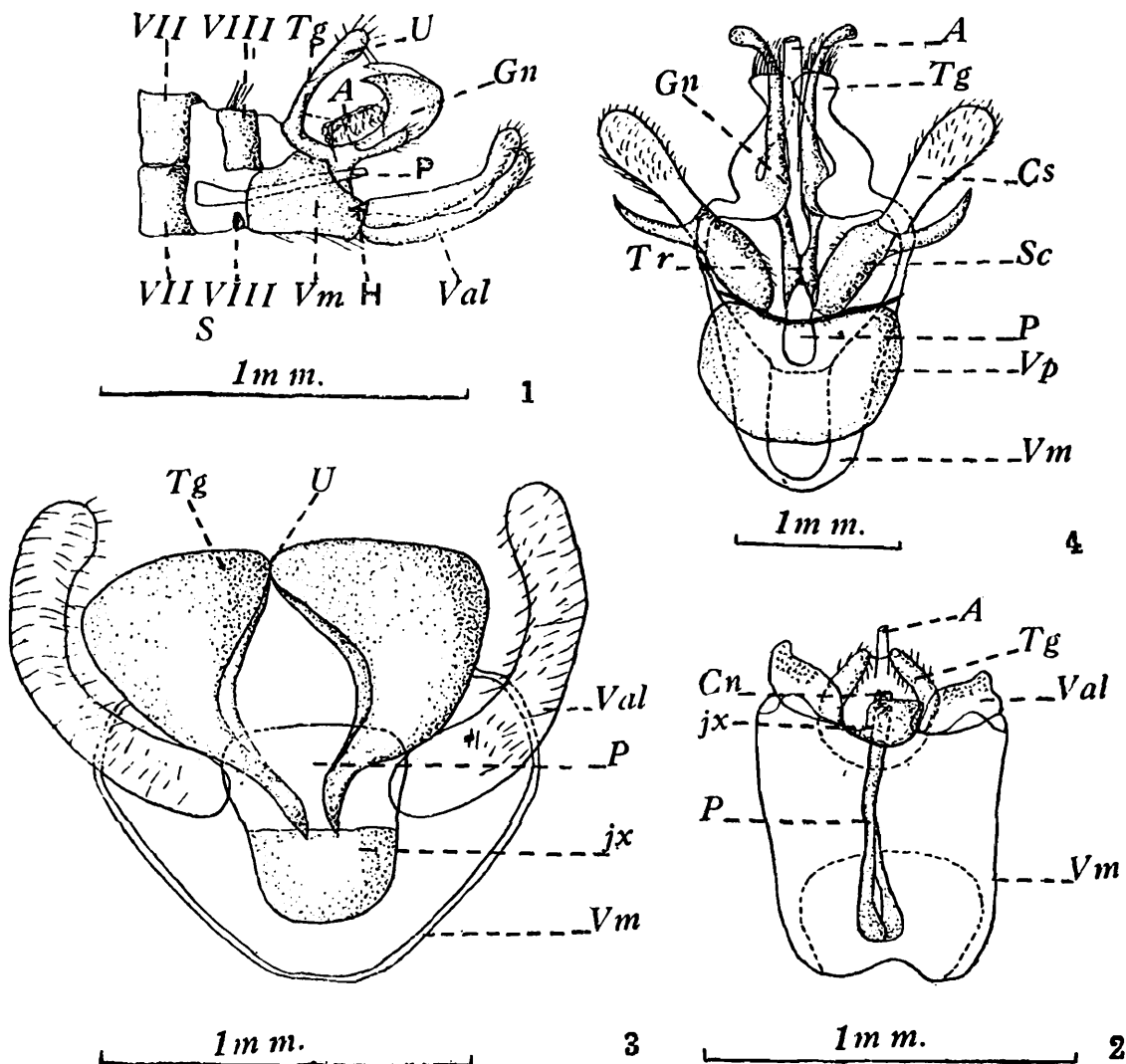
Species examined. *Micropteryx aruncella* Scop. (Text-fig. 1).

Family ERIOCRANIIDAE.

Fifth sternite with unchitinized areas or fossae.

Valvae short, reduced and scobinated. Tegumen with distinct lateral lobes connected with each other by a chitinous membrane. Vinculum broad and elongated.

Penis long, dorsal and ventral surfaces heavily chitinized and so it has the appearance of two separate pieces united basally. Juxta a strongly chitinized plate.



TEXT-FIG. 1.—*Micropteryx aruncella* Scop.

TEXT-FIG. 2.—*Eriocrania semipurpurella* Steph.

TEXT-FIG. 3.—*Hepialus lupulinus* Linn.

TEXT-FIG. 4.—*Perrisectis australasiae*. Don.

Species examined. *Eriocrania semipurpurella* Steph. (Text-fig. 2); *Mnemonica subpurpurella* Haw.

Family HEPIALIDAE.

The eighth sternite with a median ventral plate ('Vp', fig. 4) lying beneath the vinculum (e.g., *Perrisectis australasiae* Don.).

LETTERING FOR TEXT-FIGURES.

A., Anal tube; An., Anellus; Ap., Ampulla; C., Cristae; Ca., Costal margin; Cl., Clavus; Cn., Cornuti; Cr., Coremata; Cs., Cucullus; D. ej., Ductus ejaculatorius ('Vesica' in part); F., Furca; Gn., Gnathos; H., Horizontal plate; Hp., Harpe; Jx., Juxta; Lb., Labide; P., Penis; Pn., Peniculus; S., Saccus; Sc., Sacculus; Si., Socius; Sl., Side lobe; Tg., Tegumen; Tr., Trulleum; Ts., Transtilla; U., Uncus; Vm., Vinculum; Vp., Ventral plate.

Valvae simple, narrow, slightly arched (e.g., *Hepialus lupulinus* Linn., *Porina vexata* Wlk.), or, with membranous, broad cucullus, sacculus produced distally into a curved process (e.g., *Perrisectis australasiae* Don.).

Tegumen lobes broad and curved. On their inner margin they are produced towards each other and bear a pair of erect processes ('Gn', fig. 4) enclosing the anal tube on each side (e.g., *Perrisectis australasiae* Don.). Ventrally the tegumen is produced into short and pointed paired processes (e.g., *Hepialus lupulinus*, Linn.), with dentate basal arms (e.g., *Porina vexata* Wlk.). This structure has been described as the "Suspensorium" by Eyer (1924) in his account of the Hepialidae. In *Perrisectis australasiae* Don., and other allied Hepialidae, Philpott has termed a similarly situated structure as the "Trulleum" ('Tr', fig. 4), and since no homologous structure is found in any of the other Lepidoptera, he suggests that 'it is simply a development of the connecting membrane beyond the juxta'. In my preparation of this species, this piece or the 'trulleum' is perfectly continuous with the lateral lobes of the tegumen and is apically attached to them. Vinculum broad and 'U' shaped.

Penis membranous.

Species examined. *Hepialus lupulinus* Linn. (Text-fig. 3); *Porina vexata* Wlk. *Perrisectis australasiae* Don.).

Concluding Remarks on the genitalia of Homoneura.

From the forms studied above, I conclude that the Homoneura are characterized by the following genitalic features.

The ninth sternite or the 'vinculum' is characteristically broad or 'U' shaped and saccus is absent. The valvae are usually simple except in some of the Hepialidae, e.g., *Perrisectis australasiae* Don. The tegumen is hood-shaped and there is no well defined uncus or gnathos present in this group except in some of the Micropterygidae. The penis is membranous and the juxta lightly chitinized. A well developed trulleum is present in some of the Hepialidae.

Sub-Order HETERONEURA.

Superfamily TINEINA.

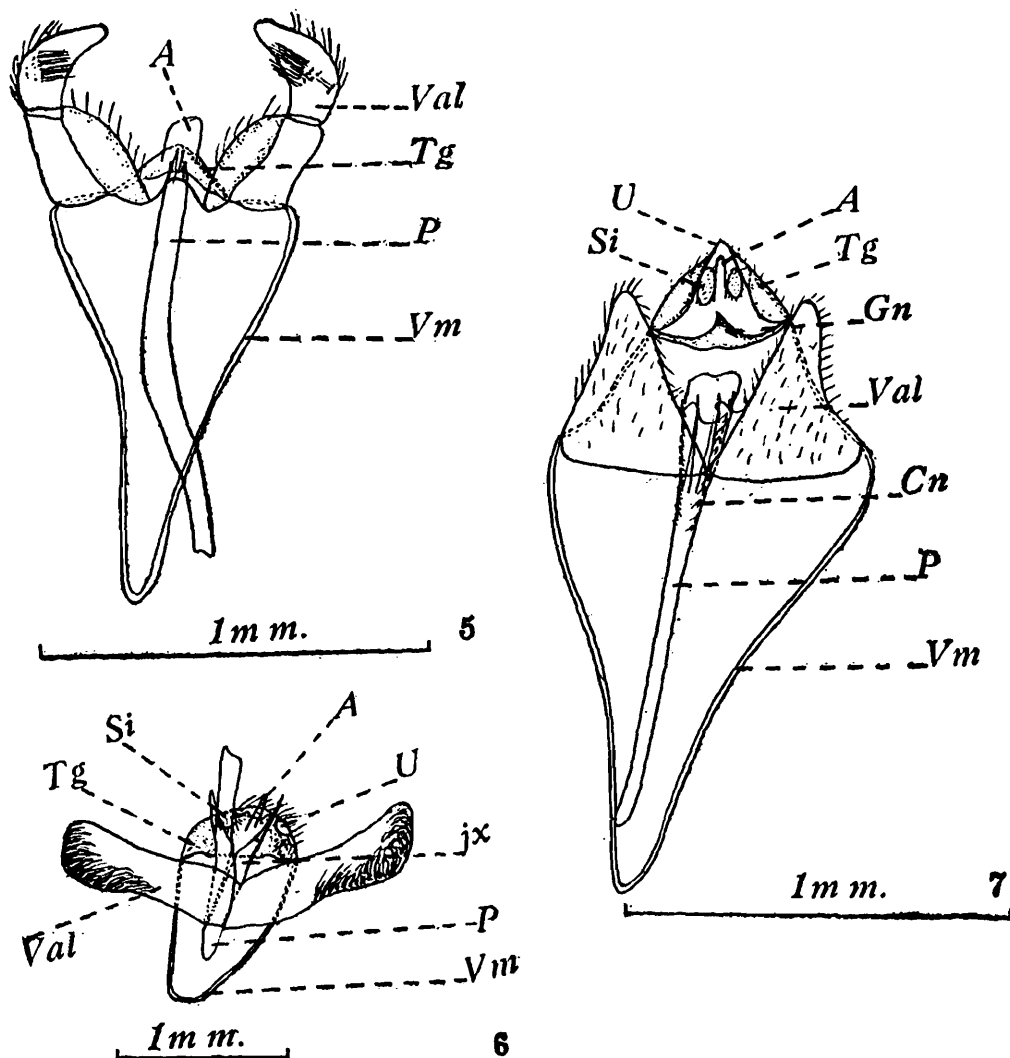
Family LAMPRONIADAE.

Valvae simple, short or digitate with two palpus lobes, sacculus broad (e.g., *Incurvaria morosa* Zell.).

Tegumen short, more or less rounded. Uncus absent or represented by setigerous lobes (e.g., *Lampronia capitella* Clerck). Socii also in the form of two small setigerous lobes. Vinculum long and 'V' shaped.

Penis long with terminal spines (e.g., *Incurvaria morosa* Zell.). Juxta well developed in *Lampronia capitella* Clerck.

Species examined. *Incurvaria morosa* Zell. (Text-fig. 5); *Lampronia capitella* Clerck (Text-fig. 6).



TEXT-FIG. 5.—*Incurvaria merosa* Zell.

TEXT-FIG. 6.—*Lampronia capitella* Clerck.

TEXT-FIG. 7.—*Nemophora schwarziella* Zell.

Family ADELIDAE.

Valvae simple and reduced.

Tegumen small, hood-shaped. Uncus rudimentary except in *Nemophora swammerdammella* Linn. Socii hairy. Anal tube long. Gnathos with central lip pointed (e.g., *Nemophora schwarziella* Zell.). Vinculum long and shaped like a 'V'.

Penis very long with several rows of cornuti.

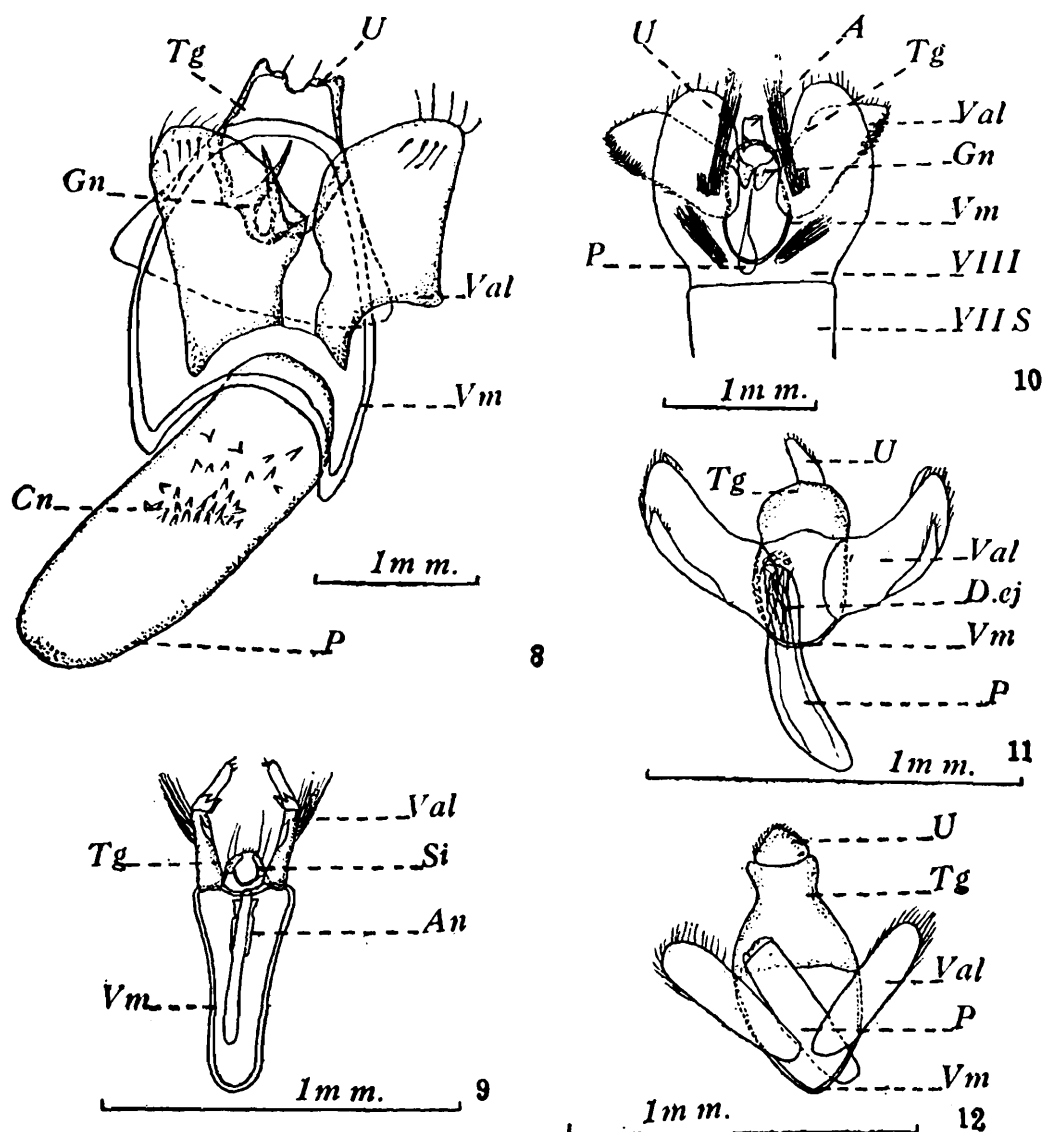
Species examined. *Nemophora swammerdammella* Linn.; *Adela croesella* Scop.; *Nemophora schwarziella* Zell. (Text-fig. 7); *Adela fibulella* Schiff.; *Nematois degeerella* Linn.

Family NEPTICULIDAE.

Valvae simple with process on costal margin. Tegumen broad with small rudimentary uncus. Gnathos well developed. Vinculum broad, basally concave.

Penis stout with thick-set cornuti.

Species examined. *Trifurcula immundella* Zell.; *Nepticula basella* Hs. (Text-fig. 8).



TEXT-FIG. 8.—*Nepticula basella* Hs.

TEXT-FIG. 9.—*Heliozela sericiella* Haw.

TEXT-FIG. 10.—*Plutella porrectella* Linn.

TEXT-FIG. 11.—*Phaulernis dentella* Zell.

TEXT-FIG. 12.—*Augasma aeratellum* Zell.

Family HELIOZELIDAE.

Valvae simple, narrow, digitiform with process on costal margin.

Tegumen small, hood-shaped. Uncus absent. Socii present. Vinculum long and 'U' shaped.

Penis long. Anellus lobes present.

Species examined. *Heliozela sericiella* Haw. (Text-fig. 9).

Family PLUTELLIDAE.

The eighth abdominal sternite is divided distally by median notch into two distinct lobes which enclose the genitalia (e.g., *Plutella porrectella* Linn.).

Valvae broad, highly spinose (e.g., *Eidophasia messingiella* Fisch.).

Tegumen short. Uncus reduced or absent. Gnathos present, bifid (e.g., *Plutella porrectella* Linn. ; *Plutella maculipennis* Curt.). Anal tube projects above the gnathos. Vinculum 'U' shaped. Saccus present or absent.

Penis bulbous at the base and gradually tapers towards the apex. Anellus lobes often present.

Species examined. *Eidophasia messingiella* Fisch. ; *Plutella porrectella* Linn. (Text-fig. 10) ; *Plutella maculipennis* Curt.

Family EPERMENIADAE.

Valvae simple, broad with process on costal margin near apex (e.g., *Phaulernis dentella* Zell.).

Uncus well developed, coniform. Gnathos absent, vinculum 'U' shaped.

Penis long, stout.

Species examined. *Epermenia* sp. ; *Phaulernis dentella* Zell. (Text-fig. 11).

Family HELIODINIDAE.

Valvae simple.

Uncus distinct, papilliform with marginal spines (e.g., *Augasma aeratellum* Zell.), or curved (e.g., *Stathmopoda pedella* Linn.). Vinculum broadly 'V' shaped. Saccus absent.

Penis stout.

Species examined. *Augasma aeratellum* Zell. (Text-fig. 12) ; *Stathmopoda pedella* Linn.

Family GRACILARIADAE.

Valvae simple.

Tegumen elongated, broad at the apex. Uncus rudimentary. Gnathos absent. Vinculum 'V' shaped. Saccus short when present.

Penis long with linear rows of small cornuti (e.g., *Parectopa ononidis* Zell.).

Species examined. *Parectopa ononidis* Zell. (Text-fig. 13) ; *Lithocolletis schreberella* Fabr. ; *Gracilaria* sp.

Family GLYPHIPTERYGIDAE.

Valvae simple, leaf-like.

Uncus elongate (e.g., *Glyphipteryx equitella* Scop. ; *Simaethis pariana* Clerck), or broad with marginal denticles. Socii present (e.g., *Choreutis myllerana* Fabr.). Anal tube long. Vinculum 'U' shaped. Saccus usually present.

Penis with several rows of cornuti.

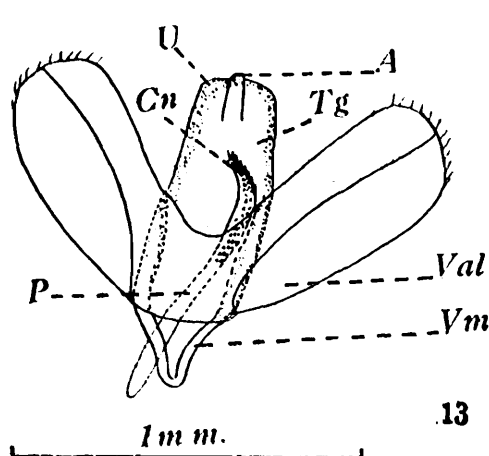
Species examined. *Glyphipteryx equitella* Scop. (Text-fig. 14) ; *Choreutis myllerana* Fabr. ; *Simaethis pariana* Clerck.

Family COLEOPHORIDAE.

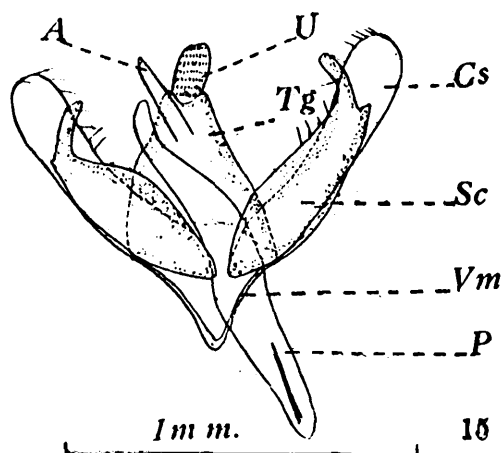
Valvae complex. Sacculus heavily chitinized and produced into a curved terminal process.

Uncus small, papilliform with several transverse rows of minute spines. Anal tube long. Vinculum 'V' shaped.

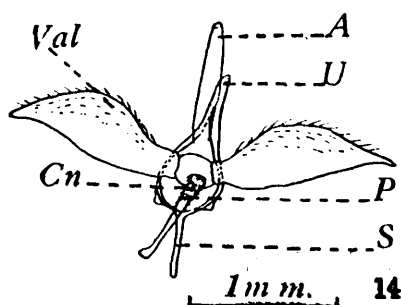
Penis long. Cornuti present.



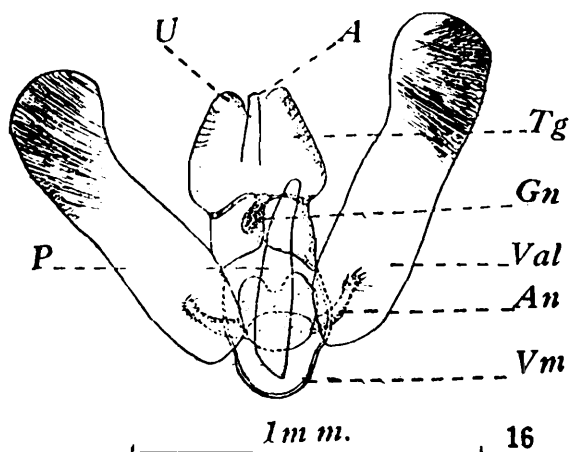
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16

TEXT-FIG. 13.—*Parectopa ononidis* Zell.

TEXT-FIG. 14.—*Glyphipteryx equitella* Scop.

TEXT-FIG. 15.—*Coleophora artemisiella* Scott.

TEXT-FIG. 16.—*Elachista argentella* Clerck.

Species examined. *Coleophora artemisiella* Scott (Text-fig. 15); *Metriotes modestella* Dup.

Family ELACHISTIDAE.

Valvae simple, apex narrow, (e.g., *Perittia obscuripunctella* Stn.).

Tegumen medially cleft at the apex and produced into lateral lobes. Uncus rudimentary, peg-like (e.g., *Perittia obscuripunctella* Stn.). Gnathos with central lip conspicuous, scobinate and supported on lateral chitinous arms. Vinculum 'U' shaped.

Penis long. Anellus lobes well developed.

Species examined. *Elachista argentella* Clerck (Text-fig. 16); *Elachista magnificella* Tengst.; *Perittia obscuripunctella* Stn.

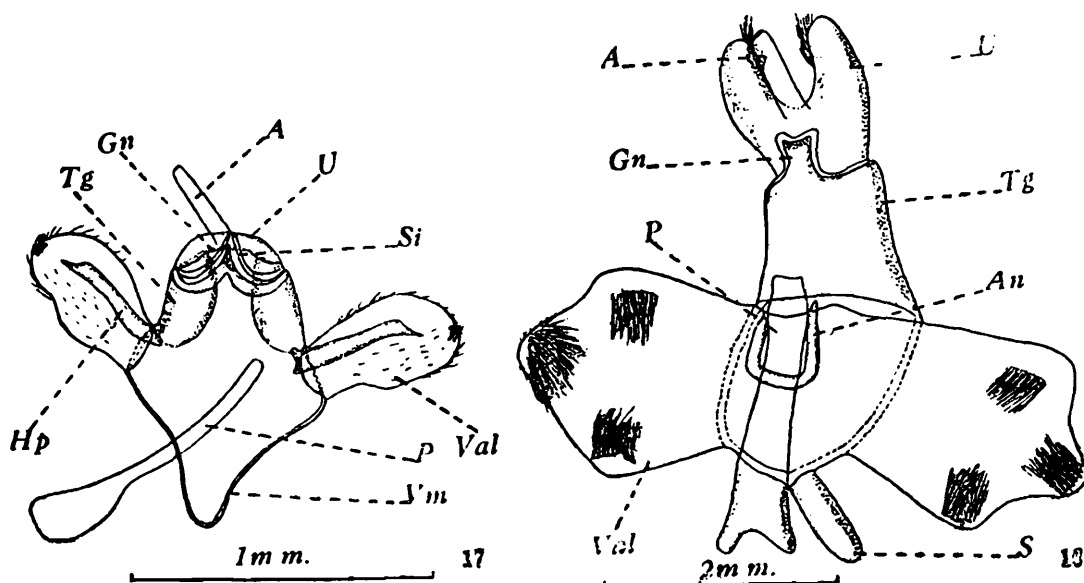
Family HYPONOMEUTIDAE.

Valvae usually simple, broad. Sacculus sometimes with elongated basal processes. (e.g., *Ethmia decemguttella* Hubn.). Sacculi sometimes united to form a vertical chitinous process (e.g., *Scythropia crataegela* Linn.).

Uncus disciform. Socii curved. Anal tube projects between the socii. Gnathos when present hinged to the base of the uncus, central lip acuminate, (e.g., *Ethmia decemguttella* Hubn.; *Atemelia troquatella* Zell.; *Scythropia crataegella* Linn.). Vinculum 'V' shaped. Saccus sometimes present.

Penis long usually bulbous at the base.

Species examined. *Hyponomeuta padella* Linn.; *Ethmia decemguttella* Hubn. (Text-fig. 17); *Scythropia crataegella* Linn.; *Atemelia troquatella* Zell.



TEXT-FIG. 17.—*Ethmia decemguttella* Hubn.

TEXT-FIG. 18.—*Trochilium apiforme* Clerck.

Family AEGERIADAE.

Valvae simple, broad, with clusters of spines distributed on three patches, (e.g., *Trochilium apiforme* Clerck).

Uncus well developed, long, (e.g., *Aegeria tipuliformis* Clerck.), bifid with two separate lobes, (e.g., *Trochilium apiforme* Clerck.). Gnathos disciform. Anal tube projects between the uncus and the gnathos. Vinculum 'U' or 'V' shaped. Saccus present.

Penis broad, angulate basally. Anellus lobes present.

Species examined. *Trochilium apiforme* Clerck (Text-fig. 18); *Aegeria tipuliformis* Clerck.

Family ORNEODIDAE.

Valvae simple, bulbous on costal margin, (e.g., *Orneodes hexadactyla* Linn.).

Tegumen broad, with uncus slightly raised. Gnathos absent. Vinculum 'U' shaped and elongated.

Penis proportionately long. Anellus lobes vertical, long.

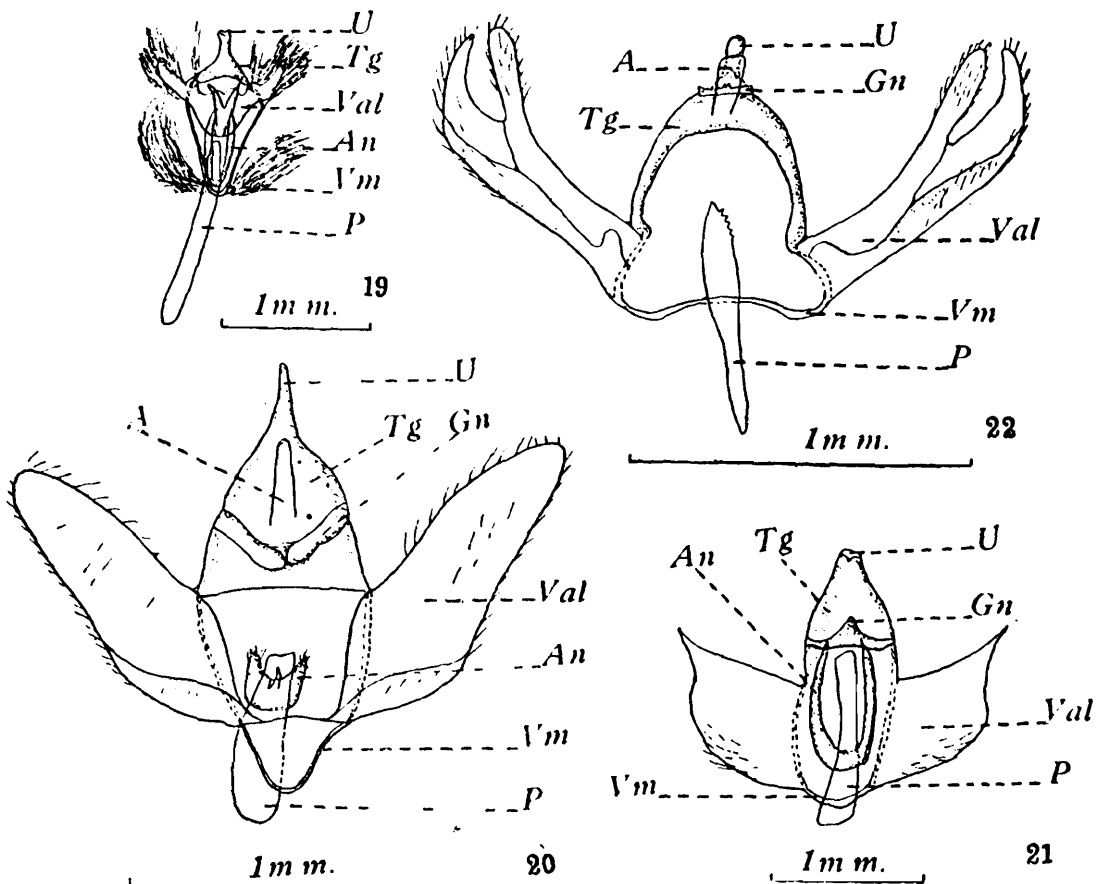
Species examined. *Orneodes hexadactyla* Linn. (Text-fig. 19).

Family OECOPHORIDAE.

Valvae simple, broad, leaf-like, bilobed near apex, (e.g., *Carcina quercana* Fabr.).

Uncus straight, pointed (e.g., *Hypercallia christiarnana* Fabr.), usually as coniform continuation of tegumen, (e.g., *Chimabache phryganella* Hubn.; *Depressaria angelicella* Hubn.). Gnathos flap-like, curved acuminate at the tip, (e.g., *Chimabache fagella* Fabr.; *Depressaria angelicella* Hubn.), round with spinous rays, (e.g., *Exaeretia allisella* Stn.), lobiform (e.g., *Hypercallia christiarnana* Linn.). Vinculum 'U' or 'V' shaped. Saccus not distinct.

Penis well developed. Cornuti band of teeth, saw-like, or single long cornutus present. Anellus lobes run on either side of penis, (e.g., *Endrosis lactella* Schiff.; *Carcina quercana* Fabr.; *Chimabache fagella* Fabr.).



TEXT-FIG. 19.—*Orneodes hexadactyla* Linn.

TEXT-FIG. 20.—*Hypercallia christiarnana* Linn.

TEXT-FIG. 21.—*Chimabache fagella* Fabr.

TEXT-FIG. 22.—*Blastobasis phycidella* Zell.

Species examined. *Endrosis lactella* Schiff.; *Carcina quercana* Fabr.; *Exaeretia allisella* Stn.; *Hypercallia christiarnana* Linn. (Text-fig. 20); *Chimabache phryganella* Hubn.; *Chimabache fagella* Fabr. (Text-fig. 21); *Depressaria angelicelea* Hubn.

Family BLASTOBASIDAE.

Valvae with cucullus medially cleft into two lobes, (e.g., *Blastobasis phycidella* Zell.).

Uncus bulbous at the apex. Gnathos a chitinous plate with median protuberances. Anal tube lies between the uncus and the gnathos. Vinculum usually 'U' shaped sometimes with basal concavity. Saccus absent.

Penis well developed with margin slightly dentate.

Species examined. *Blastobasis phycidella* Zell. (Text-fig. 22)
Auximobasis glandulella Riley.

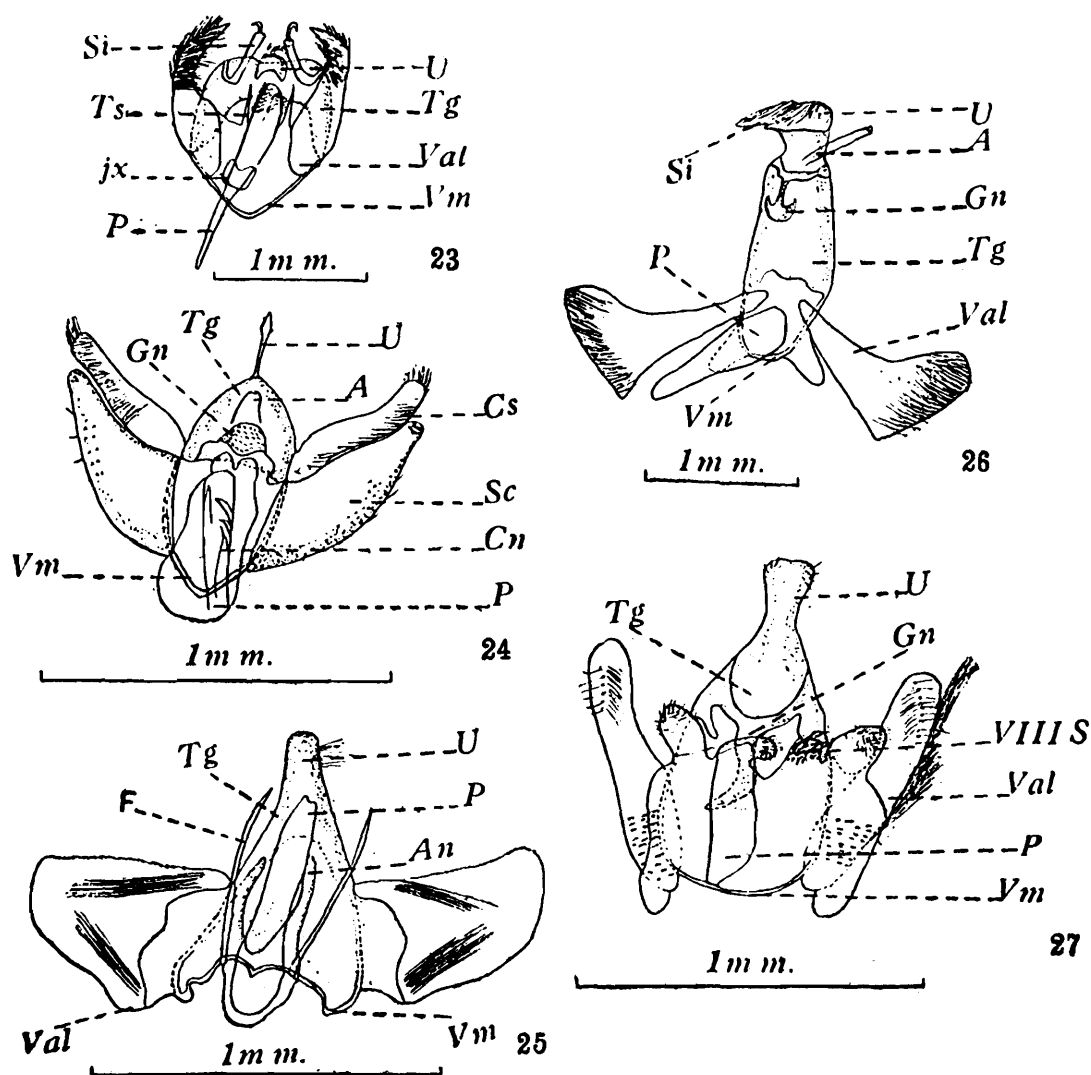
Family CARPOSINIDAE.

Valvae simple, transtilla erect.

Tegumen broad. Uncus short. Socii long, curved, with hooked process at the tip. Vinculum 'V' shaped. Saccus absent.

Penis distally broad. Cornuti numerous. Anellus plate broad.

Species examined. *Carposina subumbrata* Wlsm. (Text-fig. 23).



TEXT-FIG. 23.—*Carposina subumbrata* Wlsm.

TEXT-FIG. 24.—*Mompha fulvescens* Haw.

TEXT-FIG. 25.—*Telphusa fugitivella* Zell.

TEXT-FIG. 26.—*Platyedra malvella* Hubn.

TEXT-FIG. 27.—*Gelechia obscurella* Hein.

Family COSMOPTERYGIDAE.

Valvae divided. Sacculus heavily chitinized, (e.g., *Mompha lacteella* Steph.).

Uncus long, (e.g., *Mompha fulvescens* Haw.), ornamented with scale-like processes, (e.g., *Cosmopteryx eximia* Haw.). Gnathos distinct, central lip broad. Vinculum 'U' or 'V' shaped. Saccus present or absent.

Anellus lobes prominent and lie on either side of penis. Cornuti large.

Species examined. *Cosmopteryx eximia* Haw.; *Mompha fulvescens* Haw. (Text-fig. 24); *Mompha lacteella* Steph.

Family GELECHIADAE.

The eighth abdominal sternite divided into distal lobes (e.g., *Gelechia obscurella* Hein.; *Anacamptis populella* Clerck).

Valvae usually simple, broad (e.g., *Telphusa fugitivella* Zell.), thin and elongated (e.g., *Dichomeris marginella* Fabr.). Furca long and erect (e.g., *Telphusa fugitivella* Zell.).

Tegumen elongated flat plate (e.g., *Platyedra malvella* Hubn.). Uncus broad and spatulate. Gnathos often present, central lip well developed. Anal tube long and dorsally covers the gnathos. Vinculum 'U' or 'V' shaped, sometimes with lateral arms (e.g., *Platyedra malvella* Hubn.).

Penis stout. Cornuti present. Anellus lobes erect (e.g., *Telphusa fugitivella* Zell.).

Species examined. *Oegoconia quadripuncta* Haw.; *Parachronistis albiceps* Zell.; *Dichomeris marginella* Fabr.; *Paltodora cytisella* Curt.; *Metzneria metzneriella* Stn.; *Telphusa fugitivella* Zell. (Text-fig. 25); *Platyedra malvella* Hubn. (Text-fig. 26); *Anacamptis populella* Clerck; *Stomopteryx vorticella* Scop.; *Gelechia obscurella* Hein. (Text-fig. 27).

Family COPROMORPHIDAE.

The eighth abdominal sternite divided into lateral lobes.

Valvae complex. Costa produced into an apically pointed process. Saccus with vertical spinose arm.

Uncus long tapered and curved. Vinculum broad with lateral processes.

Penis stout. Cornuti small.

Species examined. *Copromorpha* sp. (Text-fig. 28).

Family LYONETIADAE.

The eighth sternite divided and the genitalia are withdrawn in it (e.g., *Leucoptera scitella* Zell.).

Valvae simple, broad, bulbous at the apex by constriction on anal margin (e.g., *Oinophila v-flava* Haw.).

Tegumen rounded. Uncus rudimentary or absent. Vinculum and saccus long (e.g., *Oinophila v-flava* Haw.).

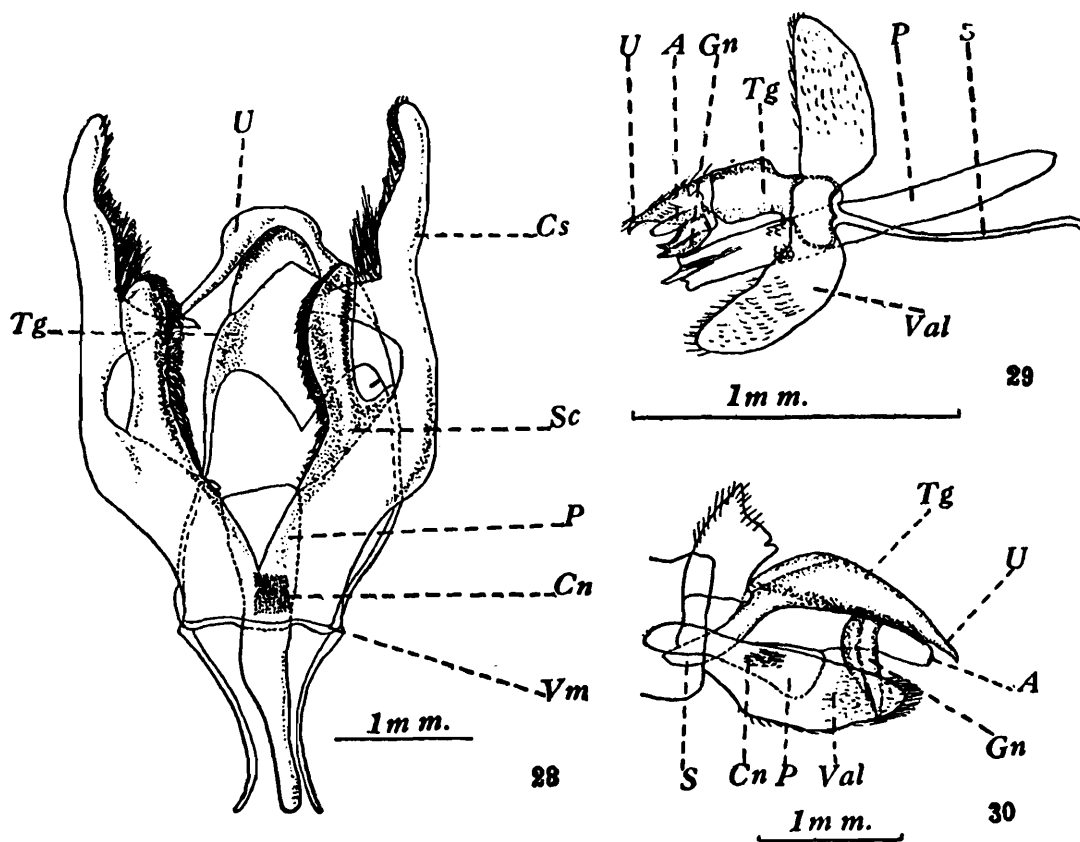
Penis long, tapered.

Species examined. *Leucoptera scitella* Zell.; *Oinophila v-flava* Haw.; *Rucculatrix cristatella* Zell.

Family TINEIDAE.

There are three conspicuous types of male genitalia recognised in the family.

Valvae simple, broad and elongated, e.g., *Tinea pellionella* Linn. (Text-fig. 29).



TEXT-FIG. 28.—*Copromorpha* sp.

TEXT-FIG. 29.—*Tinea pellionella* Linn.

TEXT-FIG. 30.—*Tinea albipunctella* Haw.

Uncus long, acuminate. Gnathos large. Anal tube passes between the uncus and the gnathos. Vinculum small. Saccus very long.

Penis very long with several spicule-like or small peg-like spine.

Valvae with narrow cucullus. Costal margin produced into inwardly directed process (e.g., *Solenobia inconspicuella* Stn.).

Tegumen broad. Uncus reduced or absent. Vinculum 'U' shaped. Saccus absent.

Penis very long and recurved.

Valvae with margin indented (e.g., *Meesia richardsoni* Wlsm.).

Uncus well developed, conical. Anal tube long. Vinculum with a pair of lateral processes (Sacci?).

Penis swollen at the base.

Species examined. *Tinea pellionella* Linn. (Text-fig. 29); *Tinea albipunctella* Haw. (Text-fig. 30); *Solenobia inconspicuella* Stn. (Text-fig. 31); *Meesia richardsoni* Wlsm.

Concluding Remarks on the genitalia of Tineina.

In the Aculeate series, the primitive features are essentially retained. The ninth sternite forms a broad or elongated usually 'U' or 'V' shaped chitinized band and saccus is not developed. The tegumen bears a pair of lateral setigerous lobes or 'socii' while the uncus and gnathos are hardly represented. The valvae are short and simple. The penis is long and develops a lightly chitinized anellus or juxta.

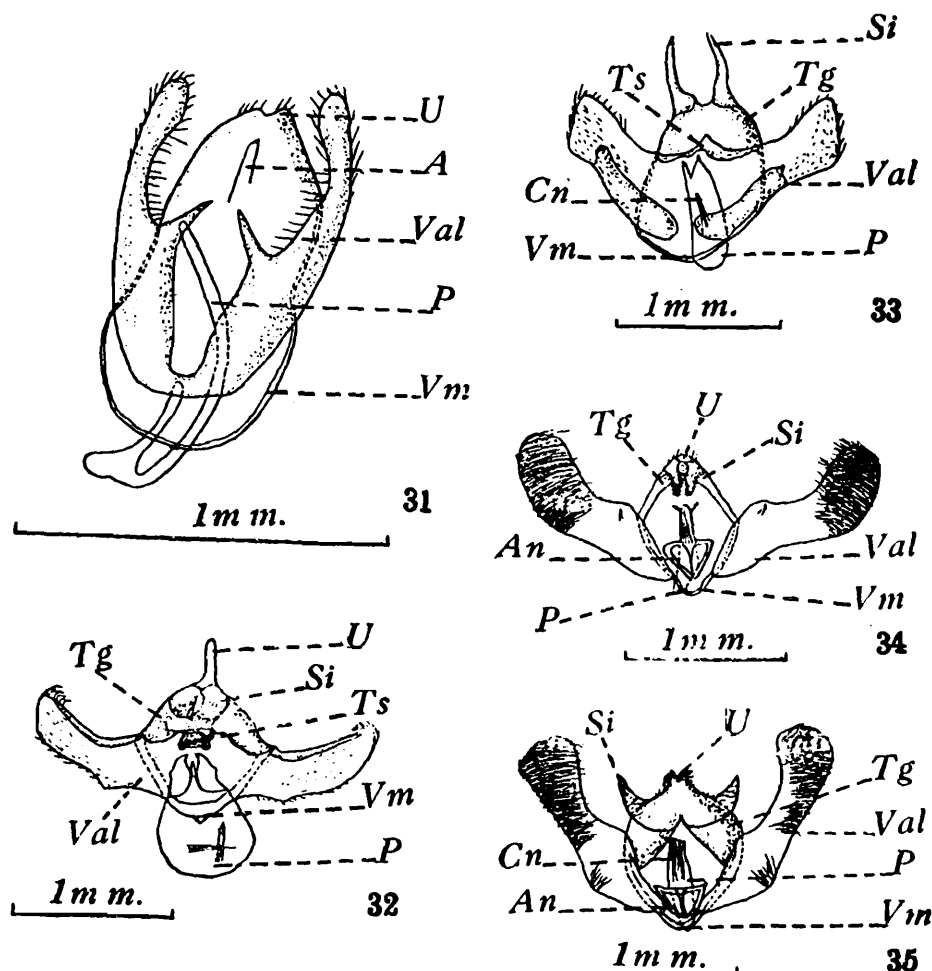
Amongst the Non-Aculeate families the ninth sternite is 'U' or 'V' shaped and develops a long saccus (e.g., Tineidae, Lyonetiidae, Aegeridae and Glyphipterygidae). The valvae exhibit slight complexity in form and may be emarginate (e.g., Blastobasidae) or partially divided into sacculus and cucullus. In the more advanced families a distinct harpe may also be present.

Superfamily TORTRICINA.

Family PHALONIADAE.

Valvae simple, short and broad. Sacculus sometimes heavily chitinated. Cucullus membranous (e.g., *Phalonia tessera* Treits.). Transstilla well developed with central lip broad and spinose [e.g., *Phtheochroa sodaliana* Haw.; *Lozopera (Aethes) dilucidana* Steph.], bifid with raised, pointed processes (e.g., *Chlidonia baumanniana* Schiff.).

Uncus long and straight (e.g., *Phtheochroa sodaliana* Haw.), bifid (e.g., *Phalonia tessera* Treits.), short, curved at the apex (e.g., *Phalonia ciliella* Hubn.) or reduced (e.g., *Chlidonia baumanniana* Schiff.; *Argyrolepis baumanniana* Schiff.), short, lobiform [e.g., *Lozopera (Aethes) dilucidana* Steph.], broad, flap-like (e.g., *Phtheochroa sodaliana* Haw.). Vinculum 'U'-shaped, broad.



TEXT-FIG. 31.—*Solenobia inconspicua* Stn.

TEXT-FIG. 32.—*Phtheochroa sodaliana* Haw.

TEXT-FIG. 33.—*Euxanthia aeneana* Hubn.

TEXT-FIG. 34.—*Pardia stripunctana* Fabr.

TEXT-FIG. 35.—*Phlaeodes tetraquetra* Haw.

Penis stout, bifurcate with dentate cornuti near the orifice, usually a single pair present [e.g., *Lozopera (Aethes) dilucidana* Steph.]. Penis base sac-like, cornuti long (e.g., *Phtheochroa sodaliana* Haw.).

Species examined. *Phalonia tesserana* Treits.; *Chlidonia baumanniana* Schiff.; *Phalonia ciliella* Hubn.; *Lozopera (Aethes) dilucidana* Steph.; *Phtheochroa sodaliana* Haw. (Text-fig. 32); *Euxanthia aeneana* Hubn. (Text-fig. 33).

Family EUCOSMIDAE.

The genitalia in this family are of four distinct types.

Valvae simple, costal margin curved.

Uncus short, hood-shaped. Socii present, usually drooping. Vinculum 'U' shaped. Penis short and straight with a vertical band of cornuti. Anellus broad.

Species examined. *Laspeyresia janthinana* Dup.; *Pardia tripunctana* Fabr. (Text-fig. 34); *Lobesia permixtana* Hubn.; *Laspeyresia nigricana* Steph.

Valvae with a convexity on the costal margin. Sacculus angulate.

Tegumen broad, uncus characteristically bifid. Socii well developed and erect. Vinculum 'U' or 'V' shaped.

Penis short with thick-set cornuti. Anellus broad.

Species examined. *Eucosma ramella* Linn. (*Lithographia paykulliana* Schiff.); *Phlaeodes tetraquetra* Haw. (Text-fig. 35); *Cartella bilunana* Haw.

Valvae with cucullus sometimes narrow; sacculus produced on the anal margin and swollen into highly spinose bulbous process (e.g., *Argyroploce arcuella* Linn.).

Uncus elongated, depressed (e.g., *Argyroploce semifasciana* Haw.; *Argyroploce arcuella* Linn.), short and conical (e.g., *Argyroploce micana* Frol.; *Argyroploce urticana* Hubn.), or reduced. Socii usually broad. Gnathos present, central lip sometimes short, curved and spinose (e.g., *Argyroploce urticana* Hubn.). Vinculum 'U' or 'V' shaped, usually broad. Saccus absent.

Penis short, pistol-like with variable number of cornuti. Sometimes a single large cornutus present (e.g., *Argyroploce semifasciana* Haw.).

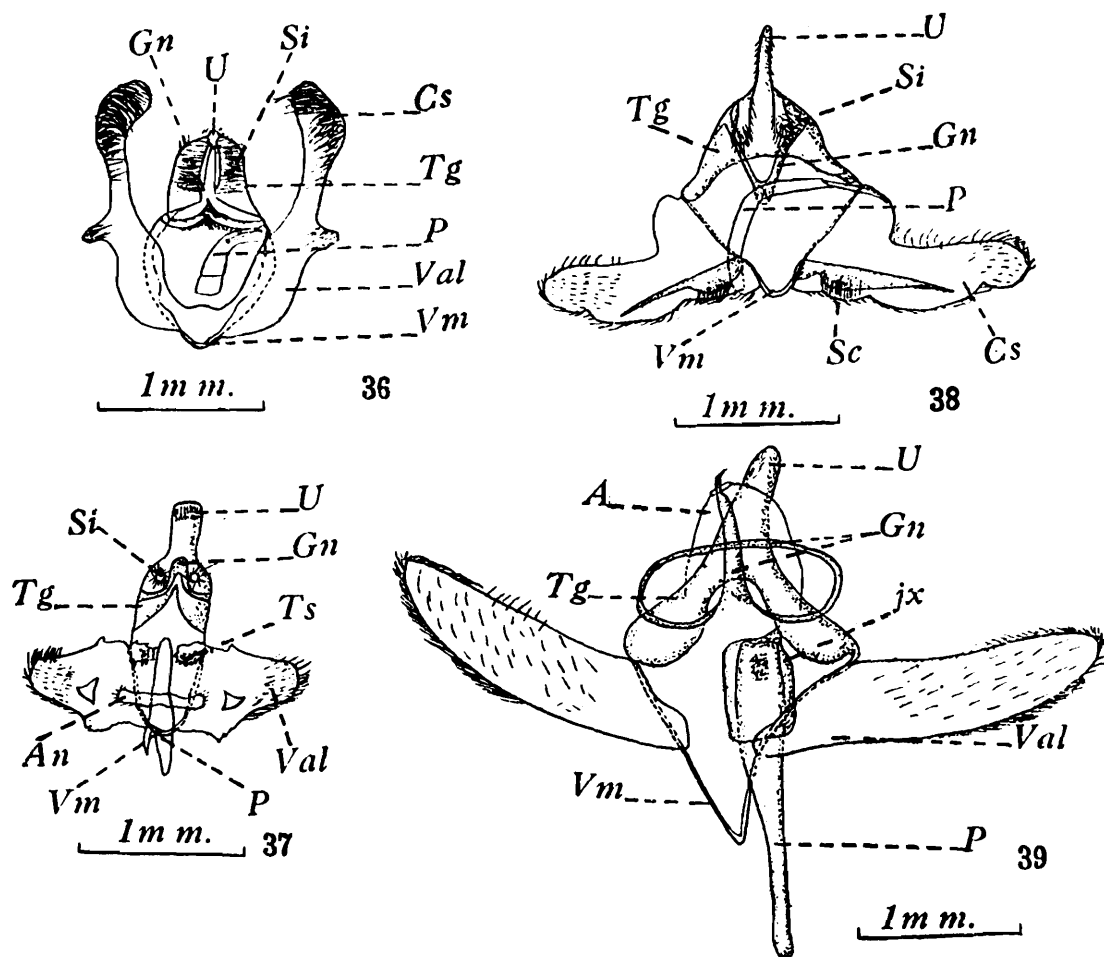
Species examined. *Argyroploce striana* Schiff.; *Argyroploce arcuella* Linn.; *Argyroploce micana* Frol.; *Argyroploce semifasciana* Haw.; *Bactra lanceolana* Hubn.; *Argyroploce urticana* Hubn. (Text-fig. 36).

Valvae with cucullus distinct, usually disciform, pad-like with deep costal convexity, profusely hairy. Sacculus narrow or broad.

Tegumen broad with rudimentary uncus (e.g., *Evetria sylvestrana* Curt.; *Notocelia uddmanniana* Linn.; *Ancylis achatana* Fabr.; *Ancylis mitterbacheriana* Schiff.), short and conical (e.g., *Hemimene alpinana* Herr-Schaff.; *Hypermezia augustana* Hubn.), rounded (e.g., *Eucosma brunnichiana* Frol.). Socii present. Usually long and drooping, broad or sometimes absent. Gnathos absent. Vinculum 'U' or 'V' shaped, often reduced.

Penis short, pistol-like. Cornuti usually present, number variable, small denticles or large band of spines. Anellus lobes united medially. Juxta sometimes present.

Species examined. *Hemimene alpinana* Herr-Schaff.; *Ancylis mitterbacheriana* Schiff.; *Eucosma scopoliana* Haw.; *Hypermezia augustana* Hubn.; *Eucosma brunnichiana* Frol.; *Dichrorampha ulicana* Guen. (*Hemimene plumbana* Scop.); *Evetria sylvestrana* Curt.; *Notocelia uddmanniana* Linn.



TEXT-FIG. 36.—*Argyroplote urticae* Hubn.

TEXT-FIG. 37.—*Tortrix rusticana* Treits.

TEXT-FIG. 38.—*Tortricodes tortricella* Hubn.

TEXT-FIG. 39.—*Tyndis proteanalys* Hmps.

Family TORTRICIDAE.

Coremata present in connection with the eighth abdominal segment (e.g., *Cacoecia rosana* Linn.).

Valvae simple flap-like expansions sometimes feather-like with curved spines arising from the mid-rib (e.g., *Peronea holmiana* Linn.). Sacculus angulate and spinose (e.g., *Cnephasia longana* Haw.), sometimes with a basal process margin sinuate (e.g., *Tortricodes tortricella* Hubn.). Transtilla spinose and lobiform (*Tortrix rusticana* Treits.).

Uncus long and straight, usually with marginal spines, terminal bulb spinose (e.g., *Pandemis ribeana* Hubn.), broad at the tip (e.g., *Tortrix rusticana* Treits.), reduced (e.g., *Argyrotoxa forskaleana* Linn.). Socii present, broad, drooping. Gnathos well developed with central lip curved, pointed or sometimes broad. Vinculum 'U' shaped.

Penis long and straight, short or stumpy (e.g., *Argyrotoxa forskaleana* Linn.), serrate at the orifice (e.g., *Cnephasia longana* Haw.). Cornuti variable. Anellus lobes usually present.

Species examined. *Pandemis corylana* Fabr.; *Cacoecia rosana* Linn.; *Tortrix* sp.; *Peronea holmiana* Linn.; *Pandemis ribeana* Hubn.; *Cnephasia logiana* Schiff.; *Argyrotoxa forskaleana* Linn.; *Batodes angustiorana* Haw.; *Cnephasia longana* Haw.; *Tortrix musculana* Hubn.; *Tortrix rusticana* Treits. (Text-fig. 37); *Tortricodes tortricella* Hubn. (Text-fig. 38).

Concluding Remarks on the genitalia of Tortricina.

The copulatory organs in this group correspond very much to those in the Superfamily Tineina. The ninth sternite is broadly 'U' or 'V' shaped and saccus is distinctly absent. The valvae usually remain simple and are connected by a transverse chitinous band—the 'trans-tilla', which assumes a characteristic form in this group. The penis is short and stumpy or shaped like a pistol. The anellus is broad and distinct.

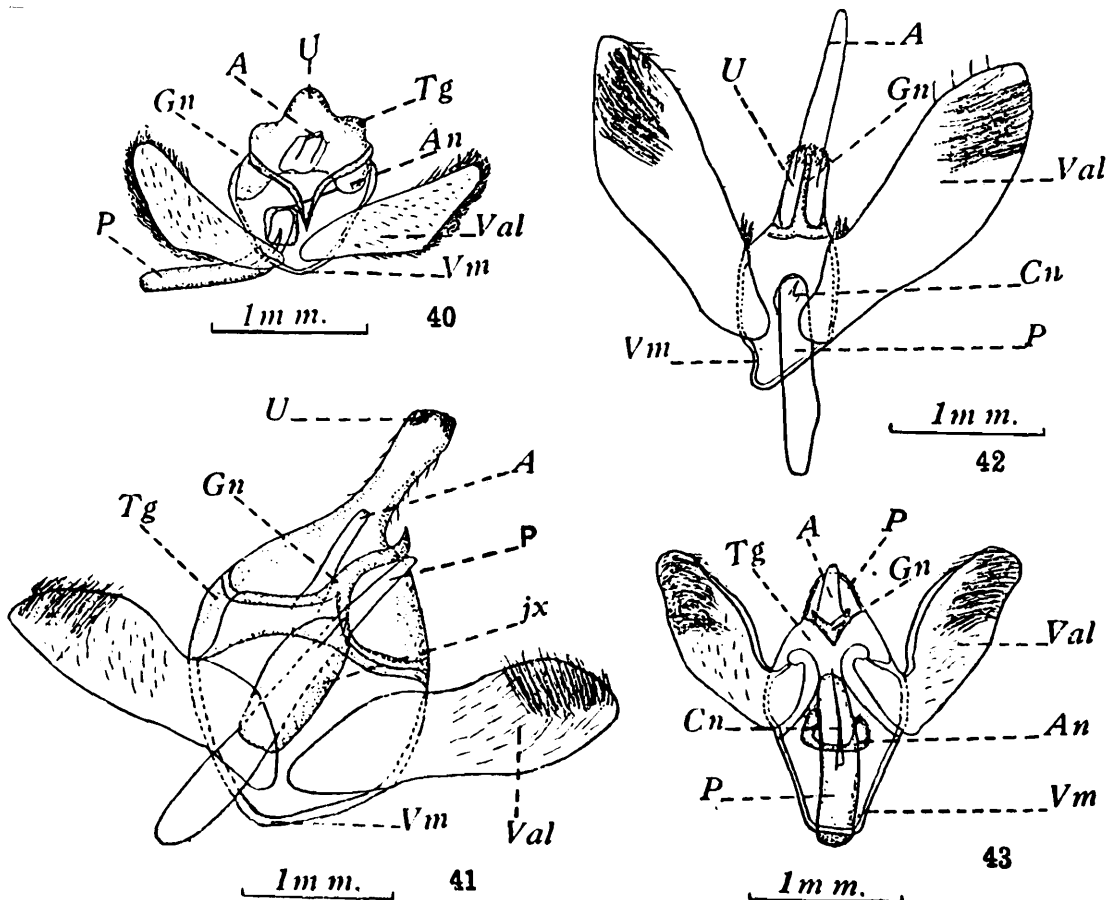
Superfamily PYRALIDINA.

Family PYRALIDAE.

Sub-family PYRALINAE.

Valvae simple.

Uncus short and broad (e.g., *Tamraca torridalis* Led.; *Pyralis farinalis* Linn.; *Stemmatophora erebalis* Hmps.), long and straight (e.g., *Tyndis proteanalis* Hmps.). Gnathos with central lip curved or



TEXT-FIG. 40.—*Pyralis farinalis* Linn.

TEXT-FIG. 41.—*Orthaga busalis* Wlk.

TEXT-FIG. 42.—*Cotachena histricalis* Wlk.

TEXT-FIG. 43.—*Ephestia elutella* Hubn.

pointed, or sometimes turned up dorsally (e.g., *Tyndis proteanal* Hmps.). Vinculum 'U' or 'V' shaped. Saccus rudimentary or absent.

Penis long. Cornuti spicule-like or as a band of teeth. A single large cornutus also present.

Species examined. *Tyndis proteanal* Hmps. (Text-fig. 39); *Paractenia allutalis* Zell.; *Tamraca torridalis* Led.; *Stemmatophora erebalis* Hmps.; *Aglossa pinguinalis* Linn.; *Udea (Pionea) ferrugalis* Hubn.; *Pyralis farinalis* Linn. (Text-fig. 40).

Sub-family EPIPASCHINAE.

Valvae simple, usually broad.

Uncus broad at the tip. Gnathos with the central lip long, curved and hooked at the tip. Vinculum broadly 'V' shaped.

Penis proportionately long. Cornuti present. Juxta well developed.

Species examined. *Orthaga basalis* Wlk. (Text-fig. 41).

Sub-family ENDOTRICHINAE.

Valvae simple and long.

Uncus well developed with a spinose, bulbous tip. Gnathos membranous. Anal tube passes between the uncus and the gnathos. Vinculum 'V' shaped.

Penis with two prominent cornuti at the tip.

Species examined. *Cotachena histricalis* Wlk. (Text-fig. 42).

Sub-family PHYCITINAE.

Valvae simple, a small process sometimes arises from the base of the sacculus (e.g., *Nephopteryx roborella* Zinck.; *Myelois advenella* Zinck.; *Pempelia palumbella* Fabr.). Another pair of chitinous processes arise from the base of the tegumen (e.g., *Eurhodope advenella* Zinck.; *Nephopteryx roborella* Zinck.).

Uncus broad. Gnathos with prominent central lip. Vinculum long and broadly 'V' shaped.

Penis stout with several thick-set or spicule-like cornuti. Anellus lobes usually present.

Species examined. *Homeosoma sinuella* Fabr.; *Eurhodope advenella* Zinck.; *Acrobasis tumidella* Zinck.; *Hypochalcia ahenella* Hubn.; *Myelois advenella* Zinck.; *Ephestia elutella* Hubn. (Text-fig. 43); *Pempelia palumbella* Fabr. (Text-fig. 44); *Nephopteryx roborella* Zinck.

Sub-family ANERASTIINAE.

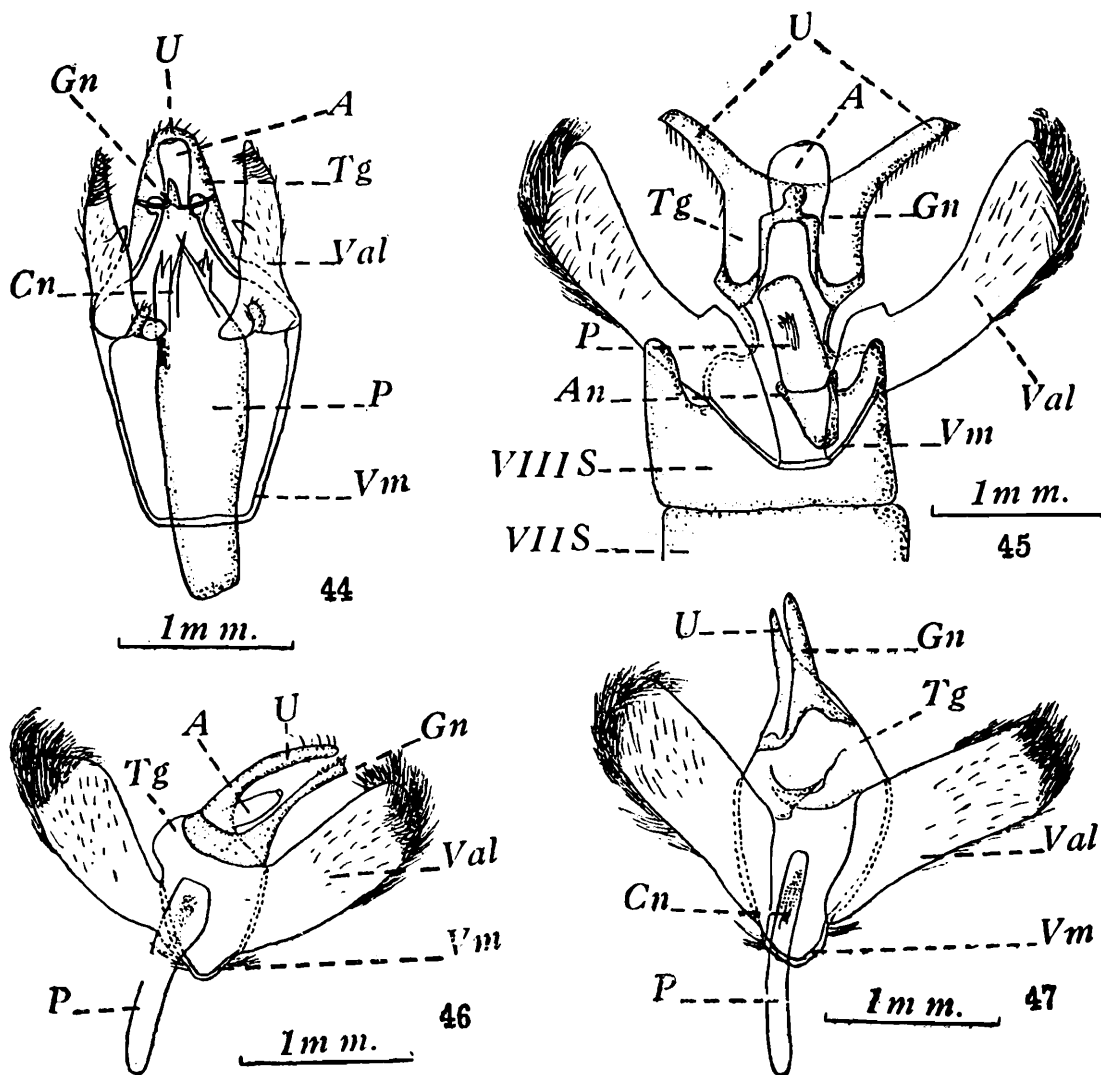
The eighth abdominal sternite in some forms is divided distally into a pair of lobes (e.g., *Alamosa piperatella* Hmps.; *Biafra concinella* Rag.).

Valvae simple and (along with the rest of genital armature) enclosed within the eighth segment.

Tegumen broad. Uncus characterized by pair of lateral horns, except in *Hypsotropha rhodochroella* Hmps.; where two pairs are present.

Gnathos usually disciform and well developed. It may be serrated. Sometimes central disc of gnathos produced into lateral arms (e.g., *Commotria rosella* Hmps.) or bears median knob-like process (e.g., *Biafra concinella* Rag.). Vinculum 'U' or 'V' shaped.

Penis stout with strong cornuti. Anellus distinct.



TEXT-FIG. 44.—*Pempelia palumbella* Fabr.

TEXT-FIG. 45.—*Biafra concinella* Rag.

TEXT-FIG. 46.—*Patissa virginea* Zell.

TEXT-FIG. 47.—*Schoenobius incertellus* Wlk.

Species examined. *Alamosa piperatella* Hmps.; *Biafra concinella* Rag. (Text-fig. 45); *Ematheudes straminella* Snell.; *Commotria rosella* Hmps.; *Saluria macrella* Rag.; *Hypsotropha rhodochroella* Hmps.; *Dembea venulosella* Rag.

Sub-family SCOPARINAE.

Valvae simple, usually short and broad.

Uncus simple and straight. Gnathos well developed. Anal tube lies between the uncus and the gnathos.

Penis short and broad with cornuti at the tip.

Species examined. *Microglossa scoparialis* Warr.; *Alucita pentadactyla* Linn.; *Scoparia crataegella* Linn.

Sub-family SCHOENOBIIINAE.

Valvae simple, short and broad or linear and leaf-like. A pair of hooked processes arise from the costal margin of the valvae (e.g., *Schoenobius incertellus* Wlk.).

Uncus long. Gnathos well developed and sometimes serrated at the tip (e.g., *Patissa virginea* Zell.). Anal tube passes between the uncus and the gnathos. Vinculum 'U' or 'V' shaped.

Penis long with several cornuti, spicule-like (e.g., *Patissa virginea* Zell.), a band of teeth (e.g., *Brihaspa chrysostomus* Zell.), or a few stout spines may also be present.

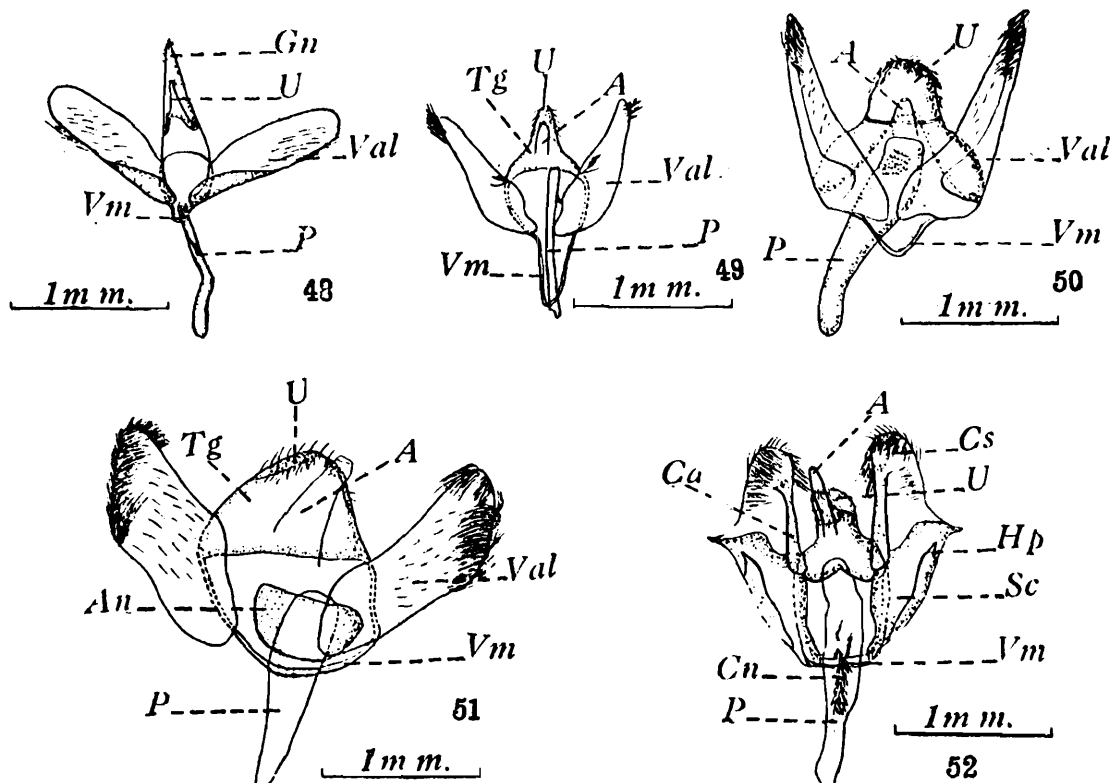
Species examined. *Brihaspa chrysostomus* Zell.; *Patissa virginea* Zell. (Text-fig. 46); *Schoenobius incertellus* Wlk. (Text-fig. 47); *Schoenobius translinealis* Hmps. n.).

Sub-family HYDROCAMPINAE.

Valvae simple, broad.

Uncus conical. Gnathos present or absent. Anal tube passes between the uncus and the gnathos. Vinculum short or elongated and 'V' shaped.

Penis long. Cornuti present.



TEXT-FIG. 48.—*Cataclysta perirrorata* Hmps. n.

TEXT-FIG. 49.—*Diathrausta fulviceps* Hmps. n.

TEXT-FIG. 50.—*Aphomia colonella* Linn.

TEXT-FIG. 51.—*Galleria ceriana* Linn.

TEXT-FIG. 52.—*Eurhypharodes bracteolalis* Zell.

Species examined. *Argyractis* sp.; *Cataclysta perirrorata* Hmps. n. (Text-fig. 48); *Tatobotys biannulalis* Wlk.; *Bradina admixtalalis* Wlk.; *Diathrausta fulviceps* Hmps. n. (Text-fig. 49); *Coptobasis mesopsectralis* Hmps. n.

Sub-family GALLERINAE.

Valvae simple, long or broad.

Tegumen broad with uncus short and hood-shaped (e.g., *Galleria ceriana* Linn.). A transverse fringe of hair characteristically present (e.g., *Aphomia sociella* Linn.; *Aphomia colonella* Linn.). Gnathos absent. Anal tube usually short. Vinculum 'U' or 'V' shaped.

Penis long and stout with several dentate cornuti.

Species examined. *Aphomia sociella* Linn.; *Aphomia colonella* Linn. (Text-fig. 50); *Myelobia smerintha* Hubn.; *Galleria ceriana* Linn. (Text-fig. 51).

Sub-family PYRAUSTINAE.

Valvae belong to two main types:—

- (i) Simple, usually elongated, sometimes short, broad, leaf-like, and with distinct harpe (e.g., *Bocchoris acamasalis* Wlk.; *Samea samealis* Dyar.; *Cnaphalocrocis medianalis* Guen.; *Marasmia venilialis* Wlk.; and others).
- (ii) Valvae with membranous cucullus distinct from the thick-set highly chitinized sacculus. Harpe distinct. A longitudinal ridge of chitin supports the costal margin of the valvae.

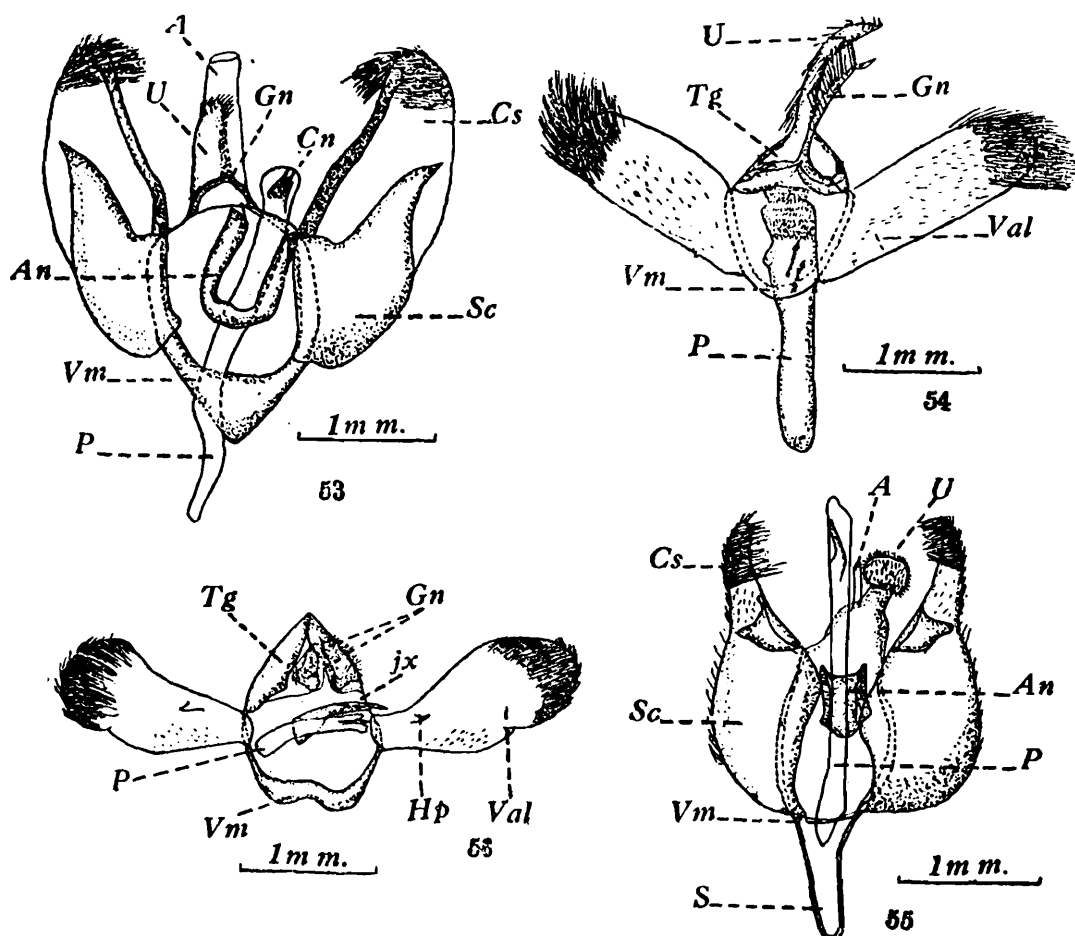
Uncus tall or curved, usually bulbous at the apex (e.g., *Tabidia insanalis* Snell.; *Hymenia Zinckenia perspectalis* Hubn.; *Spilomela perspicata* Fabr.; *Caprinia conchylalis* Guen.; *Pagyda traducalis* Zell.; *Sylepta angustalis* Snell.; and others). Sometimes it is broad (e.g., *Ulopeza latiferalis* Wlk.), diamond-tipped or tongue-shaped, or may be a simple blade without the terminal bulb (e.g., *Crocidolomia binotalis* Zell.; *Uresphita polygonalis* Schiff.). Uncus is bilobed in *Eurrhyarodes bracteolalis* Zell.; and very much reduced in *Noctuelia floralis* Hubn. *Sub-uncus* (Pierce) is sometimes present below the uncus (e.g., *Margaronia euryzonalis* Hmps.).

Anal tube projects ventral to the uncus and may be enclosed in a dorsal and ventral piece of chiten. Gnathos present or absent, when present it is free or plastered ventrally to the anal tube. Vinculum 'U' or 'V' shaped—the latter may sometimes be very long. Saccus present only in a few cases.

Penis usually long with a variable number of thick-set cornuti. Anellus lobes present as vertical chitinous bars on either side of penis.

Species examined. *Eurrhyarodes bracteolalis* Zell. (Text-fig. 52); *Tabidia insanalis* Snell.; *Hymenia (Zinckenia) perspectalis* Hubn.; *Bocchoris acamasalis* Wlk.; *Samea samealis* Dyar.; *Rhimphalea trogusalis* Wlk.; *Syngamia floridalis* Zell.; *Paraponyx bryophilalis* Hmps. (Text-fig. 53); *Ercta ornatalis* Dup.; *Cnaphalocrocis medinalis* Guen.; *Marasmia venilialis* Wlk.; *Filodes costivitalis* Guen.; *Spilomela perspicata* Fabr.; *Caprinia conchylalis* Guen.; *Pagyda traducalis* Zell.; *Dichocrocis punctiferalis* Guen.; *Phostria obscurata* Moore; *Ulopeza latiferalis* Wlk.; *Tyspanodes linealis* Moore; *Botyodes caldusalis* Wlk.; *Lamprosema niphealis* Wlk.; *Agathodes designalis* Guen.; *Margaronia euryzonalis* Hmps.; *Sylepta angustalis* Snell.; *Terastia meticulousalis* Guen.; *Hyalobathra gripusalis* Wlk.; *Evergestis straminialis* Hubn.

(Text-fig. 54); *Orenia alpestralis* Fabr.; *Ischnurges gratiosalis* Wlk. *Crocidolomia binotalis* Zell.; *Epipagis trisemalis* Dogn.; *Thliptoceras*



TEXT-FIG. 53.—*Paraponyx bryophilalis* Hmps.

TEXT-FIG. 54.—*Evergestis straminealis* Hubn.

TEXT-FIG. 55.—*Sceliodes laisales* Wlk.

TEXT-FIG. 56.—*Noctuelia floralis* Hubn.

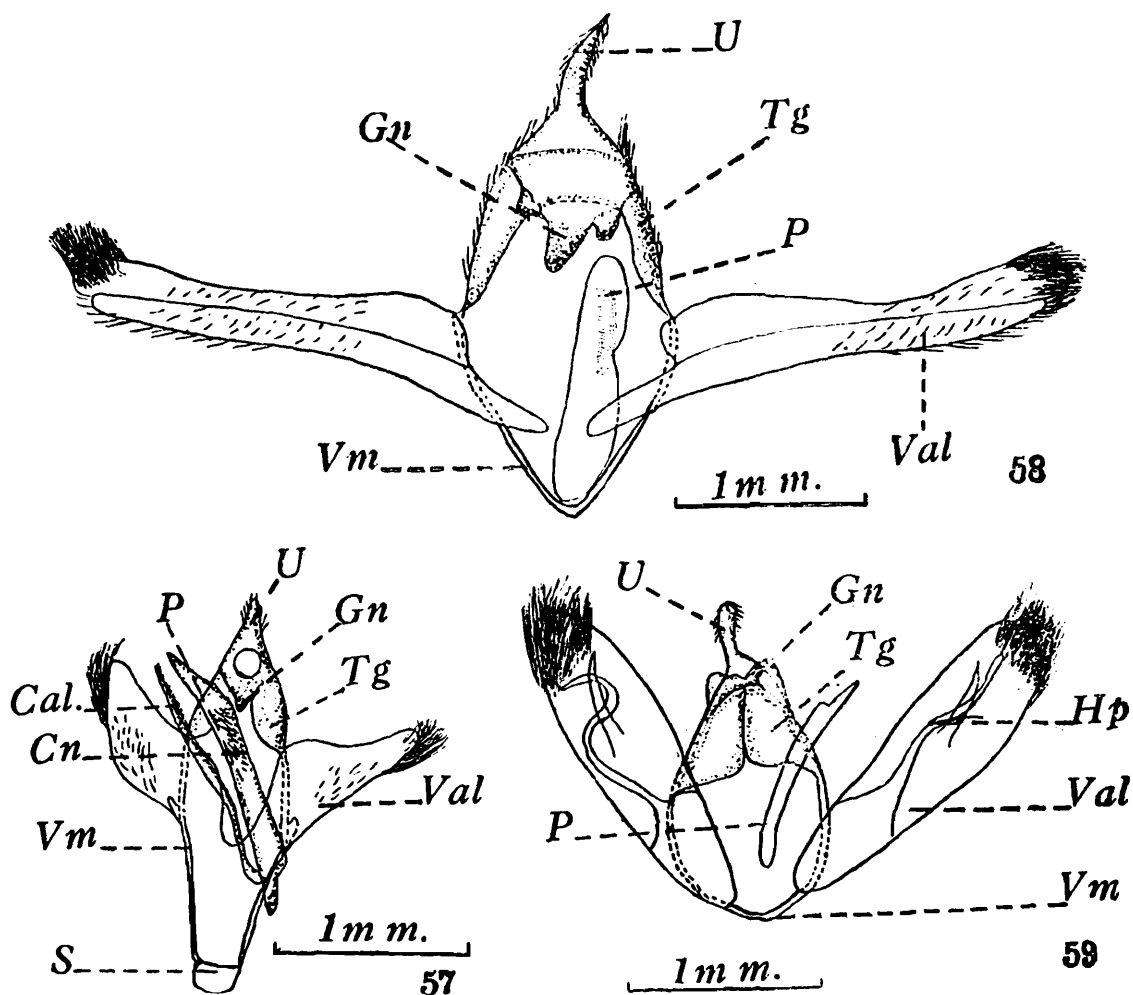
xanthomerallis Hmps.; *Archernis capitalis* Fabr.; *Phylactaenia tyres* Cram.; *Polygrammodes ponderalis* Guen.; *Antigastra catalaunalis* Dup.; *Diasemia accalis* Wlk.; *Uresphita polygonalis* Schiff.; *Condylorrhiza vestigialis* Guen.; *Anarmodia majoralis* Guen.; *Psara pallidalis* Hmps.; *Loxostege mancalis* Led.; *Prooedema inscissalis* Wlk.; *Cybolomia ossealis* Hmps.; *Titanio pollinalis* Schiff.; *Metasia arida* Hmps.; *Tegostoma comparalis* Hubn.; *Sceliodes laisalis* Wlk. (Text-fig. 55); *Noctuelia floralis* Hubn. (Text-fig. 56); *Pyrausta ostrinalis* Hubn.; *Rhodaria sanguinalis* Linn.; *Psamotis lancealis* Schiff.; *Psamotis hyalinalis* Hubn.; *Zebronia phenice* Cram.

Sub-family CRAMBINAE.

Valvae simple, blade-like (e.g., *Diatraea argentisparsalis* Hmps.; *Argyria parallelus* Zell.), or divided (e.g., *Conotalis nigroradius* Mab.; *Ommatopteryx californicalis* Pack.). Sometimes short and broad.

Uncus simple and straight. Gnathos well developed. Anal tube lies between the uncus and the gnathos. Vinculum 'U' or 'V' shaped. Saccus rudimentary or absent.

Penis long with several linear rows of cornuti. These may be spicule-like and well developed.



TEXT-FIG. 57.—*Diatraea argentisparsalis* Hmps.

TEXT-FIG. 58.—*Chilo lativittalis* Wlk.

TEXT-FIG. 59.—*Pterophorus pterodactyla* Hubn.

Species examined. *Ommatopteryx californicalis* Pack.; *Diatraea argentisparsalis* Hmps. (Text-fig. 57); *Prosmixis quercella* Schiff.; *Conotalis nigroradius* Mab.; *Platytes cersella* Schiff.; *Argyria parallelus* Zell.; *Chilo lativittalis* Wlk. (Text-fig. 58).

Family PTEROPHORIDAE.

Valvae simple, with prominent harpe.

Uncus straight. Gnathos reduced. Vinculum 'U' shaped. Saccus absent.

Penis long.

Species examined. *Pterophorus pterodactyla* Hubn. (Text-fig. 59).

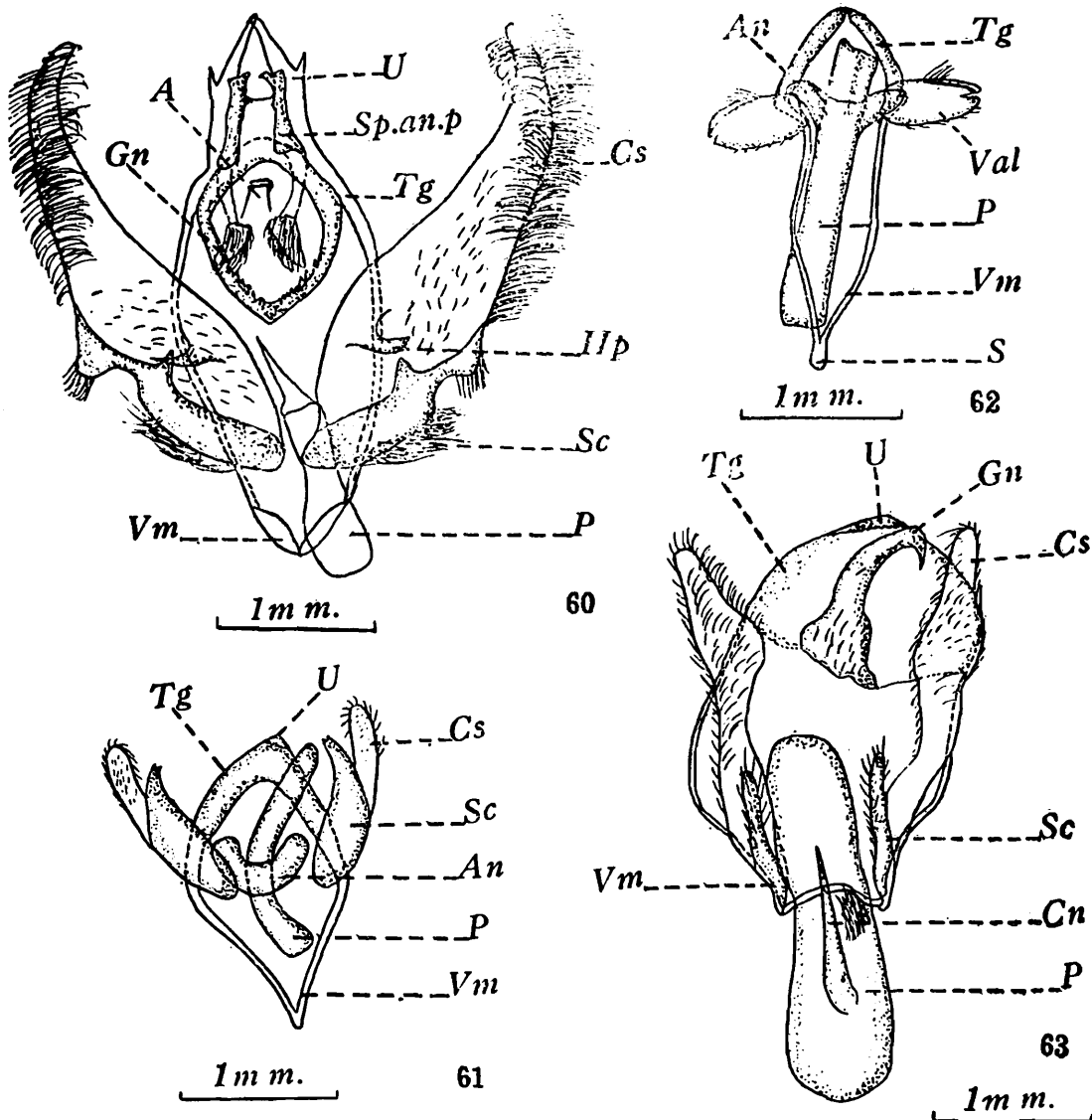
Family THYRIDIDAE.

Valvae simple, long, with or without basal process of the sacculus (Harpe).

Tegumen with large lateral expansions (e.g., *Rhodoneura taeniata* War.). Uncus simple acuminate (e.g., *Rhodoneura taeniata* War.; *Ser-cophora hypoxantha* Hmps.), broad and produced into paired lateral and terminal processes (e.g., *Thyris fenestrella* Scop.; *Brixia myrtea*

Drury.). A supra-anal process ('Scaphium of Gosse'?) arises from the base of the uncus (e.g., *Thyris fenestrella* Scop.). It is paired in *Brixia myrtea* Drury. Gnathos large. Vinculum 'U' or 'V' shaped.

Penis short or long. Cornuti variable. Anellus often well developed.



TEXT-FIG. 60.—*Brixia myrtea* Drury.

TEXT-FIG. 61.—*Pumea comitella* Ld.

TEXT-FIG. 62.—*Amicta tedaldi* Heyl.

TEXT-FIG. 63.—*Megalopyge ornata* Druce.

Species examined. *Thyris fenestrella* Scop., *Rhodoneura taniata* War.; *Sericophora hypoxantha* Hmps.; *Brixia myrtea* Drury. (Text-fig. 60).

Concluding Remarks on the genitalia of Pyralidina.

In the genital armature, this superfamily resembles the Tineina and is probably derived from it. The organs exhibit a common structure though some of the members of this group are very much specialized (e.g., Thyrididae).

The ninth sternite or the vinculum is 'U' or 'V' shaped and saccus is rudimentary or absent. The valvae, except in some of the Pyraustinae and the Crambinae, are simple. The uncus is usually straight or curved.

The gnathos has well developed arms or 'brachia' and often elongated central lip is present. The anal tube passes between the uncus and the gnathos. A supra-anal structure may also be present below the uncus.

The penis is long, armed with several cornuti and supported on a large anellus or juxta.

Superfamily PSYCHINA.

Family PSYCHIDAE.

The seventh abdominal sternite bears a pair of anteriorly directed processes (e.g., *Oreopsyche leschenaulti* Stdgr.).

Valvae usually simple, elongate or broad. Sacculi fused (e.g., *Oreopsyche leschenaulti* Stdgr.), or produced into feer arms which bear small apical spines (e.g., *Fumea comitella* Ld.). The inner mesial surface of the valvae sometimes with an elongated process. Anal margin may be produced into a fold.

Tegumen broad, usually hood-shaped. Uncus also hood-shaped, rudimentary or absent. Vinculum broad and drawn into a long 'V' Saccus distinct and long (e.g., *Oreopsyche leschenaulti* Stdgr.).

Penis usually long, arcuate (e.g., *Oiketicus kirbyi* Guild.; *Fumea comitella* Ld.). Anellus lobes prominent, long and broad (e.g., *Amicta tedaldi* Heyl.; *Oiketicus kirbyi* Guild.; *Fumea comitella* Ld.).

Species examined. *Fumea comitella* Ld. (Text-fig. 61); *Oreopsyche leschenaulti* Stdgr.; *Amicta tedaldi* Heyl.; (Text-fig. 62); *Oiketicus kirbyi* Guild.

Family ZYGAENIDAE.

Valvae long. Anal margin thickened and produced into an elongate pointed arm.

Tegumen broad. Uncus long, tapered, very much pointed at the tip. Vinculum broad.

Penis stout.

Species examined. *Procris statice* Linn.

Family LACOSOMIDAE (Perophoridae).

The genitalia are very peculiar.

Valvae simple and broad. Transtilla in the form of chitinous plates covered with long thin spines.

Uncus short and coniform. Gnathos with large central lip. Vinculum broad and basally concave.

Penis narrow at the base. Cristae present. Anellus distinct.

Species examined. *Pamea excavata* Wlk.

Family MEGALOPYGIDAE (Lagoidae).

Valvae simple, broad (e.g., *Brachysoma codeti* Aust.), elongate, narrow (e.g., *Megalopyge ornata* Druce.; *Megalopyge tharops* Stoll. *Megalopyge pedacia* Druce). A pair of elongate, lobiform processes

arise from the sacculus and the penis passes between them (e.g., *Megalopyge tharops* Stoll.).

Tegumen broad. Uncus reduced, hood-shaped or absent. Gnathos present with central lip sharply curved. Vinculum 'U' or 'V' shaped.

Penis straight with a prominent, vertical single cornutus. Cluster of cornuti also present (e.g., *Megalopyge ornata* Druce).

Species examined. *Megalopyge ornata* Druce.; (Text-fig. 63); *Megalopyge tharops* Stoll.; *Megalopyge pedacia* Druce.; *Brachysoma* (*Somabrachys* Kirby) *codeti* Aust.

Family LIMACODIDAE.

The eighth abdominal somite encloses the genitalia and is posteriorly extended into terminal lobes (e.g., *Thosea syrtis* Schaus).

Valvae simple, elongate or broad. Sacculus broad sometimes with erect basal processes (e.g., *Setora nitens* Wlk.; *Gavara velutina* Wlk.). Valvae complex (e.g., *Casphalia extranea* Wlk.) with membranous costal region and heavily chitinized anal part. A basal process from the sacculus runs along the inner mesal surface of the valvae. Sacculus with margin sometimes dentate.

Uncus simple, short (e.g., *Macroleptera fuscifusa* Hmps.; *Altha nivea* Wlk.), spinose (e.g., *Thosea syrtis* Schaus), or, long, apex pointed (e.g., *Setora nitens* Wlk.; *Contheyla chara* Swinh.), straight (e.g., *Ceratonema retracta* Wlk.; *Phocoderma ocellata* Moore.). Gnathos present with central lip elongated (e.g., *Macroleptera fuscifusa* Hmps.; *Setora nitens* Wlk.; *Contheyla chara* Swinh.), curved at the base (e.g., *Ceratonema retractata* Wlk.; *Gavara velutina* Wlk.; *Natada quadrata* Wlk.; *Asbolia sericea* Moschler.; *Taeda aetitis* Wallengren.), heavily chitinized (e.g., *Casphalia extranea* Wlk.). Vinculum usually broad or 'U' shaped. Saccus absent.

Penis usually long, stout, sometimes curved (e.g., *Macroleptera fuscifusa* Hmps.; *Taeda aetitis* Wallengren.; *Asbolia sericea* Moschler). Cornuti variable thick-set, saw-like (e.g., *Ceratonema retracta* Wlk.), band of teeth (e.g., *Natada quadrata* Wlk.), linear rows of spines (e.g., *Libine prorsa* Schaus).

Anellus usually present, anellus lobes more than one pair, spinose (e.g., *Asbolia sericea* Moschler), flap-like (e.g., *Casphalia extranea* Wlk.), margin of juxta dentate (e.g., *Phocoderma ocellata* Moore.). Calcar elongate.

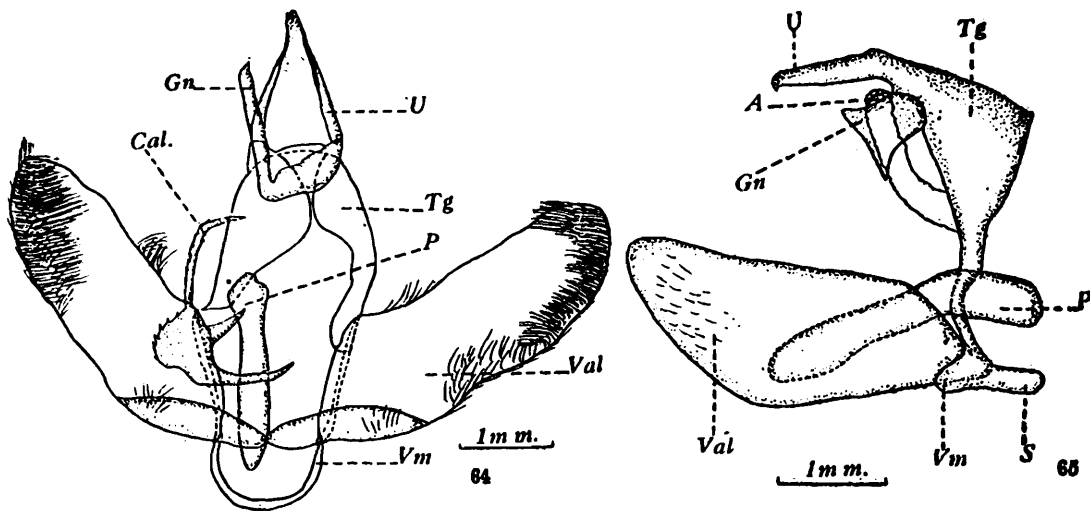
Species examined. *Macroleptera fuscifusa* Hmps.; *Thosea syrtis* Schaus.; *Setora nitens* Wlk.; *Contheyla chara* Swinh.; *Altha nivea* Wlk.; *Ceratonema retractata* Wlk.; *Gavara velutina* Wlk.; *Natada quadrata* Wlk.; *Taeda aetitis* Wallengren.; *Casphalia extranea* Wlk.; *Parasa lepida* Cram.; *Libine prorsa* Schaus.; *Phocoderma ocellata* Moore. (Text-fig. 64); *Somara albicosta* Hmps.; *Asbolia sericea* Moschler.

Family COSSIDAE.

Valvae simple, usually broad.

Tegumen triangular, very much like some of the Papilionina. Uncus long and well developed. Gnathos rarely present. Vinculum 'U' or 'V' shaped. Saccus when present short (e.g., *Givira lasia* Druce).

Penis usually straight sometimes slightly arcuate. Anellus lobes well developed in *Phragmataecia castaneae* Hubn.



TEXT-FIG. 64.—*Phocoderma ocellata* Moore.

TEXT-FIG. 65.—*Givira lasia* Druce.

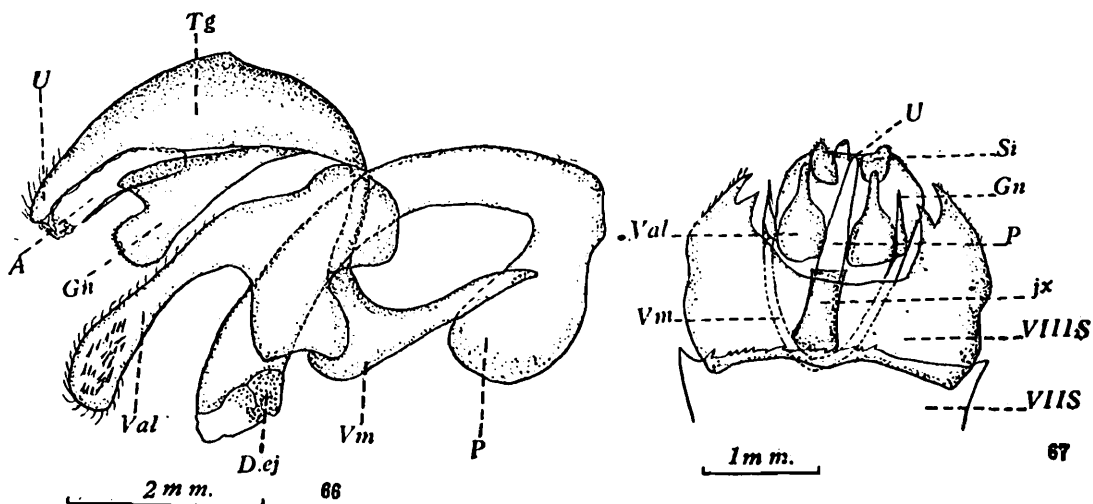
Species examined. *Phragmataecia castaneae* Hubn.; *Givira lasia* Druce (Text-fig. 65); *Xyleutis kilimandjarensis* Auriv.; *Azygophleps albobittata* B-Baker.

FAMILY CASTNIIDÆ.

The genitalia are heavily chitinized.

Valvae simple. Cucullus narrow, apex spinose. Sacculus broad.

Tegumen as viewed from the side is somewhat triangular as in the Papilionina. Hind margin concave. Uncus long and pointed at the tip. Gnathos well developed with margin minutely dentate. Vinculum with a short saccus.



TEXT-FIG. 66.—*Castnia eudesmia* Gray.

TEXT-FIG. 67.—*Malacosoma neustria* Linn.

Penis long, curved and swollen at the base.

Species examined. *Castnia eudesmia* Gray (Text-fig. 66).

Concluding remarks on the genitalia of Psychina.

This group has retained some of the primitive features. The vinculum is elongate, broad, 'U' or 'V' shaped and sometimes develops a long saccus (e.g., Psychidae). The valvae are simple or divided. The tegumen is sometimes hood-shaped with a reduced uncus (e.g., Psychidae) but in other families it is large and tapers to a point. The gnathos is usually large except in the Psychidae and Zygaenidae in which it is wanting. The penis is often long and stout with anellus lobes and juxta well developed.

Superfamily LASIOCAMPINA.

Family LASIOCAMPIDAE.

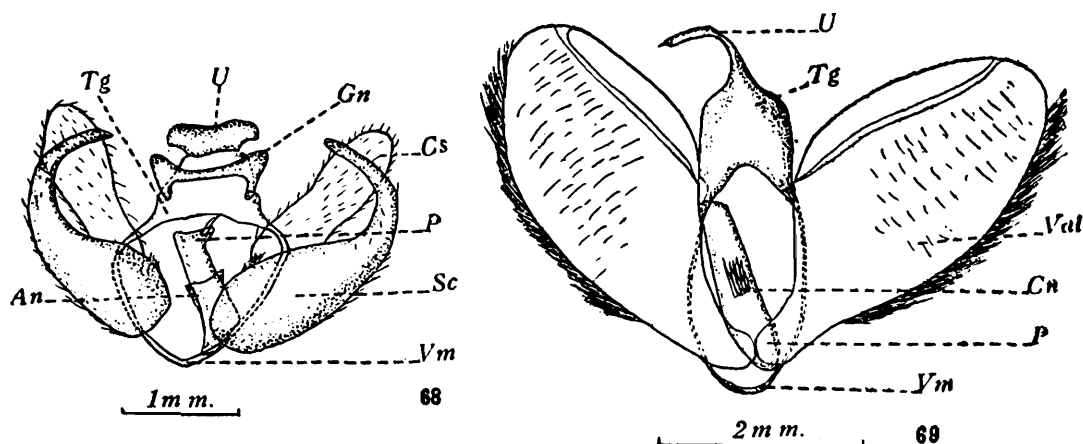
The eighth abdominal sternite medially cleft and produced into a pair of curved processes (e.g., *Cosmotricha potatoria* Linn.; *Malacosoma neustria* Linn.), or elongated median process, heavily chitinized and bifurcate at the tip (e.g., *Odonestis pruni* Linn.).

Valvae short, broad. Sometimes with inner lobiform process (e.g., *Chondrostega powelli* Oberth.), or much reduced, thick-set, heavily chitinized, margin serrate (e.g., *Dendrolimus pini* Linn.). Cucullus membranous, saccus sharply curved (e.g., *Trichiura crataegi* Linn.).

Tegumen broad with small terminal lobes (*Epicnaptera ilicifolia* Linn.; *Malacosoma neustria* Linn.; *Dendrolimus pini* Linn.). Uncus reduced, hood-shaped sometimes broad, tubular (e.g., *Chondrostega powelli* Oberth.), or disciform and heavily chitinized (e.g., *Trichiura crataegi* Linn.). Socii present, lobiform (e.g., *Anchirithra insignis* Butl.), usually absent. Gnathos often with free curved arms except in *Trichiura crataegi* Linn.; where it is heavily chitinized and disciform. Vinculum broad. Saccus absent.

Penis long, curved or short and straight. Cornuti present or absent. Anellus distinct.

Species examined. *Cosmotricha potatoria* Linn.; *Chondrostega powelli* Oberth.; *Dendrolimus pini* Linn.; *Borocera madagascariensis* Boisd.; *Anchirithra insignis* Butl.; *Malacosoma neustria* Linn. (Text-fig. 67);

TEXT-FIG. 68.—*Trichiura crataegi* Linn.TEXT-FIG. 69.—*Cleosiris erycinoides* Wlk.

Trichiura crataegi Linn. (Text-fig. 68); *Odonestis pruni* Linn.; *Chrysopsuche imparilis* Auriv.; *Dipluriella loti* Ramb.; *Lasiocampa quercus*

Linn. ; *Poecilocampa populi* Linn. ; *Olyra reducta* Wlk. ; *Trabalu vishnu* Lef. ; *Epicnaptera ilicifolia* Linn.

Family ENDROMIDAE.

Valvae broad, heavily chitinized.

Uncus shaped like a beak. Gnathos present. Vinculum round.

Penis short and stumpy. Anellus distinct.

Species examined. *Endromis versicolor* Linn.

Family CALLIDULIDAE.

Pencils of hair present. Valvae simple and broad.

Uncus long, curved and pointed at the tip. Vinculum 'U' shaped.

Penis straight. Cornuti present.

Species examined. *Tyndaris erycinata* Wlk. ; *Cleosiris erycinoides* Wlk. (Text-fig. 69).

Family DREPANIDAE.

Valvae short and broad (e.g., *Drepana falcataria* Linn.), or narrow long and with terminal process (e.g., *Rondotia lineata* Leech.).

Uncus elongate, well developed. Bifurcate with long arms (e.g., *Cilix glaucata* Scop.), or reduced (e.g., *Rondotia lineata* Leech.). Socii present, lobiform. Gnathos distinct with broad heavily scobinated central lip (e.g., *Drepana falcataria* Linn.), or long free arms (e.g., *Cilix glaucata* Scop.). Vinculum 'U' shaped, sometimes a short saccus present (e.g., *Cilix glaucata* Scop. ; *Rondotia lineata* Leech.).

Penis short and stumpy or long and slightly arcuate. Anellus lobes often well developed.

Species examined. *Drepana falcataria* Linn. ; *Cilix glaucata* Scop. ; *Rondotia lineata* Leech.

Concluding remarks on the genitalia of Lasiocampina.

The family Lasiocampidae in this group sometimes shows a peculiar development of the eighth sternite. The ninth sternite is a 'U' shaped chitinous band and saccus is rarely present. The valvae are short and broad except in some of the Lasiocampidae (e.g., *Chondrostega powelli* Oberth ; *Trichiura crataegi* Linn.), in which the distinction into sacculus and cucullus portions is maintained. The tegumen develops small terminal lobes, the uncus in such cases being reduced or hood-shaped (e.g., Lasiocampidae). The gnathos may be with free arms or fused into a prominent central lip. The penis is usually long, armed with cornuti and supported by the anellus or juxta.

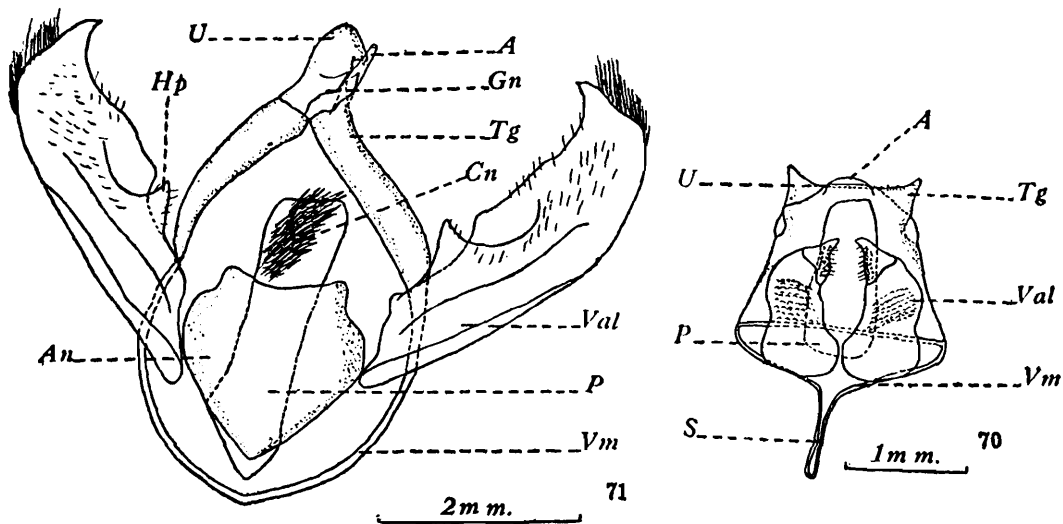
Superfamily NOTODONTINA.

Family EUPTEROTIDAE.

Valvae simple, broad and reduced, apex usually narrow and acuminate, sometimes scobinated (e.g., *Nisaga simplex* Wlk.), or emarginate with a depression on the anal margin (e.g., *Phiala marshalli* Auriv.).

Tegumen usually broad with pair of short lateral processes which may be reduced to peg-like projections. Uncus reduced, hood-shaped. Vinculum broad. Saccus long.

Penis short. Cornuti when present represented by small denticles.



TEXT-FIG. 70.—*Nisaga simplex* Wlk.

TEXT-FIG. 71.—*Notodonta carmelita* Esp.

Species examined. *Tagora postica* Wlk. ; *Eupterote flavicollis* Guerin ; *Nisaga simplex* Wlk. (Text-fig. 70) ; *Phiala marshalli* Auriv. ; *Sangatissa subcurvifera* Wlk.

Family NOTODONTIDAE.

The genitalia are usually enveloped within the eighth abdominal somite.

Valvae long with clavate arm on the costal margin (e.g., *Stauropus pallidifascia* Hmps.). Apex pointed. Harpe large (e.g., *Notodonta carmelita* Esp.).

Tegumen broad. Uncus long or short and pointed at the tip, sometimes divided (e.g., *Pterostoma palpina* Linn.). Gnathos well developed often with arms free distally (e.g., *Notodonta carmelita* Esp.). Vinculum 'U' or 'V' shaped. Saccus absent.

Penis usually long, broad at the base or slightly arcuate on the apex (e.g., *Stauropus pallidifascia* Hmps.). It may be short and stout with numerous spines (e.g., *Notodonta carmelita* Esp.). Anellus broad.

Species examined. *Stauropus pallidifascia* Hmps. ; *Nystalea ebalea* Cram. ; *Notodonta carmelita* Esp. (Text-fig. 71) ; *Pterostoma palpina* Linn.

Family BOMBYCIDAE.

Valvae comparatively short, or long and narrow. Sacculi broad, fused or free. Apex usually narrow, acuminate or curved.

Tegumen elongated. Uncus stout and divided. Gnathos usually well developed, curved (e.g., *Bombyx mori* Linn.). Vinculum broad sometimes shaped into a long 'U'

Penis long and straight or slightly arcuate. Anellus lobes often large e.g., *Bombyx mori* Linn.).

Species examined. *Bombyx mori* Linn. (Text-fig. 72); *Trilocha varians* Wlk.

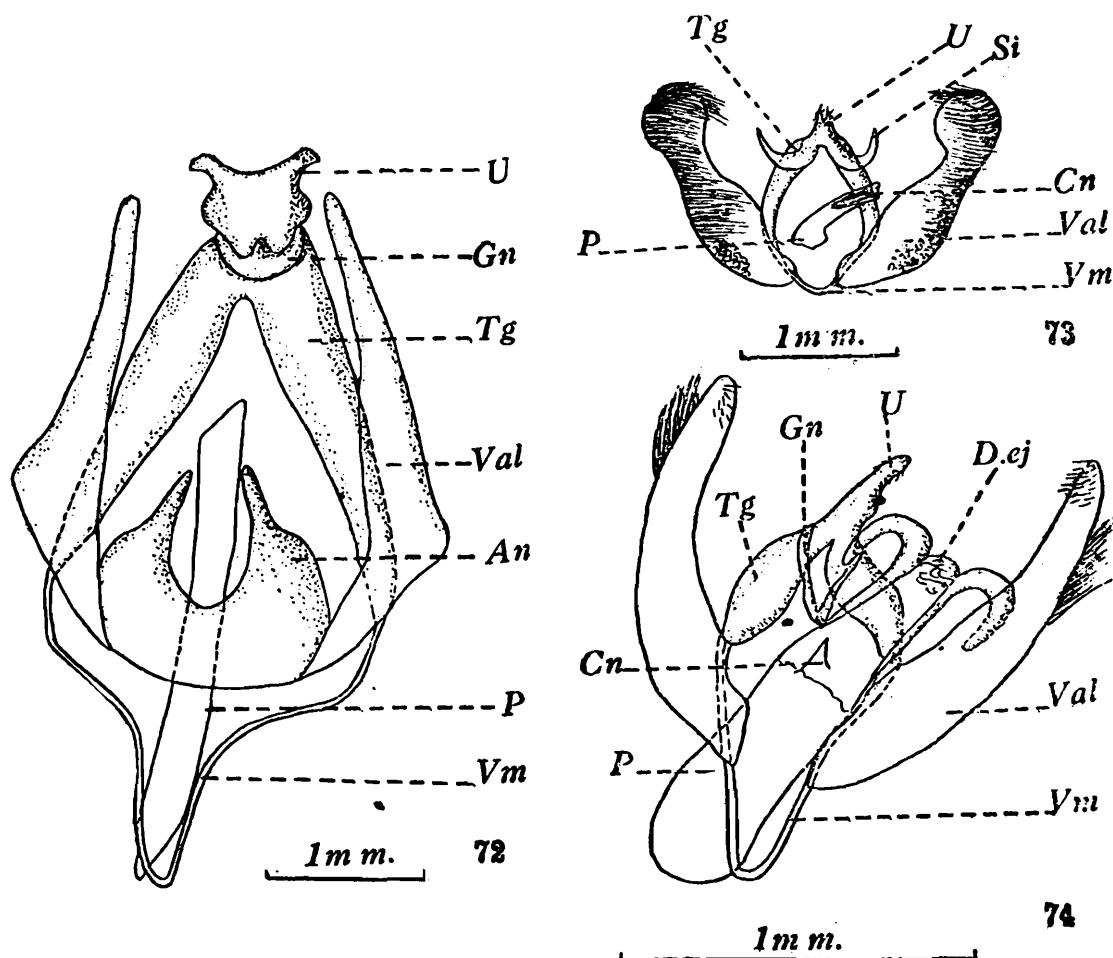
Family SELIDOSEMIDAE.

Valvae simple and long.

Tegumen broad. Uncus distinctly bifid. Socii curved. Vinculum broadly 'V' shaped.

Penis short. Cornuti present.

Species examined. *Selenia bilunaria* Esp. (Text-fig. 73).



TEXT-FIG. 72.—*Bombyx mori* Linn.

TEXT-FIG. 73.—*Selenia bilunaria* Esp.

TEXT-FIG. 74.—*Eois circuitaria* Hubn.

Family STERRHIDAE.

Valvae simple and long.

Tegumen with straight uncus. Gnathos large. Vinculum 'V' shaped.

Penis long and stout with curved heavily chitinized terminal processes. Vesica distinct.

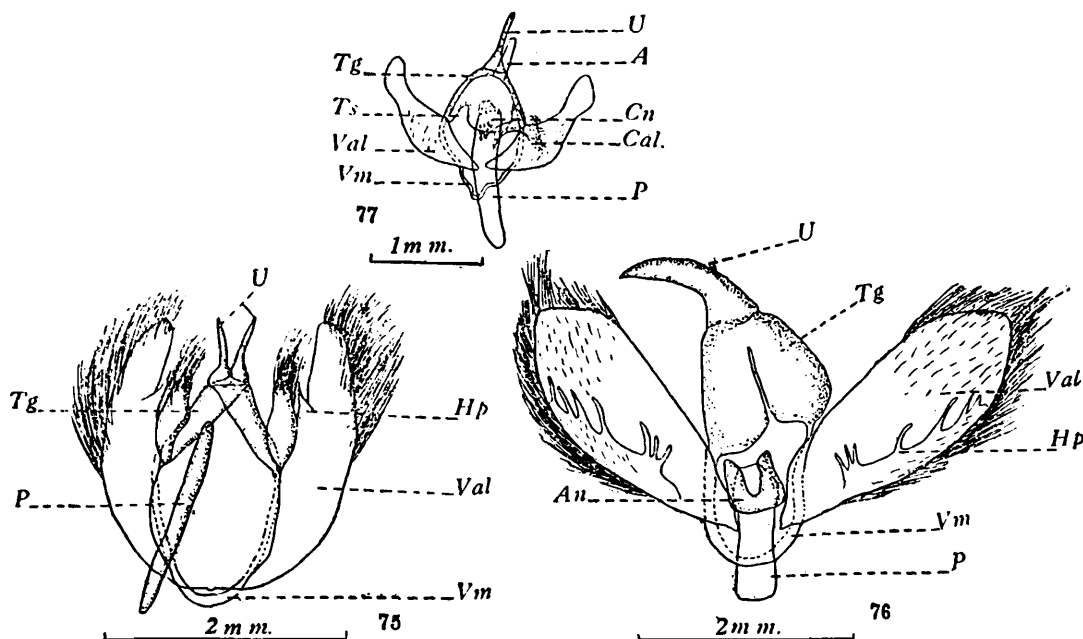
Species examined. *Eois circuitaria* Hubn. (Text-fig. 74).

Family URANIADAE.

Valvae large, usually broad. Costal margin often sinuate and produced into hairy lobe. (e.g., *Chrisiridia rhipheus* Drury). Anal fold sometimes produced into several (eight) finger-like processes (e.g., *Sematura lunus* Linn.). Harpe often present, hooked (e.g., *Acropteris parvidentata* Warr.).

Uncus usually long, tapered. Apex acuminate, sometimes bifid (e.g., *Acropteris parvidentata* Warr.; *Epicopia hainesi* Holl.). Vinculum 'U' shaped. Saccus when present usually short (e.g., *Urania leilus* Linn.)

Penis long, arcuate and stout. Cornuti often well developed.



TEXT-FIG. 75.—*Acropteris parvidentata* Warr.

TEXT-FIG. 76.—*Sematura lunus* Linn.

TEXT-FIG. 77.—*Xanthorhoe fluctuata* Linn.

Species examined. *Acropteris parvidentata* Warr. (Text-fig. 75); *Urania leilus* Linn.; *Sematura lunus* Linn. (Text-fig. 76); *Erosia birostrata* Guen.; *Chrisiridia rhiphens* Drury.; *Epicopia hainesi* Holl.; *Urania fulgens* Wlk.; *Lyssidia achillari* Hubn.; *Alcidis aruns* Feld.

Family GEOMETRIDAE.

The male genitalia in this family are characterized by the presence or absence of gnathos. Pierce (1914) found it convenient to divide the family into Agnathoi and Gnathoi according to the presence or absence of this organ. I have adopted his arrangement which is reproduced below.

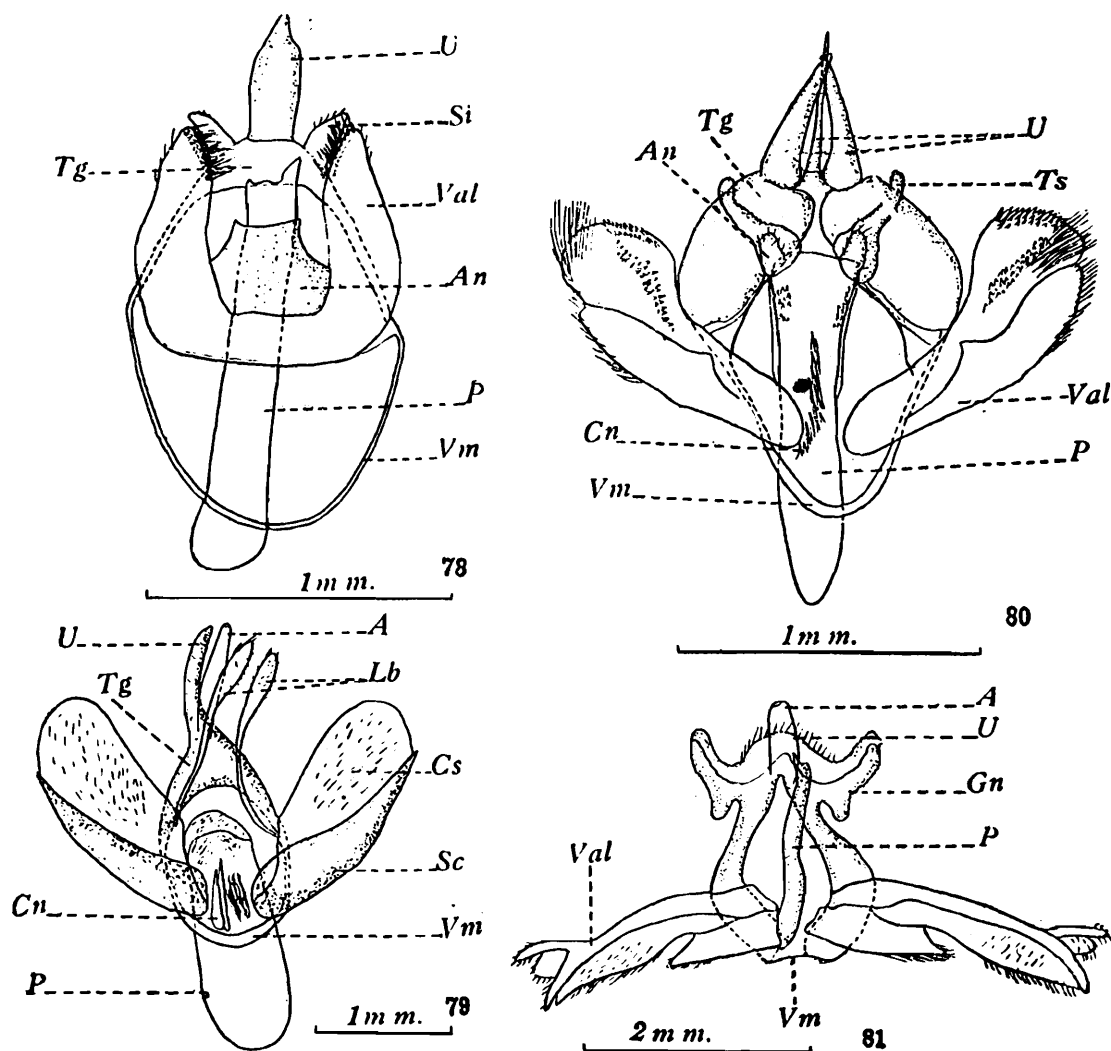
Agnathoi.

The eighth sternite broad and produced into long curved lateral arms or the "Rami" (Poljanec, 1902) (e.g., *Leptomeris imitaria* Hubn.).

Valvae apically emarginate, with single or more processes (e.g., *Leptomeris imitaria* Hubn.; *Euphanessa mendica* Wlk.; *Cosmorhoe subangulata* Koll.; *Alsophila aescularia* Schiff.). Harpe well developed (e.g., *Alsophila aescularia* Schiff.; *Sarcinodes debitoria* Wlk.; *Aspilates virgata* Rott.; *Hypenophora perlimbata* Guen.). Saccus produced into a fold along the anal margin (e.g., *Acidalia dubiosata* Wlk.; *Collix hyperythras* Hmps.). Costal margin sometimes thickened, highly spinose. Transtilla raised, hairy (e.g., *Xanthorhoe fluctuata* Linn.), or lobed with margin dentate (e.g., *Cataclysmine bilineata* Linn.; *Pelurga comitota* Schiff.; *Larentia limitata* Scop.), or produced into curved

dentate arms (e.g., *Aspilates virgata* Rott.). In *Heterusia quadriplicaria* Hubn.; Valvae are broad, costal margin minutely serrate and the cucullus bears a brush of sensory hairs with curious terminal papillae. Labides long and erect (e.g., *Eulype hastata* Linn.; *Poilocambogia pluristrigata* Moore).

Tegumen usually broad. Uncus long and tapered or short and coniform and sometimes spatulate (e.g., *Acidalia dubiosata* Wlk.). In *Leptomeris imitatoria* Hubn.; the tegumen is sometimes rounded on the apex and the uncus is divided into lateral processes or lobes. In *Aspilates virgata* Moore., the uncus consists of paired lateral lobes and an elongated median arm. Uncus may be reduced (e.g., *Collix hyperythras* Hampsn.). Socii present (e.g., *Tanaorhinus vittata* Moore.; *Sauris hirudinata* Guen.; *Lythia purpuraria* Linn.). Vinculum 'U' or 'V' shaped. Saccus absent except in *Calostigia aptata* Hubn.; in which the vinculum is basally involuted and a median saccus is present.



TEXT-FIG. 78.—*Rhodometra sacraria* Linn.

TEXT-FIG. 79.—*Eulype hastata* Linn.

TEXT-FIG. 80.—*Aspilates virgata* Rott.

TEXT-FIG. 81.—*Calothysanis amata* Linn.

Penis usually long, curved (e.g., *Traminda obversata* Wlk.), sometimes straight or stout with terminal cluster of thick-set long spines. Anellus lobes invariably present often long and broad, or fused to form a long arm—the "Calcar" (e.g., *Xanthorhoe fluctuata* Linn.; *Mesoleuca ruficillata* Guen.; *Cataclysme bilineata* Linn.).

Species examined. *Cosmorhoe subangulata* Koll.; *Alsophila aescularia* Schiff.; *Sarcinodes debitaria* Wlk.; *Tanaorhinus vittata* Moore.; *Leptomeris imitaria* Hubn.; *Organopoda carnearia* Wlk.; *Dindica polyphaenaria* Guen.; *Lygris pyropata* Hubn.; *Xanthorhoe fluctuata* Linn. (Text-fig. 77); *Ephyaxa rosearia* Dbld.; *Calostigia aptata* Hubn.; *Scopula imitaria* Hubn.; *Cleta pygmacaria* Hubn.; *Euphia miata* Linn.; *Emmiltis rubiginata* Hubn.; *Traminda obversata* Wlk.; *Perizoma albulata* Schiff.; *Mesoleuca ruficillata* Guen.; *Cataclysmes bilineata* Linn.; *Euphanessa mendica* Wlk.; *Pelurga comitata* Schiff.; *Sauris hirsutata* Guen.; *Hydrelia sylvata* Schiff.; *Poilocambogia pluristrigata* Moore.; *Rhodomestra sacraria* Linn. (Text-fig. 78); *Lythia purpuraria* Linn.; *Eulype hastata* Linn. (Text-fig. 79); *Heterusia quadriplacaria* Hubn.; *Calostigia molata* Feld.; *Acidalia dubiosata* Wlk.; *Collix hyperythra* Hmps.; *Aspilates virgata* Rott. (Text-fig. 80); *Larentia limitata* Scop.; *Hypenophora perlumbata* Guen.; *Anisogonia carnea* Butl.; *Patelia medardaria* H-Sch.

Gnathoi.

This group, according to Pierce (1914), is marked by the presence of a distinct gnathos.

The eighth abdominal segment sometimes completely encloses the genital armature (e.g., *Oenospila flavifusata* Wlk.). Coremata present in connection with the eighth sternite. (e.g., *Pithecia continua* Wlk.; *Hylemera circumcincta* Prout.).

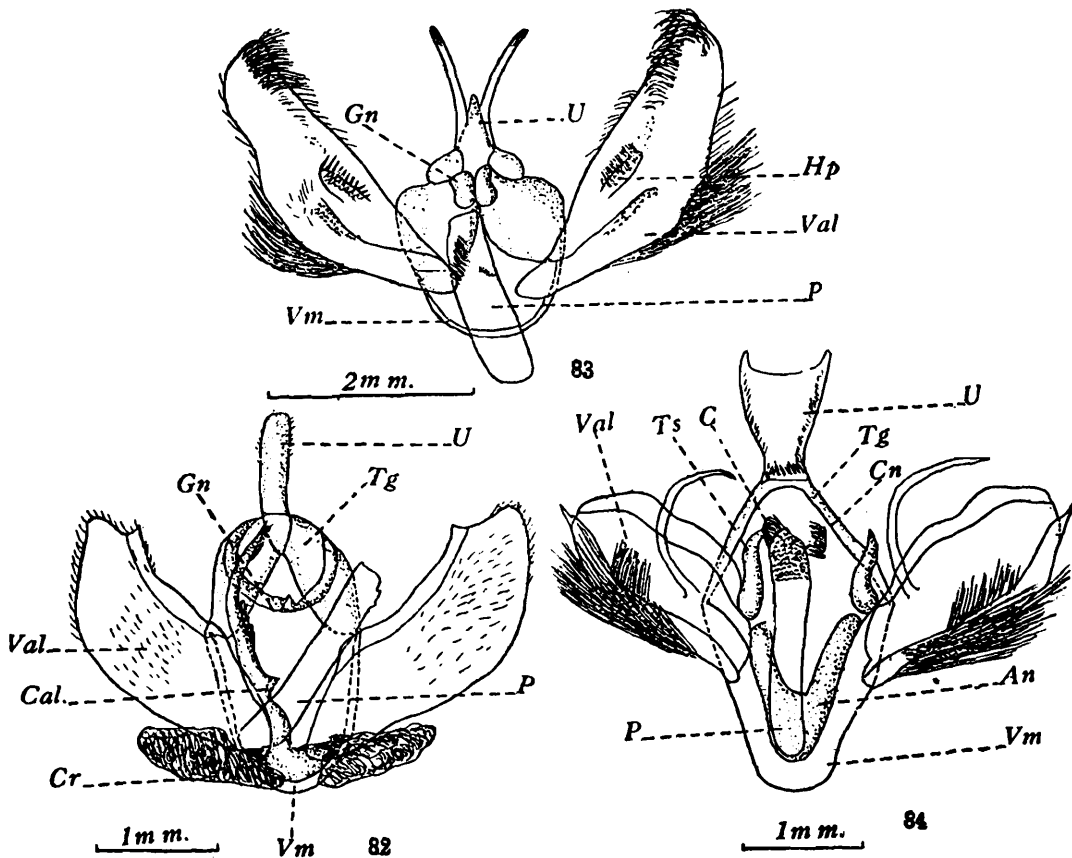
Valvae simple, elongate or broad or slightly curved (e.g., *Cosmostola subtiliaria* Brem.). Valvae sometimes with margin irregular, incised (e.g., *Agathia lyceanaria* Koll.), or produced into long, narrow, finger-like processes or cucullus forked (e.g., *Calothysania amata* Linn.). A chitinous fold runs along the anal margin and terminates in a small process (e.g., *Dilophodes elegans* Butl.; *Nothabraxas irregularis* Prout.; *Cleora leucophaea* Snell.; *Pradarisa comparataria* Wlk.; *Pseudocoremia productata* Wlk.; *Amraica divisaria* Wlk.). Costal margin usually thickened and in many cases heavily spinose. Harpe small or hooked (e.g., *Zerene procellata* Schiff.), or elongate (e.g., *Hirasa scripturaria* Wlk.), rounded or clavate (e.g., *Pseudocoremia productata* Wlk.; *Phigalia pedaria* Fabr.) heavily spined (e.g., *Hemerophila separata* Wlk.). In *Codonia punctata* Stoll., the membranous cucullus is distinct from the sacculus which has a raised prominence on the costal margin. This in turn, bears a curved process.

Uncus may be long and straight, sometimes lobulate (e.g., *Codonia punctata* Stoll.), or tip of the uncus divided and produced into two or three prominences (e.g., *Pradarisa comparataria* Wlk.; *Pseudocoremia productata* Wlk.; *Arachanna ramosa* Wlk.; *Phigalia pedaria* Fabr.; *Cusiala decursaria* Wlk.). It may be small, coniform and pointed (e.g., *Pingasa tephrosiaria* Guen.; *Dilophodes elegans* Butl.). Socci long and lobiform (e.g., *Eretmopus dissita* Wlk.; *Nephodia exularia* Wlk.), or broad and drooping (e.g., *Codonia punctata* Stoll.; *Crocallis tusciaria* Borkh.). Tegumen sometimes produced into terminal arms one on either side of the uncus (e.g., *Cabera punctaria* Linn.; *Hemerophila separata* Wlk.; *Boarmia castaria* Guen.). In *Cosmostola subtiliaria*

Brem., these are long, curved and with peculiar terminal bulbs. Gnathos usually curved and central lip elongated or broad. The arms sometimes form a wide ventral loop and the central lip in such cases remains broad and rounded (e.g., *Hylemera circumcincta* Prout.; *Obeidia gigantearia* Leech.; *Nothabraxas irregularis* Prout.; *Boarmia castaria* Guen.; *Nephodia exularia* Wlk.; *Paradarisa comparataria* Wlk.; *Arachanna ramosa* Wlk.). Gnathos compact rounded lobes (e.g., *Pythea continua* Wlk.; *Hemerophila seperata* Wlk.), entirely reduced (e.g., *Cabera punctaria* Linn.). Vinculum rounded or 'U' shaped.

Penis usually long, straight or short and stout. Cornuti often well developed spines. Anellus lobes distinct and fused to form the calcar (e.g., *Hylemera circumcincta* Prout.; *Pythea continua* Wlk.).

Species examined. *Pingasa tephrosiaria* Guen.; *Petovia dichroaria* H-Sch.; *Agathia lyceanaria* Koll.; *Eretmopus dissita* Wlk.; *Oenospila flavifusata* Wlk.; *Calothyranis amata* Linn. (Text-fig. 81); *Codonia punctata* Stoll.; *Cabera punctaria* Linn.; *Cosmostola subtiliaria* Brem.; *Zerene procellata* Schiff.; *Obeidia gigantearia* Leech.; *Hylemera circum-*



TEXT-FIG. 82.—*Hylemera circumcincta* Prout.

TEXT-FIG. 83.—*Hemerophila seperata* Wlk.

TEXT-FIG. 84.—*Hydriomena sordidata* Fabr.

cincta Prout. (Text-fig. 82); *Dilophodes elegans* Butl.; *Nothabraxas irregularis* Prout.; *Ectropis crepuscularia* Hubn.; *Hemerophila seperata* Wlk. (Text-fig. 83); *Cleora leucophaea* Snell.; *Boarmia castaria* Guen.; *Pythea continua* Wlk.; *Nephodia exularia* Wlk.; *Cingilea catenaria* Cram.; *Leucula ablinearia* Guen.; *Paradarisa comparataria* Wlk.; *Hirasa scripturaria* Wlk.; *Pseudocoremia productata* Wlk.; *Arachanna ramosa* Wlk.; *Percnia ductaria* Wlk.; *Lycia hirtaria* Clerck.; *Phigalia pedaria* Fabr.; *Polla vesulia* Cram.; *Therapsis evonymaria* Schiff.;

Compaea margeritata Linn.; *Amraica divisaria* Wlk.; *Cusiala decursaria* Wlk.; *Crocallis tusciaria* Borkh.

Family HYDRIOMENIDAE.

Valvae simple and broad. Sacculus with long, curved basal process. Transtilla horn-shaped, stout (e.g., *Hydriomena sordidata* Fabr.). Gnathos absent. Vinculum 'U' or 'V' shaped.

Penis with strong cornuti. Anellus distinct.

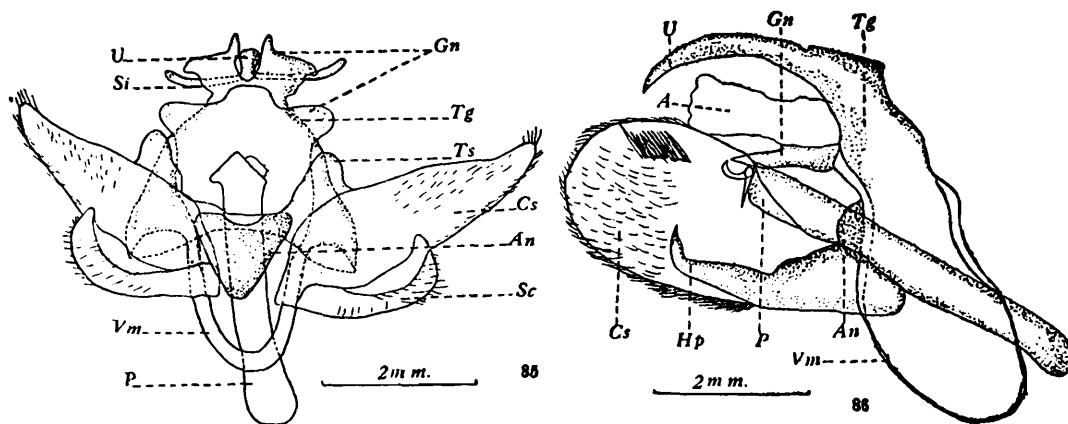
Species examined. *Hydriomena sordidata* Fabr. (Text-fig. 84); *Eucymatoge scabiosata* Borkh.

Family POLYPLOCIDAE.

Valvae simple, elongate or broad. Sacculus broad and slightly angulate (e.g., *Gaurena florens* Wlk.), or sometimes free (e.g., *Polyploca orbicularis* Moore.). Transtilla lobed (e.g., *Polyploca orbicularis* Moore.).

Tegumen broad. Uncus long and short, straight or curved. Socii long, erect or curved (e.g., *Palimpsestis* or Gmelin.). In *Polyploca orbicularis* Moore., the gnathos is a complicated structure and forms a thick chitinous piece with margin produced into three pairs of processes—two lateral and a single distal, median pair. Gnathos sometimes completely wanting (e.g., *Thyatira batis* Linn.; *Gaurena florens* Wlk.; *Palimpsestis* or Gmelin.; *Apha subdives* Wlk.). Vinculum broadly 'U' shaped.

Penis long or broad near the orifice. Anellus prominent. Juxta often well developed plate.



TEXT-FIG. 85.—*Polyploca orbicularis* Moore.

TEXT-FIG. 86.—*Nephele didyma* Fabr.

Species examined. *Thyatira batis* Linn.; *Gaurena florens* Wlk.; *Palimpsestis* or Gmelin.; *Polyploca orbicularis* Moore. (Text-fig. 85); *Apha subdives* Wlk.; *Polyploca flavicornis* Esp.

Family SPHINGIDAE.

Valvae simple, long or broad. Harpe often well developed (e.g., *Temnora iapygoides* Holl.; *Basiothis laticornis* Butl.; *Clerio euphorbiae* Linn.; *Nephele didyma* Fabr.; *Pholus fasciatus* Sulzer.; *Pseudoclanis postica* Wlk.; *Sphinx ligustri* Linn.). Sacculus sometimes with an anal fold which terminates into curved process. Valvae may be thickly

clothed with hair and long spines (e.g., *Nephele didyma* Fabr. ; *Pachylia ficus* Linn.). Apex notched (e.g., *Mimas tiliae* Linn.).

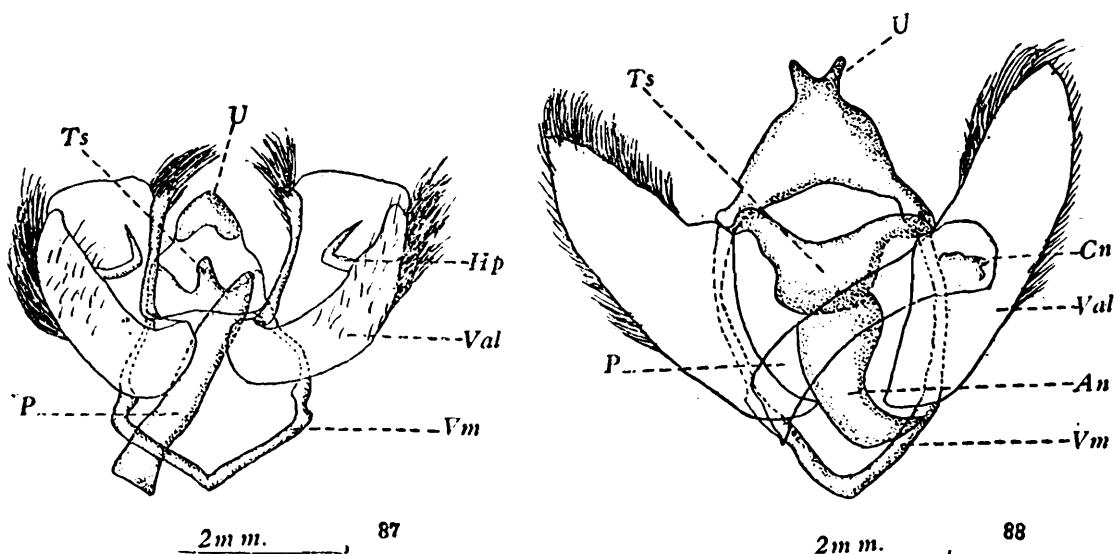
Uncus usually well developed, simple, elongated or short, curved and bifid (e.g., *Hippotion boerhaviae* Fabr. ; *Pseudoclanis postica* Wlk.) the divisions may be long, erect lobiform processes (e.g., *Erinnys ello* Linn. ; *Pachylia ficus* Linn.). Tip of the uncus often acuminate or divided (e.g., *Sphinx ligustri* Linn.). Gnathos large, heavily chitinized, usually long, curved or pointed, sometimes forms a complete ring on base of the uncus (e.g., *Cephonodes hylas* Linn.). The tip often pointed dentate (e.g., *Celerio euphorbiae* Linn.), forked (e.g., *Sphinx ligustri* Linn.). In *Erinnys ello* Linn., and *Pseudosphinx tetrio* Linn. ; the gnathos arms are long and free distally arising from base of the uncus. Anal tube long and lies between the uncus and the gnathos. Vinculum round, 'U' or 'V' shaped. A short saccus present in *Pholus fasciatus* Sulzer. ; *Pachylia ficus* Linn. and *Pseudosphinx tetrio* Linn.

Penis usually very long and narrowed at the orifice. Cornuti variable number of long spines, sometimes short, stout and dentate (e.g., *Temnora iapygoides* Holl.). Juxta often present, elongate or broad. Anellus lobes broad and well developed (e.g., *Cephonodes hylas* Linn.) or fused basally and raised on either side of the penis (e.g., *Pseudosphinx tetrio* Linn. ; *Pseudoclanis postica* Wlk.).

Species examined. *Theretra latreillei* Macleay. ; *Hippotion boerhaviae* Fabr. ; *Macroglossum gyrans* Wlk. ; *Leucostrophus nirundo* Grestaecker ; *Temnora iapygoides* Holl. ; *Basiothia laticornis* Butl. ; *Celerio euphorbiae* Linn. ; *Nephele didyma* Fabr. (Text-fig. 86) ; *Deilephila hypothus* Cram. ; *Epistor lugubris* Linn. ; *Erinnys ello* Linn. ; *Cephonodes hylas* Linn. ; *Mimas tiliae* Linn. ; *Protoparce quinquemaculatus* Haw. ; *Pseudosphinx tetrio* Linn. ; *Pseudoclanis postica* Wlk. ; *Sphinx ligustri* Linn. ; *Pholus fasciatus* Sulzer. ; *Pachylia ficus* Linn.

Family SATURNIDAE.

Eighth segment produced into terminal process (e.g., *Cyrtogone nenia* Westw.).



TEXT-FIG. 87.—*Catocephala nigrosignata* Pholisant,

TEXT-FIG. 88.—*Cricula trifenestrata* Helf,

Valvae usually large, complex and costal margin thickened. Anal margin sometimes flap-like and produced into central process. Valvae sometimes heavily denticulated (e.g., *Urota sinope* Westw.). Harpe often present. Transtilla sometimes large, broad or apically produced.

Uncus usually simple, heavily chitinized sometimes bifid (e.g., *Attacus atlas* Linn.). Vinculum 'U' shaped, saccus often present.

Penis long, straight and thick-set. Anellus conspicuously large and broad or elongate.

Species examined. *Heliconisa pagenstecheri* Gerer.; *Catocephala nigrosignata* Pholisant. (Text-fig. 87); *Urota sinope* Westw.; *Cricula trifenestrata* Helfer. (Text-fig. 88); *Ludia smithi* Holl.; *Cyrtogone nenia* Westw.; *Gonimbrasia nictitatus* Fabr.; *Attacus atlas* Linn.

Concluding remarks on the genitalia of Notodontina.

The genitalia on the whole are of a specialized character. The ninth sternite is 'U' or 'V' shaped and saccus is short and often absent. The valvae may be simple, short and fused (e.g., Eupterotidae) or emarginate, divided and develop accessory structures such as the harpe, furca, and labides (e.g., Geometridae and Hydriomenidae). A large uncus and gnathos are present, the latter structure usually attains considerable size (e.g., Polyplocidae). The socii may be present. The penis is short or long, heavily chitinized and armed with strong denticles or cornuti. The anellus lobes are prominent or fused to form a large juxta which is sometimes produced into a long arm called the 'calcar' (e.g., Geometridae).

Superfamily NOCTUINA. (Caradrinina).

Family HYPSIDAE.

Valvae usually long, narrow or broad with an apical process (e.g., *Caryatis phileta* Drury.). Saccus often produced into basal process (harpe) and in *Sommeria cribraria* Fabr., it reaches the cucullus.

Tegumen sometimes produced into lateral lobes (e.g., *Sommeria cribraria* Fabr.). Uncus long, straight or curved and pointed at the tip. Vinculum 'U' or 'V' shaped.

Penis usually straight sometimes arcuate (e.g., *Caryatis phileta* Drury.). Juxta, when present, is a large plate.

Species examined. *Sommeria cribraria* Fabr.; *Asota versicolor* Don. (Text-fig. 89); *Amphicallia bellatrix* Dalm.; *Argina syringa* Cram.; *Caryatis phileta* Drury.

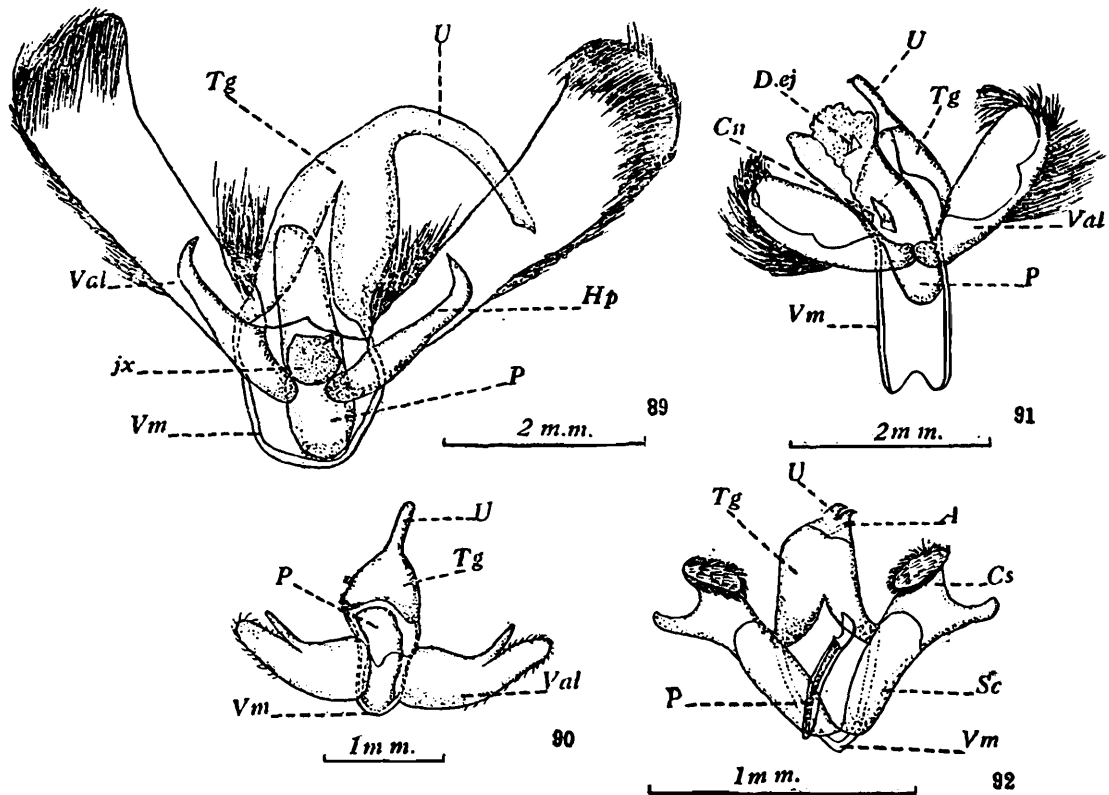
Family OCNERIADAE (Lymantridae).

Valvae simple, saccus usually broad and produced into a process on the costal margin (e.g., *Orgyia antiqua* Linn.).

Uncus simple, linear or slightly curved. Vinculum 'U' shaped. Saccus present in *Lymantria dispar* Linn.

Penis short or long, narrowed terminally (e.g., *Lymantria dispar* Linn.).

Species examined. *Orgyia antiqua* Linn. (Text-fig. 90); *Lymantria dispar* Linn.



TEXT-FIG. 89.—*Asota versicolor* Don.

TEXT-FIG. 90.—*Orgyia antiqua* Linn.

TEXT-FIG. 91.—*Lithosia complanata* Costa.

TEXT-FIG. 92.—*Earias fabia* Stoll.

Family ARCTIADAE.

Valvae simple, broad, sometimes produced into short apical process.

Uncus usually simple, straight or shaped like a beak (e.g., *Utetheisa pulchella* Linn.); sometimes bifurcate (e.g., *Secusio mania* Druce.), or with four processes (e.g., *Estigmene tenuistrigata* Hmps.). Gnathos absent. Anal tube projects below the uncus. Vinculum 'U' shaped, more or less rounded sometimes long (e.g., *Lithosia complanata* Costa).

Penis usually long with vesica (*D. ej.*) well developed.

Species examined. *Secusio mania* Druce.; *Utetheisa pulchella* Linn.; *Perricallia ricini* Fabr.; *Teracotona submacula* Wlk.; *Estigmene tenuistrigata* Hmps.; *Ilema vagesa* Moore.; *Lithosia complanata* Costa (Text-fig. 91).

Family HYLOPHILIDAE.

Pencils of hair present (e.g., *Hylophila prasinana* Linn.). Valvae simple, broad, apically notched and produced into lateral lobes, inner lobe disciform hairy pad.

Uncus simple, straight or bifid (e.g., *Earias fabia* Stoll.). Vinculum 'V' shaped.

Penis short with a single bulbed cornutus (e.g., *Hylophila prasinana* Linn.).

Species examined. *Hylophila prasinana* Linn.; *Earias fabia* Stoll. (Text-fig. 92).

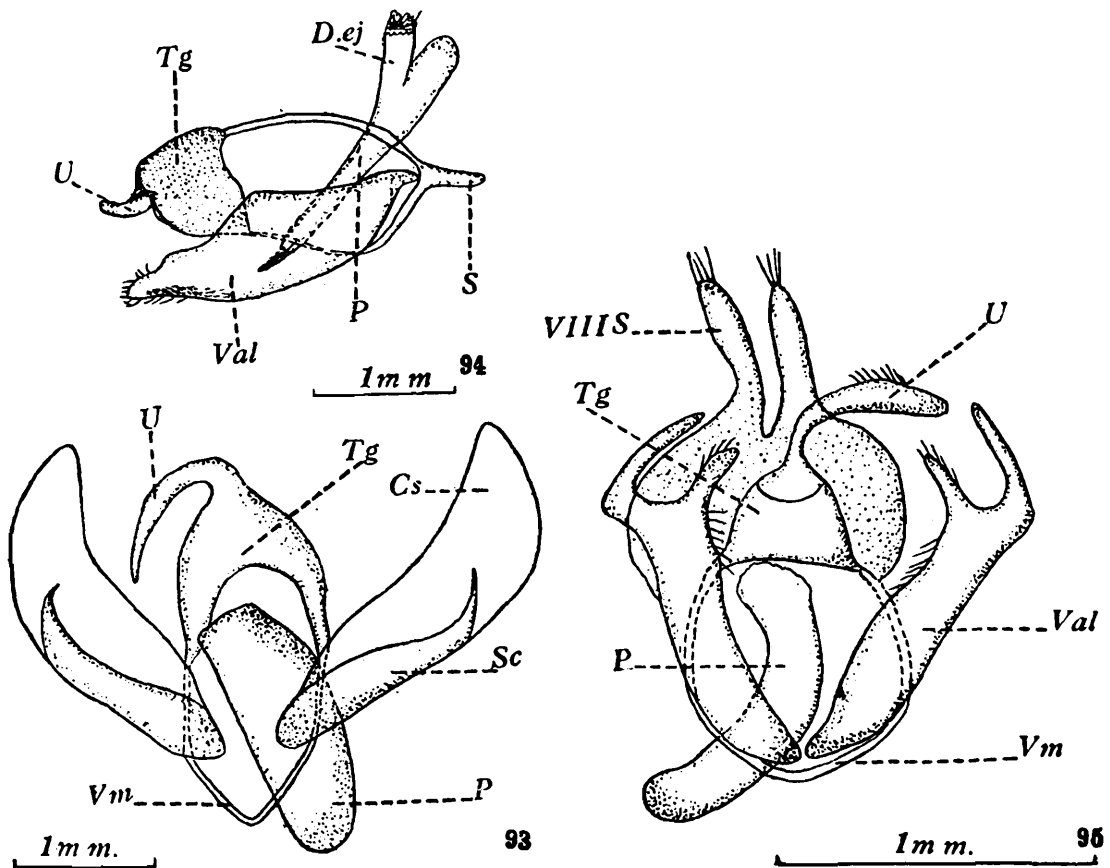
Family AGARISTIDAE.

Valvae simple, broad, often with well developed apically curved harpe arising from base of the sacculus.

Uncus long, tapering and curved, sometimes short. Gnathos absent. Vinculum broadly 'V' shaped.

Penis short or long, vesica sometimes everted. Juxta elongate when present.

Species examined. *Agarista agricola* Donovan.; *Hespagarista rendalli* Roths.; *Tuerta trimeni* Feld.; *Crameria amabilis* Drury.; *Aegocera rectilinea* Boisd. (Text-fig. 93).



TEXT-FIG. 93.—*Aegocera rectilinea* Boisd.

TEXT-FIG. 94.—*Amata cerbera* Linn.

TEXT-FIG. 95.—*Holocryptis melanosticta* Hmps.

Family SYNTOMIDAE (Amatidae).

Valvae usually simple, with an apical scobinated bulb (e.g., *Epitoxis amazoula* Boisd.), lobiform process (e.g., *Amata cerbera* Linn.), or notched and produced into lateral lobes (e.g., *Psychotoe duvauceli* Boisd.).

Tegumen of characteristic shape, often long. Uncus coniform. Vinculum long, broadly 'V' shaped. Saccus sometimes present (e.g., *Amata cerbera* Linn.).

Penis long. Cornuti sharp spines.

Species examined. *Epitoxis amazoula* Boisd.; *Amata cerbera* Linn. (Text-fig. 94); *Psychotoe duvauceli* Boisd.

Family NOCTUIDAE.

Pencils of hair as they are termed by Pierce (1909), or anal brushes (Eltringham, 1925) are found in connection with the eighth or ninth

sternite in many of the Noctuidae. They appear to have no taxonomic value.

The eighth abdominal sternite distally produced into elongate lobi-form processes or rami (e.g., *Holocryptis melanosticta* Hmps.).

The genitalia exhibit considerable variation and are here grouped from the apparently simpler to more complex types.

(i) Valvae simple, short or long, broad or narrow often with marginal spines sometimes apex slightly produced (e.g., *Brachionycha nubeculosa* Esp.; *Cloantha solidaginis* Hubn.; *Ercheia cyllaria* Cram.). Apical margin sinuate (e.g., *Lithocodia vialis* Moore.), or emarginate (e.g., *Holocryptis melanosticta* Hmps.).

Tegumen usually broad. Uncus long, tongue-shaped (e.g., *Azeta versicolor* Fabr.), tapered, straight or curved, cygnate, often with terminal spines (e.g., *Ercheia cyllaria* Cram.; *Cyclodes omma* Van der Hoev.; *Phytometra albostrata* Brem.; *Bendis formularis* Hubn.). Uncus short and broad (e.g., *Othreis materna* Linn.; *Brachionycha nubeculosa* Esp.), or pointed (e.g., *Odontodes aleuca* Guen.), sometimes bulbous—ending with a terminal spine (e.g., *Carea vexilla* Swinh.). Supra-anal process present (e.g., *Maurelia iconice* Wlk.; *Anomis erosa* Hubn.). Vinculum 'U' or 'V'-shaped. Saccus rarely present, long in *Phytometra albostrata* Brem.

Penis short and thick, basally broad (e.g., *Azeta versicolor* Fabr.), long and straight or curved (e.g., *Ommatophora fulvastra* Guen.). Cornuti variable, a single large cornutus present in *Odontodes aleuca* Guen.

Species examined. *Raghuva multiradiata* Hmps.; *Chloridea dipsacea* Linn.; *Adisura atkinsoni* Moore.; *Timora decorata* Moore.; *Brachionycha nubeculosa* Esp.; *Cloantha solidaginis* Hubn.; *Ozarba perplexa* Saalm.; *Lithocodia vialis* Moore.; *Tathothripa continua* Wlk.; *Odontodes aleuca* Guen.; *Carea vexilla* Swinh.; *Enmonodia capensis* H-Schaff.; *Ercheia cyllaria* Cram.; *Cyclodes omma* Van der Hoev.; *Phytometra albostrata* Brem.; *Azeta versicolor* Fabr.; *Othreis materna* Linn.; *Anomis erosa* Hubn.; *Bendis formularis* Hubn.; *Holocryptis melanosticta* Hmps. (Text-fig. 95); *Maurelia iconica* Wlk.; *Ommatophora fulvastra* Guen.

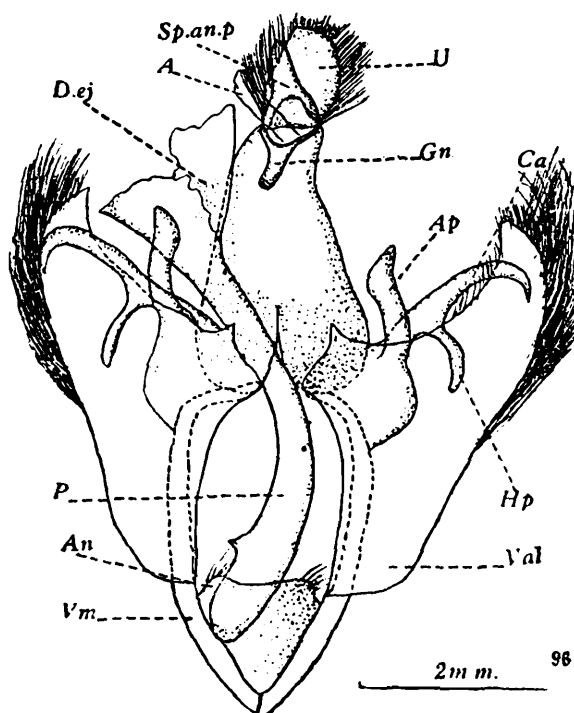
Valvae usually long, cucullus with characteristic apical spines. Saccus sometimes distally emarginate and produced into lateral arms (e.g., *Coenurgia crassiuscula* Haw.). Harpe sometimes small and rudimentary often well developed, curved and arise from base of the saccus and may extend and terminate on the cucullus into hook-shaped process. It may be bifurcate (e.g., *Gonospileia glyphica* Linn.; *Oxyodes scrobiculata* Fabr.). Ampulla of varied form, usually long process. Saccus sometimes develops a fold on the anal margin which often extends almost to the apex (e.g., *Barathra brassicae* Linn.; *Mania maura* Linn.; *Trachea stoliczkae* Feld.; *Erygia apicalis* Guen.).

Tegumen usually broad sometimes develops latero-basal hairy pads, i.e., "Peniculus" of Pierce (1909). Uncus short, broad and bulbous or long usually cygnate, tongue-shaped, diamond-tipped, sometimes disciform (e.g., *Perigea* sp.), or long and sinuate with terminal spines (e.g., *Labanda fasciatus* Wlk.). A supra-anal process arises from base of the uncus (e.g., *Erebus hieroglyphica* Drury.; *Calliodes prattiosissima* Holl.; *Heliophisma klugii* Boisd.; *Isadelphina cheilosema* Hmps.);

Plusiodonta metalensis Wlk.). Gnathos present in *Heliophisma klugii* Boisd. Vinculum 'U' or 'V' shaped. Saccus rudimentary or absent.

Penis short and stumpy (e.g., *Oxicesta geographica* Fabr.), usually long, well developed, basally broad or flask-shaped. Cornuti variable—long spines or small denticles. Anellus broad or rounded. Juxta large cup-shaped and scobinated (e.g., *Eumichtis roboris* Hubn.), or disciform (e.g., *Ancara obliterans* Wlk.).

Species examined. *Rhizogramma comma* Schiff.; *Actinotia radiosa* Esp.; *Euxoa porphricollis* Guen.; *Feltia subgothica* Haw.; *Hermonassa consignata* Wlk.; *Pachnobia carnea* Thumb.; *Agrotis spina* Guen.; *Episilia festiva* Schiff.; *Lycophotia margaritosa* Haw.; *Mythimna rubricosa* Schiff.; *Eurois prasina* Schiff.; *Neurois atrovirens* Wlk.; *Barathra brassicae* Linn.; *Scotogramma trifolii* Rott.; *Polytela gloriosae* Fabr.; *Eriopyga puerilis* Grote.; *Oxicesta geographica* Fabr.; *Cucullia umbratica* Linn.; *Euscotia inextricata* Moore.; *Epunda nigra* Steph.; *Miselia bimaculosa* Linn.; *Psylla celsia* Linn.; *Agriopis aeruginea* Hubn.; *Antitype polymita* Linn.; *Eumichtis roboris* Hubn.; *Polia olivacea* Steph.; *Amathes lota* Clerck.; *Amphipyra tragopogonis* Linn.; *Trachea stoliczkae* Feld.; *Ancara obliterans* Wlk.; *Acronycta psi* Linn.; *Simyra venosa* Borkh.; *Spodoptera mauritia* Boisd.; *Prodenia litura* Fabr.; *Perigea* sp.; *Hydroecia petasitis* Doubl.; *Nonagria despecta* Treits.; *Laphygma exigua* Hubn.; *Proxenus pectinifera* Auriv.; *Eublemma admota* Feld.; *Cerynea thermesialis* Wlk.; *Oruza latifera* Wlk.; *Lophoptera xista* Swinh.; *Chamyris cerintha* Treits.; *Eustrotia erectia* Moore.; *Eulocastra argentifrons* Butl.; *Marathyssa cuneata* Saalm.; *Tarachidia condefacta* Hubn.; *Paectes subapicalis* Wlk.; *Gyrtona proximalis* Wlk.; *Labanda fasciatus* Wlk.; *Corgatha costinotalis* Moore.; *Negeta albigrisea* Hmps.; *Leocyma appolinis* Guen.; *Catocala concubens* Wlk.; *Erebus hieroglyphica* Drury.; *Entomogramma torsa* Guen.; *Calliodes pratiosissima* Holl.; *Speiredonia retorta* Linn.; *Ischyja eyndhovii* Voll.; *Dermaleipa junio* Dalm.; *Anua triphaenoides* Wlk.; *Helophisma*



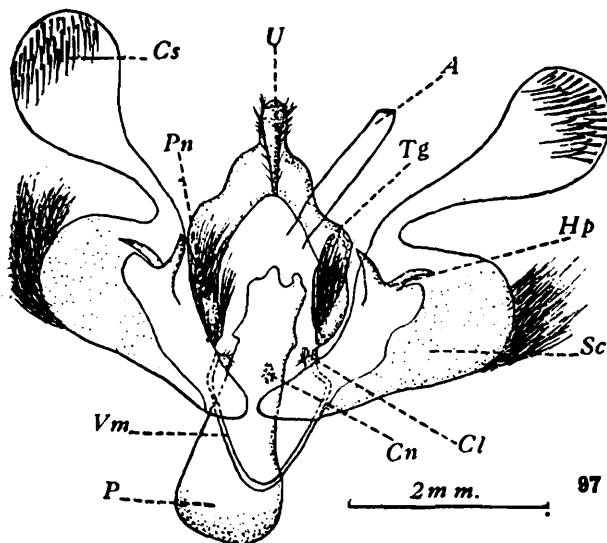
TEXT-F1. —*Helophisma klugii* Boisd.

klugii Boisd. (Text-fig. 96); *Gonospileia glyphica* Linn.; *Coenurgia crassiuscula* Haw.; *Pericyma glaucinans* Guen.; *Erygia apicalis* Guen.; *Polydesma umbricola* Boisd.; *Calophasia hohenwarthi* Hochenw.; *Syngrapha circumflexa* Linn.; *Tathorhynchus exsiccata* Zell.; *Apopestis spectrum* Esp.; *Antophila dilucida* Hubn.; *Athyrra adjutrix* Cram.; *Deinopa aspila* Hmps.; *Baniana culminifera* Hmps.; *Fodina pallula* Guen.; *Isadelphina cheilosoma* Hmps.; *Oxyodes scrobiculata* Fabr.; *Micragrotis puncticostata* Hmps.; *Plusiodonta metalensis* Wlk.

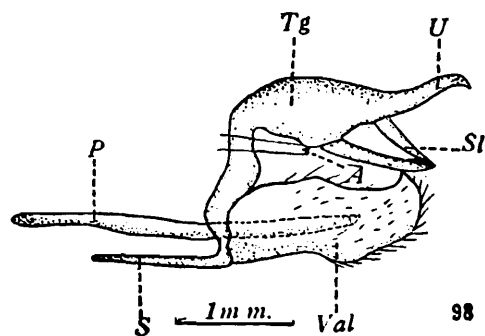
Valvae complex, division into cucullus and saccus almost complete. Anal margin usually notched near the apex so that the cucullus is separated into a trigonate heavily spined corona and a broad saccus. In such cases the cucullus may be 'battledore', 'trigonate', or 'C' shaped. Sometimes reduced and raised on a narrow stalk (e.g., *Leucania pudorina* Schiff.). Saccus sometimes free and produced into a long arm (e.g., *Amyna leucostriga* Hmps.; *Achaea ezea* Cram.; *Bareia* sp.). Harpe well developed, form varied. Ampulla often present. Clavus small, rounded and toothed or large, lobiform (e.g., *Nephelodes emmedonia* Cram.).

Tegumen usually broad, sometimes with large lateral expansions (e.g., *Eremobia ochroleuca* Schiff.; *Miana arcuosa* Haw.). Peniculus well developed in *Lasiplexia chalybeata* Wlk.; and *Amyna leucostriga* Hmps. Uncus long curved, heavily spinose, cygnate or tongue-shaped. Sometimes short broad and drooping (e.g., *Senta albilinea* Hmps.), or spatulate (e.g., *Nephelodes emmedonia* Cram.). Gnathos long, central lip pointed (e.g., *Parallelia proxima* Hmps.; *Achaea ezea* Cram.). Vinculum 'U' or 'V' shaped. Saccus absent.

Penis long and stout or basally broad. Cornuti variable, sometimes rows of several long spines present (e.g., *Borolia amens* Guen.). Juxta often present as an elongate plate.



TEXT-FIG. 97.—*Chabuata conigera* Schiff.



TEXT-FIG. 98.—*Adopaea thaumas* Hubn.

Species examined. *Craterestra media* Wlk.; *Hadena reticulata* Vill.; *Chabuata conigera* Schiff. (Text-fig. 97); *Senta albilinea* Hubn.; *Tri-cochlea albicolon* Sepp.; *Nephelodes emmedonia* Cram.; *Persectania ewingi* Westw.; *Miselia persicariae* Linn.; *Cirphis L-album* Linn.;

Borolia amens Guen.; *Leucania pudorina* Schiff.; *Sideridis lithargyrea* Esp.; *Euplexia lucipara* Linn.; *Miana rufuncula* Haw.; *Eremobia ochroleuca* Schiff.; *Amyna leucostriga* Hmps.; *Lasiplexia chalybeata* Wlk.; *Beara dichromella* Wlk.; *Parallelia proxima* Hmps.; *Achaea exea* Cram.; *Bareia* sp.; *Miana arcuosa* Haw.

Concluding remarks on the genitalia of Noctuidae.

The copulatory organs have attained considerable specialization in this group and this is specially evident in the family Noctuidae. The vinculum is 'U' or 'V' shaped. The valvae are usually very complicated and show a division into distinct cucullus and sacculus. Accessory prehensile structures like the harpe and the ampulla are also borne on them. The tegumen is usually broad and develops a broad peniculus on each side (e.g., Noctuidae). The uncus is prominent structure and assumes variable shape—a character very useful in taxonomy. A gnathos may be present or absent. The penis is usually long and the cornuti may be in the form of long spines or sharp denticles.

Superfamily PAPILIONINA.

Family HESPERIIDAE.

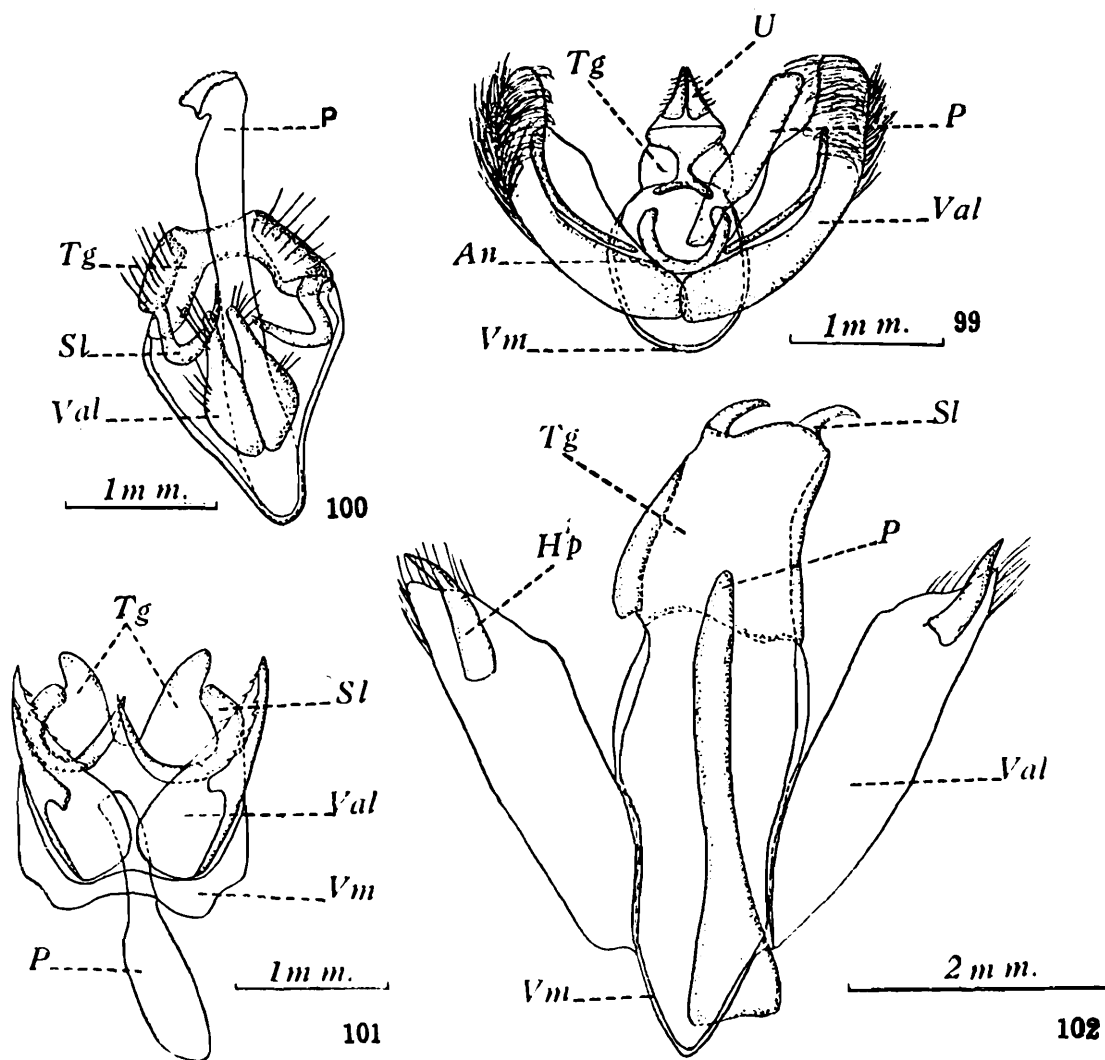
Valvae simple, usually broad (e.g., *Pamphila sylvanoides* Edw. *Pamphila agricola* Bdv.; *Hylephila phyleus* Drury.), costal margin produced into curved, peg-like process, apical margin dentate (e.g., *Catia otho* Sm. & Abbot.).

Valvae complex (e.g., *Hesperia notata* Plotz.) with an inner membranous and outer (anal), more heavily chitinized part. A basally directed process hangs freely from the costal margin. A costal fold sometimes runs along the inner, mesial surface of the valvae ending in spine-like processes near the apex (e.g., *Atalopedes mesogramma* Latr.; *Atrytone melane* Edw.; *Systasea erosus* Hubn.). Tegumen broad, more or less saddle-shaped with pair of terminal lobes which may be small (e.g., *Atalopedes mesogramma* Latr.; *Cogia calchas* Herr-Sch.), or long, erect (e.g., *Atrytone melane* Edw.; *Pamphila sylvanoides* Edw.; *Eudamus proteus* Linn.; *Systasea erosus* Hubn.; *Pamphila agricola* Bdv.; *Hesperia notata* Plotz.). The lobes coalesce into a single, median lobe in *Atalopedes mesogramma* Latr. Sometimes it is long and straight, apparently homologous with the uncus (Gosse) (e.g., *Ceratrachia flava* Murr.; *Thymelicus athenion* Hubn.; *Limochares baracoa* Lucas; *Adopaea christi* Rbl.). Side lobes usually present, long or curved and very prominent. Vinculum 'U' or 'V' shaped. Saccus usually present, very long (e.g., *Adopaea thaumas* Hubn.; *Adopaea christi* Rbl.); absent in *Cogia calchas* Herr-Sch.; *Systasea erosus* Hubn.; *Hesperia notata* Plotz.

Penis long, usually straight with apical cluster of cornuti. Juxta sometimes present. Anellus distinct.

Species examined. *Polites vibex* Hubn.; *Thymelicus vibex* Hubn.; *Ceratrachia flava* Murr.; *Thymelicus athenion* Hubn.; *Pamphila sylvanoides* Edw.; *Pamphila agricola* Bdv.; *Hylephila phyleus* Drury.;

Hesperia Sp.; *Adopaea thaumas* Hubn. (Text-fig. 98); *Limochares boracoa* Lucas.; *Catia otho* Sm. & Abbot.; *Atalopedes mesogramma* Latr.; *Atrytone hobomok* Harr.; *Choranthus radians* Luc.; *Eudamus proteus* Linn.; *Adopaea christi* Rbl.; *Hesperia syrichthus* Fabr.; *Cogia*



TEXT-FIG. 99.—*Hesperia notata* Plotz.

TEXT-FIG. 100.—*Rapala lazulina* Moore.

TEXT-FIG. 101.—*Loxura atymnus* Cram.

TEXT-FIG. 102.—*Parnassius epaphus* Bdv.

calchas Herr-Sch.; *Systasea erosus* Hubn.; *Hesperia notata* Plotz. (Text-fig. 99); *Atrytone melane* Edw.

Family LYCAENIDAE.

The genitalia are withdrawn into the abdomen, and in *Rapala melampus* Cram.; extend as far as the IV abdominal sternite, sometimes deeply notched medially, partly enclosing the genitalia.

Valvae simple, usually broad, costal margin sometimes notched near apex or raised into a prominence. Apical process curved, apical margin dentate in *Lampides boeticus* Linn.; *Zizera lysinion* Hubn.; *Horsfieldia anita* Hew.; *Chrysophanus alciphron* Rott. Valvae sometimes reduced (e.g., *Rapala lazulina* Moore.; *Hypolycaena erylus* Godt.; *Surendra quercetorum* Moore; *Virachola isocrates* Fabr.; *Eumaeus minyas* Hubn.). Sacculii in such cases fused on costal margin, cucullus free, narrow and straight.

Tegumen broad, usually developed into lateral lobes (terminal) by a deep distal convexity. No well defined uncus present. At the base of these lobes, more on latero-ventral line arise paired long, curved spine-like processes called the "Side lobes" (B. White, 1876). These may be homologized with processes similarly situated on the tegumen in Heterocera and called "Socii" (Pierce, 1914). Vinculum 'U' shaped usually broad. Saccus usually absent.

Penis usually long, cornuti present on the orifice. Anellus distinct.

Species examined. *Horsfieldia anita* Hew.; *Rapala melampus* Cram.; *Virachola isocrates* Fabr.; *Chrysophanus alciphron* Rott.; *Thecla pholus* Cram.; *Eumaeus minyas* Hub.; *Chilades trochilus* Frey.; *Lycaena acmon* Westw. & Hew.; *Cupido sagittigera* Fel.; *Uranothauma falkensteini* Dew.; *Tarucus telicanus* Lang.; *Lampides boeticus* Linn.; *Lycaenesthes larydas* Cram.; *Axiocerses harpax* Fabr.; *Zizera lysinion* Hubn.; *Zeltus etolus* Fabr.; *Rapala lazulina* Moore (Text-fig. 100); *Spindasis lohita* Horsf.; *Catochrysops cnejus* Fabr.; *Amblypodia amantes* Hew.; *Hypolycaena erylus* Godt.; *Surendra quercetorum* Moore; *Loxura atymnus* Cram. (Text-fig. 101); *Spindasis ictis* Hew.; *Zesius chrysomallus* Hubn.; *Iraota timoleon* Stoll.

Family PAPILIONIDAE.

Valvae simple, broad or elongated, usually with well developed heavily chitinized harpe.

Tegumen broad, uncus slender, acuminate (e.g., *Papilio demoleus* Linn.), slightly curved (e.g., *Eurycus cressida* Fabr.). A pair of side lobes present in *Parnassius epaphus* Bdv., and *Eurycus cressida* Fabr. Scaphium of Gosse (Supra-anal process) well developed in the Papilionidae, central lip divided (e.g., *Papilio demoleus* Linn.). Vinculum 'U'-shaped.

Penis long and stout. Anellus lobes often present, absent in *Parnassius epaphus* Bdv.

Species examined. *Parnassius epaphus* Bdv. (Text-fig. 102); *Papilio demoleus* Linn.; *Eurycus cressida* Fabr.

Family NYMPHALIDAE.

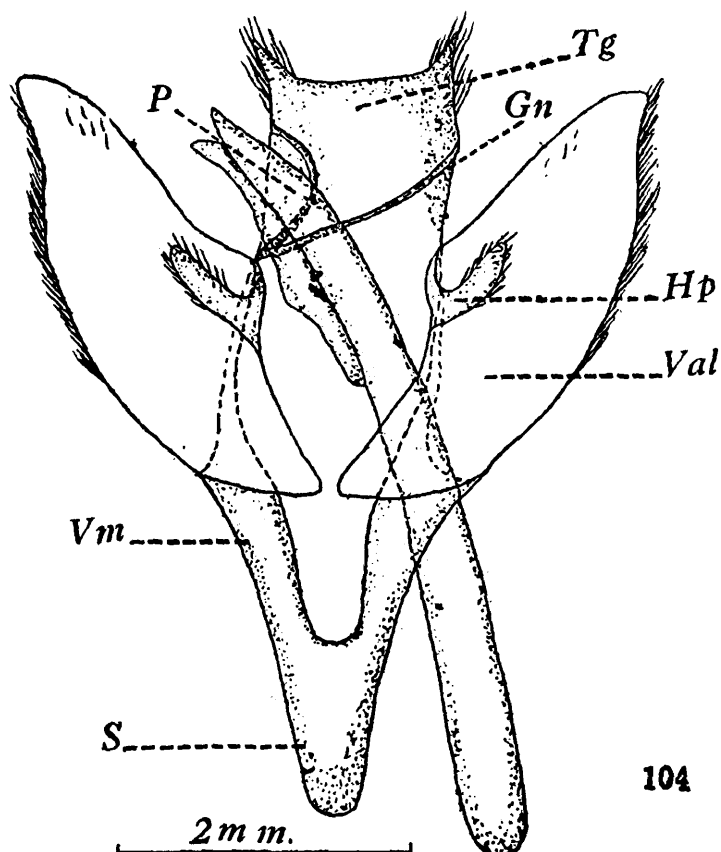
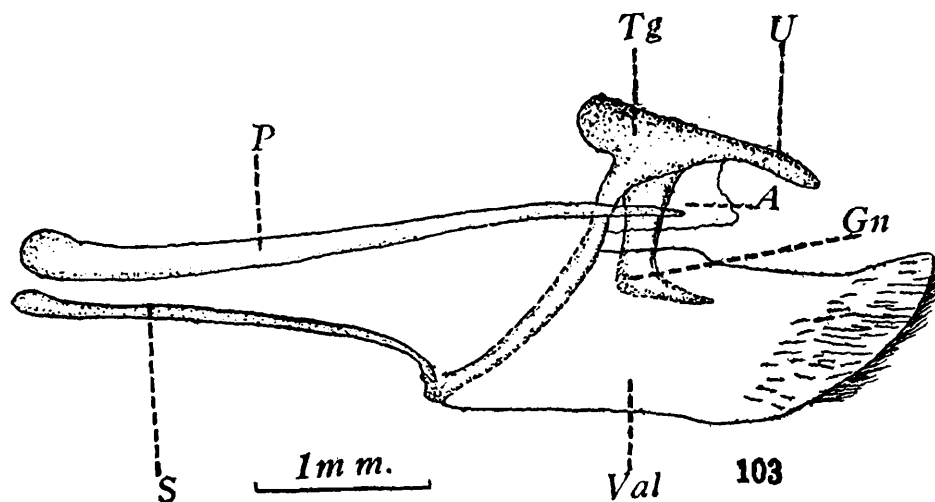
Valvae usually simple, broad and elongate, sometimes with broad sacculus and narrow curved cucullus (e.g., *Symbrenthia niphanda* Moore); Costal margin sinuate in valvae of *Argynnis pales* Schiff.; and produced into tall, curved process in *Cynthia erota* Fabr.; *Cupha erymanthis* Drury. Apex sometimes with lateral and terminal processes (e.g., *Pyrameis cardui* Linn.; *Parhestina persimilis* Westw.; *Araschnia levana* Linn.). Harpe often well developed (e.g., *Antanartia hippomene* Hubn.), club-shaped (e.g., *Callinaga lhatso* Oberth.).

Tegumen broad, sometimes it develops terminal lobes by a distal convexity as in the Lycaenidae (e.g., *Charaxes polyxena* Cram.; *Charaxes etheocles* Cram.). Uncus long, tapered or reduced (e.g., *Eulepis athamas* Drury.). Gnathos usually present. Central lip curved, the arms arising from the base of the uncus. Saccus often present and very long. In such cases it extends to the VI abdominal somite (e.g., *Rohana parisatis* Westw.; *Apatura ilia* Linn.; *Dilipa morgiana* Westw.;

Helcyra hemina Hew.). Absent in *Vanessa polychloros* Linn. and *Cupha erymanthis* Drury.

Penis usually of moderate length but sometimes it is very long and runs almost parallel to the saccus and extends as far as the fifth abdominal segment. Cornuti variable. Anellus usually distinct.

Species examined. *Rohana parisatis* Westw. (Text-fig. 103); *Neptis vermona* Moore; *Vanessa polychloros* Linn.; *Euthalia lepidea* Butl.; *Euthalia magnolia* Stgr.; *Symbrenthia niphanda* Moore; *Pyrameis cardui* Linn.; *Antanartia hippomene* Hubn.; *Argynnis pales* Schiff.;

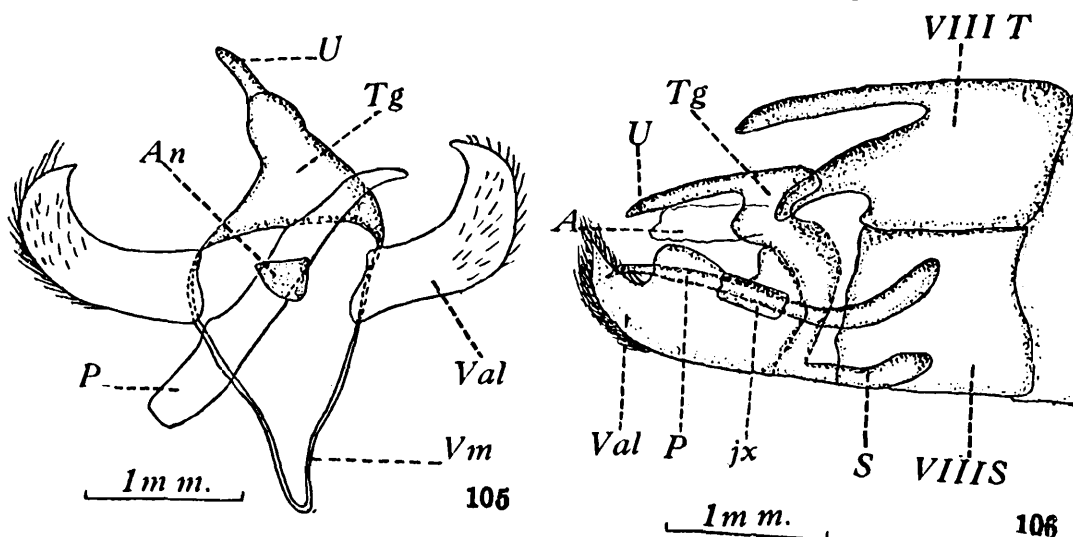


TEXT-FIG. 103.—*Rohana parisatis* Westw.

TEXT-FIG. 104.—*Charaxes polyxena* Cram.

Eulepis athamas Drury.; *Charaxes polyxena* Cram. (Text-fig. 104); *Charaxes etheocles* Cram.; *Cynthia erota* Fabr.; *Apatura ambica* Koll.; *Apatura ilia* Linn.; *Dilipa morgiana* Westw.; *Helcyra hemina* Hew.; *Parhestina persimilis* Westw.; *Cupha erymanthis* Drury.; *Precis almana* Linn.; *Araschnia levana* Linn.; *Actinote hyllonome* Dbl.; *Acraea uvu*;

Gr.-Sm. ; *Acraea perenna* Dbl. ; *Acraea encedon* Linn. ; *Acraea bonasia* Fab. (Text-fig. 105) ; *Pseudergolis wedah* Kott. ; *Calinaga lhatso* Oberth.



TEXT-FIG. 105.—*Acraea bonasia* Feb.

TEXT-FIG. 106.—*Libythea myrrha* Godt.

Family LIBYTHEIDAE.

Eighth abdominal tergite emarginate and produced into lateral processes.

Valvae broad, usually with a costal bulb and pointed apex.

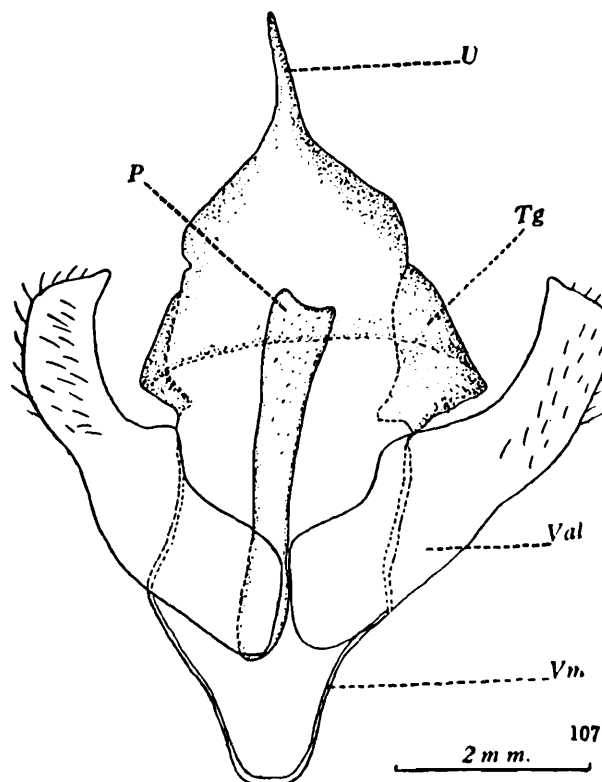
Tegumen with long acuminate and depressed uncus. Saccus long. Penis long, curved. Cornuti absent.

Species examined. *Libythea myrrha* Godt. (Text-fig. 106) ; *Libythea celtis* Esp. ; *Libythea lepita* Moore.

Family BRASSOLIDAE.

Valvae simple, long, apex curved.

Tegumen broad. Uncus straight. Vinculum broadly 'V' shaped.



TEXT-FIG. 107.—*Brassolis sophorae* Linn.

Penis long and straight.

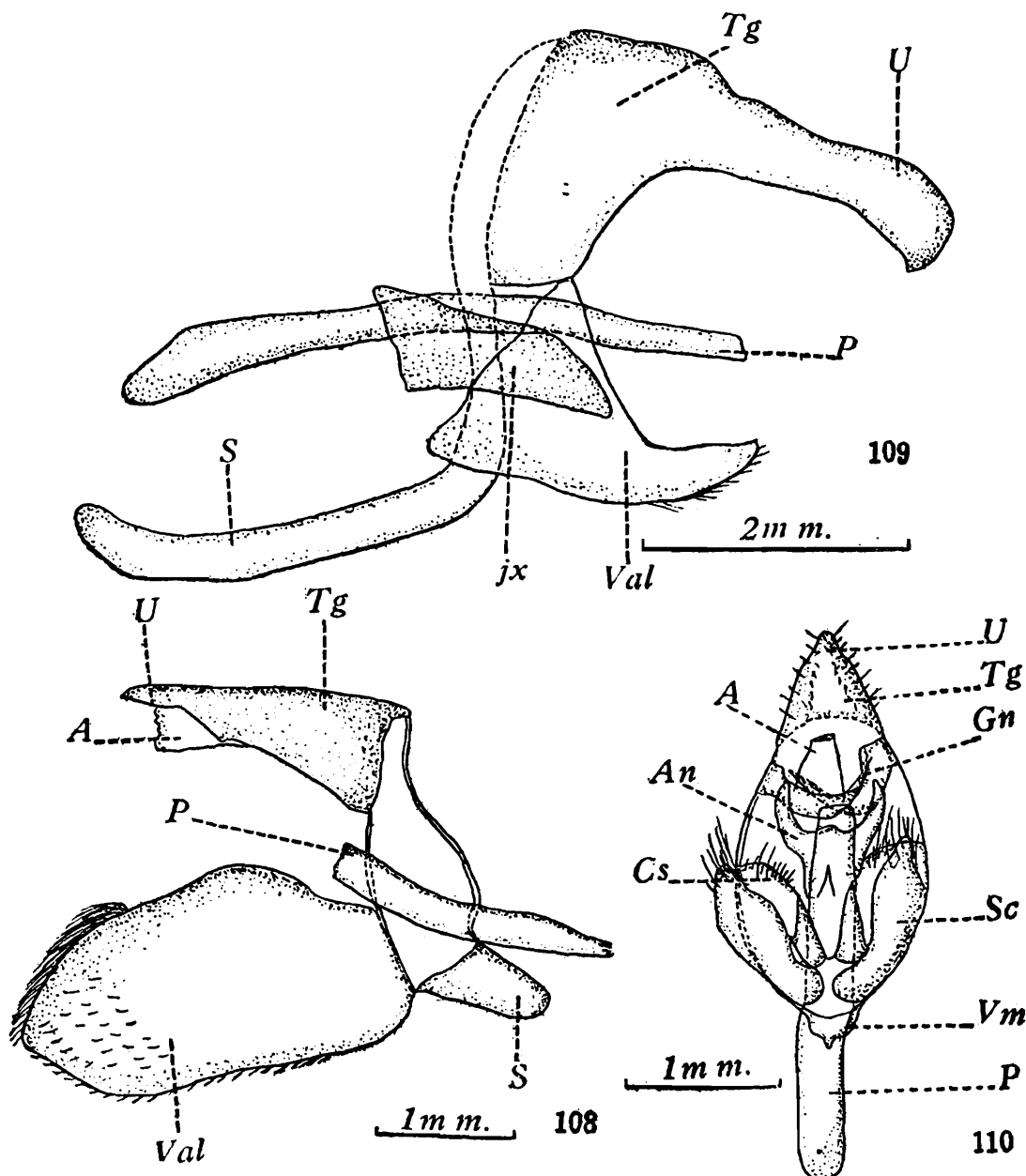
Species examined. *Brassolis sophorae* Linn. (Text-fig. 107).

FAMILY PIERIDAE.

Valvae simple, very broad, harpe well developed, digitate (e.g., *Terias hecabe* Linn.); costal margin fused. Cucullus narrow (e.g., *Delias* sp.).

Tegumen broad. Uncus acuminate. Saccus short.

Penis long, slightly bent or with basal digitate processes (e.g., *Appias nero* Fabr.). Cornuti variable.



TEXT-FIG. 108.—*Pieris rapae* Linn.

TEXT-FIG. 109.—*Enispe cynus* D. W. & H.

TEXT-FIG. 110.—*Abisara fylla* Moore.

Species examined. *Terias hecabe* Linn.; *Delias* sp.; *Delias caenius* Linn.; *Teracolus halimede* Klug.; *Appias nero* Fabr.; *Delias belladonna* Fab.; *Nychitona nina* Fabr.; *Pieris rapae* Linn. (Text-fig. 108).

Family AMATHUSIIDAE.

Valvae simple, broad. Apical process long. Costal margin irregular, produced into an inner process. Apex spinose (e.g., *Tenaris honrathi* Stgr.).

Tegumen broad, usually with a long beak-like uncus. A pair of lateral processes sometimes arise from the tegumen. Saccus long.

Penis very long and in *Enispe cygnus* D. W. & H. ; reaches the VI abdominal segment. Juxta plate well developed.

Species examined. *Discophora tullia* Moore ; *Enispe cygnus* D. W. & H. (Text-fig. 109) ; *Tenaris honrathi* Stgr.

Family NEMEOBIIDAE.

Valvae simple, short and broad. Sometimes with chitinous fold on anal margin which is terminally produced into lobiform process (e.g., *Abisara fylla* Moore).

Tegumen broad. Uncus distinct. Gnathos with free curved arms. Saccus reduced.

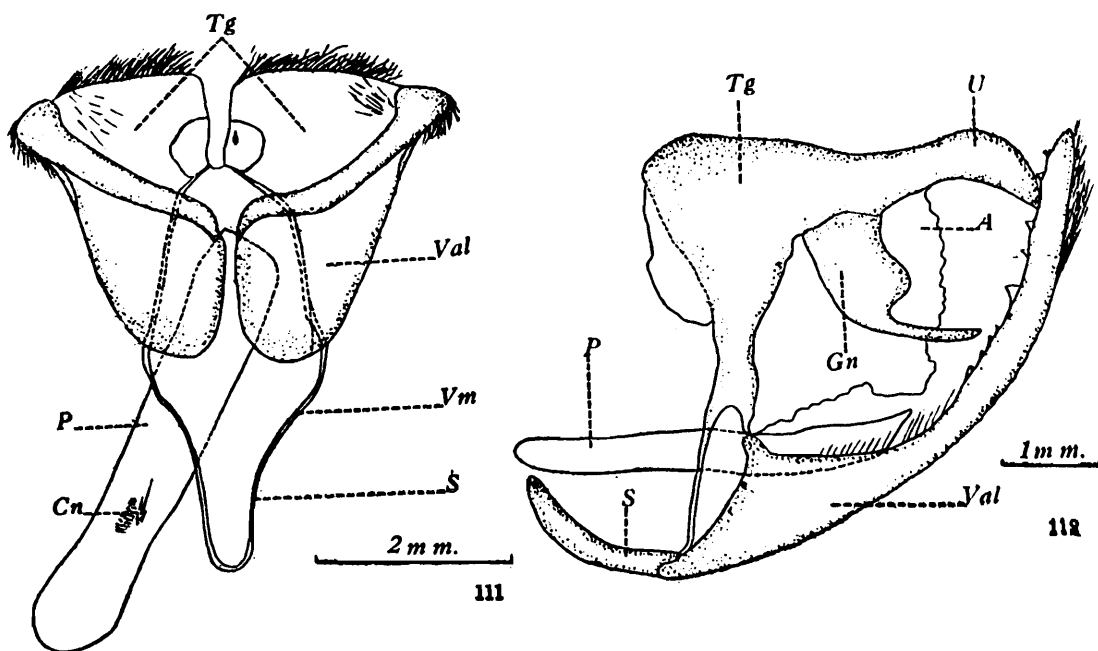
Penis long and straight. Cornuti present. Anellus lobes well developed.

Species examined. *Abisara fylla* Moore (Text-fig. 110) ; *Dodona durga* Koll. ; *Dodona ouida* Moore.

Family DANAIIDAE.

Pencils of hair characteristically present.

Valvae simple, very broad, saccus angulate (e.g., *Radena similis* Linn.). Apex produced (e.g., *Danaïs archippus* Fabr.). Harpe thick set with dentate process (e.g., *Lycorea ceres* Cram.).



TEXT-FIG. 111.—*Euploea mulciber* Cram.

TEXT-FIG. 112.—*Caligo oileus* Feld.

Tegumen broad. Uncus usually hood-shaped, reduced or absent. Vinculum 'V'-shaped. Saccus long.

Penis well developed, usually long. Cornuti present.

Species examined. *Danaïs archippus* Fabr.; *Euploea mulciber* Cram. (Text-fig. 111); *Lycorea ceres* Cram.; *Radena similis* Linn.

Family MORPHIDAE.

Valvae long, narrow, costal margin sparsely dentate.

Tegumen broad. Uncus depressed. Gnathos with two curved free processes. Saccus curved.

Penis long and stout.

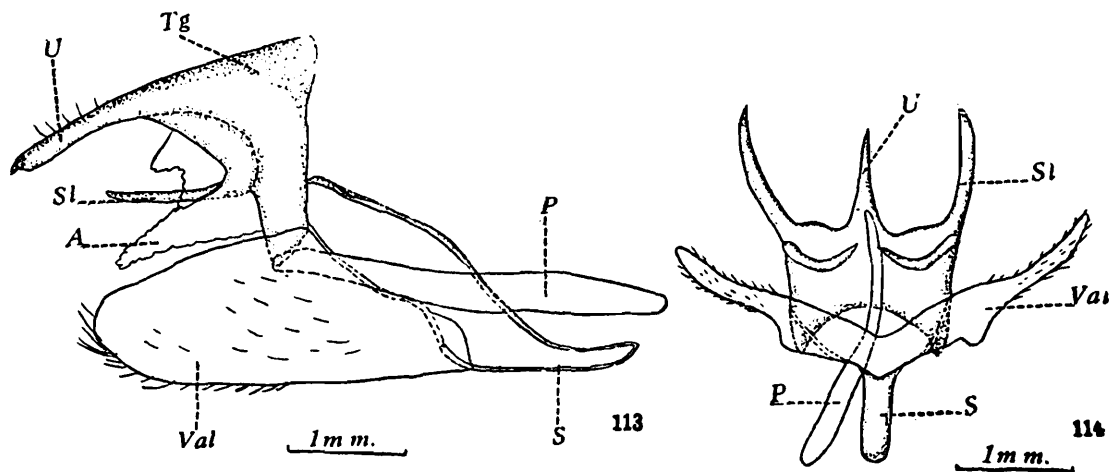
Species examined. *Caligo oileus* Feld. (Text-fig. 112).

Family SATYRIDAE.

Valvae simple, usually elongate or broad.

Tegumen broad. Uncus long, pointed at the apex, or curved (e.g., *Lethe diana* Butl.). A pair of long processes arise from the tegumen and have been termed 'Side lobes' by White (1876) in *Caenonympha*, but as these are ventral to the anal tube, the homology does not stand. Also in *Mycalesis anapita* Moore, besides similarly placed processes, there exists another pair of such organs arising from the tegumen dorsal to the anal tube. These are the 'side lobes'. Saccus present and usually long.

Penis long and slightly bent.



TEXT-FIG. 113.—*Elymnias singhala* Moore.

TEXT-FIG. 114.—*Mycalesis anapita* Moore.

Species examined. *Elymnias singhala* Moore (Text-fig. 113); *Elymnias hypermnestra* Linn.; *Melanitis leda* Linn.; *Ypthima argus* Butl., *Lethe diana* Butl.; *Mycalesis anapita* Moore (Text-fig. 114).

Concluding remarks on the genitalia of Papilionina.

This group possesses genitalia of a character which differs from the Heterocera in the form of the tegumen and its appendages. The ninth sternite is a chitinized band, more or less 'U' or 'V' shaped, and a long saccus is often developed. The valvae are simple and develop a harpe. The tegumen often bears a pair of side lobes which are charac-

teristic of this superfamily. The uncus and the gnathos are well developed. The penis is long and develops several cornuti which may be in the form of long spines or sharp denticles. A large anellus or juxta is often present.

Conclusions in Phylogeny.

It is now generally agreed that the Order Lepidoptera is naturally divisible into two Sub-orders, *e.g.*, Homoneura and Heteroneura, separable by important anatomical characters. In the Homoneura or Jugatae (Comstock), the neuration of both wings is substantially the same, a jugum is developed at the base of the dorsum of the forewing and a spiral proboscis is absent. The Heteroneura are characterized by a reduction of the radial sector to a single vein in the hind wing, presence of a frenulum, and a usually spiral proboscis.

The Homoneura present considerable similarity to the Trichoptera, particularly in the head capsule, character of the mouth parts, the nature of the thoracic sclerites, the wing venation and the presence of a coupling apparatus of the primitive jugo-frenate type, the general character of the terminal abdominal structures and the occurrence of moss-inhabiting larvae. (Crampton, 1920, Braun, 1919). The nature of this alliance is controversial and it is believed that, either the Lepidoptera have descended by way of the Micropterygides directly from the Trichoptera or that Trichoptera and Lepidoptera have arisen from a common ancestor. Recent researches seem to favour the latter idea and Tillyard (1918) has shown that Lepidoptera could be traced back to the Protomecopterous or some similar extinct type.

By common consent the family Micropterygidae is regarded as the most primitive of the Lepidoptera and *Sabatinca* is generally admitted to be the most archaic genus of the family. The evidence accumulated in this direction has been chiefly derived from study of the characters of the egg (Chapman, 1896), caterpillar (Dyar, 1895, and Fracker, 1915), pupa (Chapman, 1896 and Mosher, 1916) and the imago. The most reliable conclusions have been arrived at by working out the wing-venation (Meyrick, 1895, 1927, Hampson, 1898-1920, Tillyard, 1918, 1919 and others) while the scales or aculeae (Kellog, 1895, Comstock, 1925), the wing-coupling apparatus (Comstock) and mouth parts (Packard, 1895) have afforded more or less confirmatory evidence. Quite recently Eyer (1924) and Philpott (1924, 1926) have also held that the Micropterygidae possess a primitive type of male genitalia comparable to that in Mnesarchaeidae, Eriocraniidae, Prototheoridae and the Hepialidae. Eyer (1924) has shown that the male genitalia of the Prototheoridae resemble those of the Hepialidae while the Mnesarchaeidae are intermediate in their structure between the Hepialidae and the Micropterygidae, Eriocraniidae and the Aculeate Tineoidea.

In the possession of a hooded tegumen, the large and broad vinculum, the membranous penis with lightly chitinized juxta and almost general absence of the uncus, gnathos and saccus, I regard the Homoneura as primitive because these organs are here presented in their simplest

form, being very similar to the corresponding organs in the Trichoptera, Mecoptera and Neuroptera. The Micropterygidae appear to be the earliest members of this group and the genitalia in *Sabatinca* (Philpott, 1923) are of the most generalized type as is shown by the presence of the greatly enlarged ninth sternite, hood-shaped tegumen, simple valvae and lightly chitinated penis. The Mnesarchaeidae, according to Eyer (1924) possess the usual characters found in the Micropterygidae, and in the absence of a tube-like aedeagus and the form of the vinculum they resemble the Hepialidae. The genitalia in the family Prototheoridae are comparable to those in the Hepialidae and they together differ from the genitalia of the other Homoneura in the valvae being divided ; a short saccus is sometimes provided to the vinculum, the trulleum is present and the penis is not tubular. This line of specialization in the copulatory organs may be correlated with the more active habits of the males in these families. The Eriocraniidae, though more specialized in the mouth parts and wing venation, present no genitalic features specially marking them from other Homoneura.

The Superfamily Tineina has been divided by Comstock (1925) into two groups which are distinguished by the presence or absence of aculeae. In the Aculeate category are included the families Lamproniadae (Incurvariidae), Adelidae and the Nepticulidae. The genitalia in this group are typically primitive and resemble the similar organs in the Eriocraniidae. This does not, however, necessarily suggest that the Aculeate Tineina are directly derived from this family, but certainly it does emphasize their close relationship. Possibly both have followed a similar line of descent. Amongst the Non-Aculeate families of Tineina there is evident a slow though marked differentiation and development of parts in the male genitalia, yet the organs can hardly be called specialized. The Heliozelidae have retained a primitive type of genital armature very similar to the Aculeate Tineina. The Plutellidae in the possession of a large gnathos come next, while the other families exhibit a greater development of these organs. In the rest of Tineina the uncus is marked, socii and gnathos are present and saccus is well developed. This group forms the base from which the superfamilies Tortricina, Pyralidina and Psychina are probably derived.

The Tortricina are a compact group with Tineid affinities. Thus members of the family Carposinidae in the latter group possess genitalia more or less identical with those in the tortricid family Phaloniadae. The tegumen is broad with a short uncus, socii are well developed, and the valvae are simple with an erect transtilla. The families Eucosmidae and Tortricidae also exhibit these features, though they are more advanced in some respects, viz., in the development of uncus and gnathos and complex valvae.

In the male genitalia, the superfamily Pyralidina resembles the Tineina. The moths of the family Pyralidae typically possess a long uncus, and a large gnathos with elongated central lip ; the valvae simple and harpe sometimes present. The penis bears a variable number of cornuti. Minor deviations from this type are noticed in the different sub-families. The Galleriinae possess a hood-shaped uncus recalling the Tineid condition and the gnathos is absent. In this respect they

are widely separated from the rest of the Pyralidae. In the *Anerastinae* the uncus is divided into lateral horns and a large gnathos is present.

The *Pterophoridae* have a comparatively simple type of male genitalia similar to that in the *Pyralidae*.

The *Thyrididae*, though related to the *Pyralidae*, possess a very advanced type of male genitalia with a well developed uncus which is often broad and produced into paired lateral and terminal lobes or processes. Besides this another supra-anal process arises from the base of the uncus. The gnathos is large, with the two brachia joined to form a loop, the central lip being poorly developed. Meyrick (1927) believes that the "*Pyralidina* has for its earliest existing form the *Thyrididae*" The extreme specialization of the genital armature does not support this, nor can one reasonably derive the four segmented palp in the maxillae of the *Pyralidae* from the *Thyrididae* with at most a two segmented organ. (Philpott, 1927; also refer to 'Meyrick's Law', 1895).

The *Psychina* are an ancient group and the family *Psychidae* exhibits some primitive features in the male genitalia and in this respect is related to the *Tineina*. The uncus is reduced and the tegumen more or less hood-shaped. The vinculum is large and the valvae remain simple. The penis is often very long with well developed anellus lobes. The possession of these characters by the *Zygaenidae* and the *Psychidae* points to the close relationship of these families. The *Lacosomidae*, however, are of uncertain affinity. The *Megalopygidae*, on account of a simple tegumen, short uncus, and a prominent gnathos are probably related to the family *Limacodidae*. The *Cossidae* possess a simple type of male genital armature. The tegumen is triangular and the uncus is well developed. They resemble the *Castniidae* in this respect. The *Cossidae*, notably in the venation, are one of the most primitive families of *Lepidoptera*. Forbes (1923) believed that they form the base of a series leading directly to the butterflies, yet the only definite butterfly character in this family is the upright egg of the *Cossinae*. The genitalia, however, lend support to Forbes' theory, for in the *Castniidae* the tegumen has the triangular shape with hind margin more or less concave, the uncus is tapered and a long penis is present; all these features are in common with several of the *Papilionina*.

The *Lasiocampina* are probably derived from the *Psychina*, though little evidence is afforded by genitalia in the forms studied. The *Lasiocampidae* possess genitalia very similar to those of the family *Eupterotidae* (*Notodontina*) especially in the form of the valvae, a hood-shaped or reduced uncus and presence of terminal lobes on the tegumen. The resemblance in the larvae of *Lasiocampidae* and *Eupterotidae* has been previously described by Dyar in 1895.

The *Notodontina* perhaps originate from the *Lasiocampina* as has been indicated by the similarity in copulatory organs between the *Lasiocampidae* and some of the *Geometridae* and *Eupterotidae*. Extreme specialization of these organs is emphasized in the *Geometridae* *Gnathoi* and the family *Hydriomenidae*. Meyrick (1927) held that

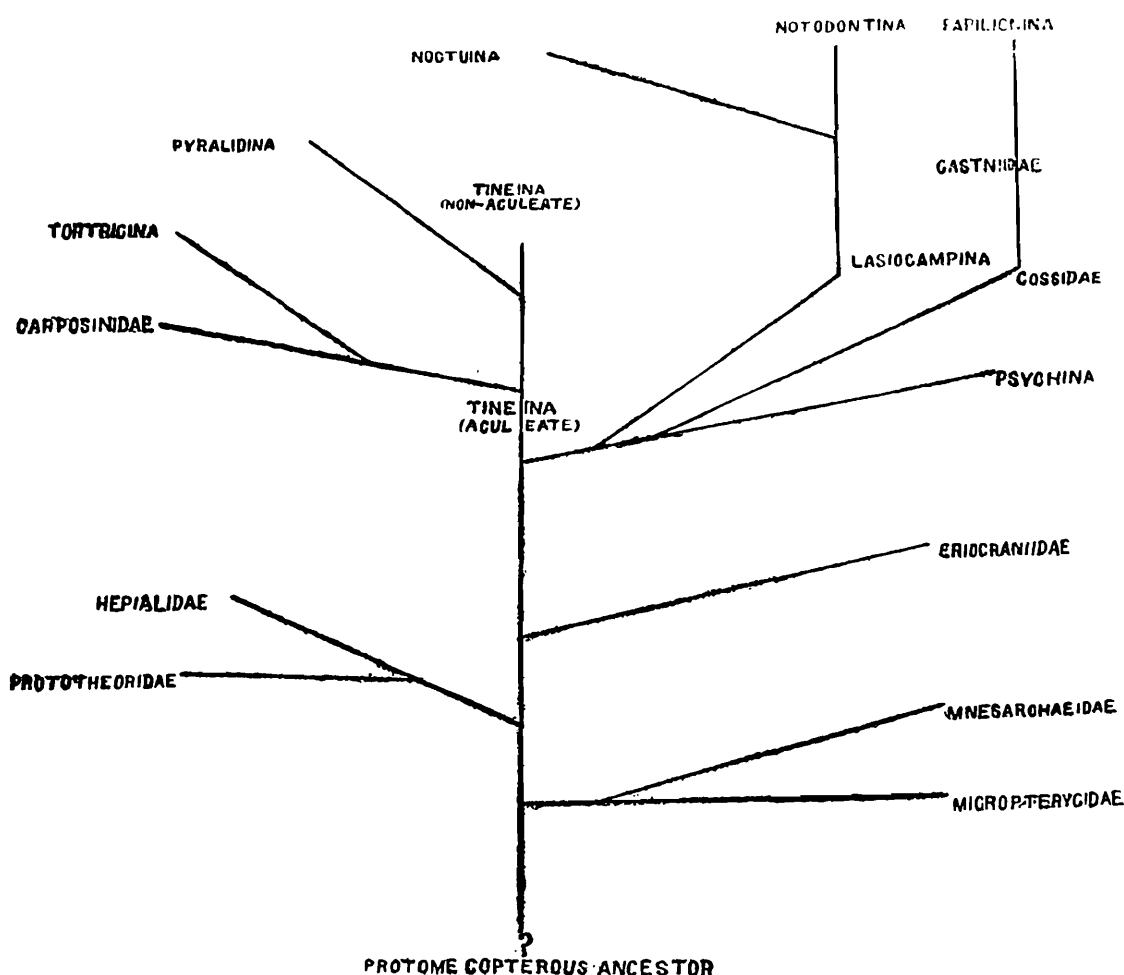
“The Notodontidae and Sphingidae are correlated offshoots from an early form of the line and the Polyplocidae are derived from near the same point” Apparently the copulatory organs in these families are similar and of an advanced type as is indicated by the massive development of the uncus and the gnathos, the transtillae and the valvae.

The genital armature in the Noctuina follows similar lines of specialization, *e.g.*, presence of harpe, ampulla and such other prehensile processes corresponding to the harpe, labides, etc., as in the Notodontid family Geometridae. It is very difficult to say whether they are derived from the latter group (Hampson, 1898) or (as according to Meyrick, 1927), “whether they form another great branch of equally fixed type developing parallel with the Notodontina” The families Hypsidae, Ocneriadae, Arctiidae, Agaristidae, Hylophilidae and Syntomidae have relatively simple genitalia, and the gnathos as a rule is wanting. As we pass on to the family Noctuidae gradually specialization is attained, and the genitalia become complex. In this connection, the valvae show complexity of form, and division into sacculus and cucullus is evident. The peculiar prehensile organs like the harpe, ampulla, clavus, etc., are present. The uncus is large and assumes variable form. The tegumen is often provided with a large hairy peniculus on either side.

Opinions vary as to the probable line of descent of the Papilionina. Packard (1895), Forbes (1923) and others derive them from the family Castniidae. Hampson (1898) traces them from the Zygaenidae and Meyrick (1927) states that “They are referable in origin to the neighbourhood of Callidulidae” The relationship between the general plan of the male genitalia in the families Cossidae, Castniidae and Papilionina is fairly evident. The form of the tegumen and the uncus is characteristically similar while a large gnathos and a relatively long penis also emphasize their close affinity. Besides this, Forbes (1923) has suggested “That in the Castniidae the tongue which is lost in the Cossidae is preserved, the habits have become butterfly-like, the upper fork of Media is lost, the wings have become ample and the cell is relatively small, and the antennae are clubbed”.

The genitalia in the families Hesperidae and Lycaenidae resemble one another, and are characterized by the presence of side lobes or socii, and a long penis with terminal cornuti. The latter appears to be connected with the Papilionidae through the species *Parnassius epaphus*, a Papilionid which possesses the side lobes characteristic of the Lycaenid type. In the same way the relationship between the Lycaenidae and Nymphalidae is substantiated through the intermedium of the species *Charaxes polyxena* which also possesses a similar set of these organs. The Pieridae possess simple valvae, and a long uncus, and in this respect they resemble the Brassolidae. The Libytheidae, in the presence of a long penis and saccus resemble the Nymphalidae. The other families of Papilionina are also interrelated as is indicated by an almost similar plan of the genital armature. In all such cases the uncus is usually long, a large gnathos is present, the valvae are simple flap-like expansions, and in the family Satyridae a pair of side lobes is also present on the tegumen.

The interrelationships between the various groups of Lepidoptera, as based on a study of the male genitalia, are expressed, in the form of a phylogenetic tree which is reproduced below.



SUMMARY.

In the absence of any sound system of nomenclature for the description of male genitalia in Lepidoptera, a scheme on a priority basis is presented in this memoir.

A comparative account dealing with the morphology of male genitalia is given and the various families in the Systematic part are grouped chiefly on the basis of specialization.

It has long been recognised that the male genitalia offer useful characters for the discrimination of genera and species but hitherto there has been considerable scepticism regarding their value for establishing phylogenetic relationships. It has been possible to show in this study that the male copulatory organs in the superfamilies of Lepidoptera, present definite structural homologies prominent enough to bring out their mutual affinities.

The Homoneura possess a decidedly primitive type of male genitalia and the families in this group are interrelated on these characters.

The Aculeate Tineina with the genitalia similar to the family Eriocraniidae are perhaps related to them. From the Non-aculeate stem of the Tineina are derived the superfamilies Tortricina, Pyralidina and Psychina.

The Lasiocampina are referable in origin to the Psychina. The Notodontina present certain close affinities with the family Lasiocampidae, and are probably derived from this group.

The extreme specialization of corresponding parts in the male genitalia of the superfamilies Notodontina and Noctuina are very suggestive of their close relationship.

The Papilionina present certain peculiarities in the genital armature which are much in common with those of the Castniidae and the Cossidae. Since the other butterfly characters are also indicated in these two families of Psychina, their affinities with Papilionina are all the more emphasized.

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