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(*NEW SERIES.*) No. 54.

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BY

OFFICERS OF THE MEDICAL AND SANITARY DEPARTMENTS

OF THE

GOVERNMENT OF INDIA

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No. 1

***PHILAEMATOMYIA INSIGNIS*, AUSTEN**

BY

CAPTAIN F. W. CRAGG, M.D., I.M.S.

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Studies on the Mouth Parts and Sucking Apparatus in the Blood-Sucking Diptera.

No. 1.

PHILAEMATOMYIA INSIGNIS, AUSTEN.

BY

CAPTAIN F. W. CRAGG, M.D., I.M.S.,

The King Institute, Guindy, Madras.

Philæmatomyia insignis is a small greyish-brown fly, found throughout the Oriental region, and recorded also from Tropical Africa. The genus is closely allied to *Musca*, and in general appearance, breeding habits, venation, etc., there is little to distinguish it. The characteristic feature, on account of which the genus was founded, is the presence of a ring of stout chitinous teeth at the tip of the proboscis. It is, in fact, in spite of its innocent appearance, a voracious blood-sucker. It preys exclusively, so far as is known, on cattle, and in the neighbourhood of this Institute it is much the commonest blood-sucking fly found on them. It is especially fond of feeding on the abdomen of calves which have been shaved for vaccination. Both male and female suck blood, and possibly also feed on the dung in which their eggs are laid.

The proboscis is completely retractile, like that of *Musca*, and it is only exceptionally the case that the teeth can be seen in dried specimens; even if the proboscis happens to be extended the teeth are not visible unless the labellar walls are retracted so as to disclose them. It is therefore probable that it will be found to be much commoner and more widely distributed than the present records state, when it is more systematically looked for.

Methods.

For the study of the chitinous parts the material was cleared in 2 per cent. potash solution for varying periods. The best results are obtained by allowing the potash to act for a prolonged period in the cold, rather than by boiling, as this is apt to distort the parts on account of the sudden expansion of the contained air. The biting parts are extremely densely pigmented, and it was necessary to decolorize them, to a degree varying in different preparations, with chlorine gas. The soft parts were studied chiefly by dissection of freshly killed flies. Sections of newly hatched flies were prepared by the combined paraffin and celloidin method and stained with Iron-hæmatoxylin and Eosin. Sections are, however, rather

difficult to interpret, since one cannot be certain of the exact degree of extension of the proboscis and eversion of the teeth once the material is placed in the fixative. The best results were obtained by dropping whole heads of etherized flies into absolute alcohol, and immediately pressing on the head with a needle above the lunule. This manœuvre causes the proboscis to shoot out and distends the oral lobes, and one can sometimes get the parts definitely fixed in this position.

I am greatly indebted to Captain Patton, I.M.S., Acting Director of this Institute, for many valuable hints on the habits of the fly, and for a batch of pupæ.*

General Account.

As indicated above, the proboscis bears a close resemblance to that of *Musca*, and in the following description the terms generally used for the mouth parts of *Musca* will be adhered to as far as possible, leaving the question of the relation of the parts to the corresponding ones in other blood-sucking muscids to be discussed later. The proboscis consists of three parts, *viz.*, the *rostrum*, *haustellum*, and the *labella*. The *rostrum* is shaped like a truncated cone, the broad base of which fits into an orifice on the under surface of the head. It is composed of a chitinous framework, the *fulcrum*, and a loose investing membrane, which serves to attach the fulcrum to the head, and also encloses the soft structures of the rostrum. The *haustellum* is about the same length as the rostrum. It is somewhat cylindrical in shape, with the middle portion expanded. Its posterior and lateral walls, which are rounded so as to form about two-thirds of a circle in cross sections, are formed by a chitinous plate, the *theca*. The anterior side, which is flattened, is membraneous, and has running down the whole length in the middle line a thick pigmented chitinous rod, which is deeply grooved on its anterior surface. This groove contains the labrum-epipharynx and the hypopharynx, and the rod may be called the *labial gutter*, since it corresponds to the structure described in *Stomoxys* by Stephens and Newstead under that name. The *labella* are attached to the end of the haustellum. When fully expanded they form a gently rounded globular extremity to the proboscis. The two labella are fused together, and their walls are continuous except on the anterior surface, where there is a narrow and deep groove, which contains the teeth, and is continuous with that of the labial gutter. They closely resemble those of *Musca*. The oral surface bears a well developed pseudo-tracheal membrane, while the aboral surface consists of a flexible membrane strengthened by the development of thin plates of chitin, the whole being supported by a strong horse-shoe shaped arch, the *furca*.

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* An account of the breeding habits of Philæmatomyia and the closely allied form Pristirhynchomyia Brunetti will be published shortly.

When fully extended the proboscis hangs down at a right angle to the long axis of the fly, the rostrum having a slight forward inclination. The whole organ can be completely retracted under the head, the rostrum being folded backwards on to the under surface of the head, the haustellum forwards on the rostrum and the labella backwards on the haustellum. In the subsequent detailed description, the organ will be considered as extended for use, so that the terms anterior and posterior will apply to those surfaces which are, in the extended position, continuous with the dorsal and ventral surfaces of the fly.

It is unfortunate that the term "proboscis" has no accepted meaning. It is used by some authors, as for instance Stephens and Newstead in their accounts of *Glossina* and *Stomoxys*, to indicate the haustellum and labella only, the rostrum being disregarded, while other writers use it for the labium only. In this paper the word is used to signify all the protruding mouth parts. The constituent parts of the proboscis have each commonly accepted names, and it would certainly conduce to clearness of description if the term were only used in a general sense, so as to be equally applicable to all insects.

The Rostrum.

The *Fulcrum* (Plate I, Fig. 1) consists of a posterior plate, two lateral plates, and a thick arch which connects the two lateral plates in front. Kræpelin described the corresponding structure in *Musca domestica* as resembling a Spanish stirrup iron; the posterior plate would then represent the foot plate, and the anterior arch the bar to which the stirrup leather is attached. The posterior plate is oblong, its greatest breadth, which is a little above the middle, being about one-third its length. It is slightly concave forwards, and the lateral edges are raised up into strong ridges, which project beyond the upper and lower borders as diverging cornua. The lateral plates, which are shaped roughly like isosceles triangles, pass directly forwards from these lateral ridges. The anterior border of each plate is deeply incurved in its lower third, and has on it, just above the recess so formed, a sharp spine projecting downwards and forwards. The upper border is also deeply incurved and is almost semi-circular in outline. The anterior arch is a thick and strongly ridged band of chitin which passes between the projecting anterior angles of the lateral plates. The ridges on this piece are continued into the upper and anterior margins of the fulcrum. The upper orifice of the fulcrum, bounded by the posterior and lateral plates, is quadrilateral in outline, and lies immediately below the epistomium.

The *Membrane* of the rostrum encloses the fulcrum. It is attached to the border of the epistomium, and to the clypeus, genæ, and gulomental plate,

and to the anterior borders of the sides of the fulcrum, converting it into a closed cavity, which is occupied by the pharyngeal muscles. Posteriorly it runs downwards to the lower end of the rostrum, enclosing the muscles, tracheæ and salivary duct, which lie posterior to the fulcrum. The membrane is thrown into numerous folds when the proboscis is withdrawn.

The *Palps* are attached to the membrane on the anterior surface of the rostrum, in its lower third. Each arises from a small raised and partially chitinized area, on the outer projecting angle of which there are two large macrochetæ. The palps are clavate, moderately long, and clothed with numerous very fine recumbent hairs and many large pigmented chetæ. The palps are folded back against the anterior surface of the rostrum when it is withdrawn, and are erected when it is extended.

The *Pharynx* (Plate V, Fig. 22) is composed of two chitinous plates, normally superimposed and in contact with one another. The posterior of these is the posterior plate of the fulcrum. The anterior plate is of the same size and shape, but is somewhat thinner. It has a stout median ridge running down its anterior surface. The sucking action is produced, as in other diptera, by the separation of these two plates.

The sucking portion of the pharynx does not extend quite to the lower end of the rostrum. At the extreme end the food canal consists (Plate IV, Fig. 20) of a concave posterior plate, only partially chitinized, and a membraneous anterior wall. A little higher up (Plate V, Fig. 20) two lateral plates are developed, and the attenuated end of the anterior plate is seen appearing in the anterior wall. This arrangement permits of flexion at the junction of the rostrum and haustellum when the proboscis is withdrawn.

The *Salivary Duct* in the upper portion of the rostrum is a simple tube of thin chitin, lying in the middle line on the posterior surface of the pharynx. At the lower end the walls are membraneous, and the duct lies embedded in a dense mass of cellular tissue. A short distance above the point at which the duct emerges from the haustellum there is a small valve resembling that of Musca.

The *Muscles of the Rostrum* (Plate V, Fig. 22)) resemble those in *Musca*, though some of those described by Kraepelin have not been traced. Their function is to retract the proboscis and to assist in extending it.

The *Dilators of the Pharynx* (D. ph) arise from the sides of the fulcrum throughout its upper two-thirds, and from the adjacent membrane covering in the anterior surface. They run inwards and backwards to be inserted into the anterior plate of the pharynx, most of the fibres being attached to the median ridge on that plate.

The *Flexors of the Haustellum* (F. H.) arise from the sides of the occipital foramen, and are inserted into the distal ends of the labral apodemes; they lie external to the tracheal sacs in the rostrum.

The *Retractors of the Haustellum* (R. H.) are long round bundles, situated behind the pharynx and on either side of the salivary duct. They arise from the inner surface of the posterior wall of the head cavity, and, passing downwards behind the brain and external to the occipital foramen, are inserted into the thickened mass of chitin at the base of the theca, by a membraneous expansion.

The *Extensors of the Haustellum* (Ex. H.) arise from the cornua at the distal end of the fulcrum, and run obliquely upwards and outwards to the proximal end of the labral apodemes.

The *Retractors of the Fulcrum* (R. F.) arise on each side from the internal edges of the genæ, and are inserted into posterior cornua at the proximal end of the fulcrum. They lie in a fold of membrane at the anterior lateral angle of the rostrum.

The *Tracheæ* resemble those of *Musca*. There are two large tracheal sacs, lying on either side of the salivary duct. In dissection these sacs can frequently be separated out while still distended with air, appearing as large sausage-shaped white bodies. In sections they are usually constricted, and so come to have a corrugated outline and a relatively thick wall.

The Haustellum.

This comprises the true mouth parts, *viz.*, the labrum, epipharynx, hypopharynx and the labium. Of these only the labium can be distinguished without dissection, the other parts being concealed in the labial gutter. The labium consists of two pieces of chitin, the *theca* and the *labial gutter*, and a connecting membrane.

The *Theca*, which forms the main part of the labium, is a hollow scaphoid trough, much deeper in its upper part than below, and having its open side directed forwards. The margins of the space so formed are thickened into strong ridges, which run parallel to one another throughout the length of the labium. The upper end of the theca is somewhat truncated and narrowed, and contains at the extreme end a Y shaped median ridge for muscle attachment. The upper end of the labial gutter is fused with the converging margins at this end of the theca. At the lower end there is another Y shaped median ridge, the lateral arms of which are reinforced by fibrous bands from the lateral ridges of the theca, and which pass outwards, downwards and slightly forwards, to articulate, as will be seen later, with the furca of the labella. Near the tip of each of these rods there is a small

barb-like projection. In preparations treated with potash for a prolonged time, it is seen that these projecting rods are not of equal thickness throughout, but that there is, about the middle of their length, a weaker portion which probably functions as a joint.

The *Labial Gutter* (L. G.) is a thick deeply pigmented rod, grooved on its anterior surface in such a way that it appears U shaped in transverse section. It lies in front of the theca, and is connected with it by a rather tough membrane, which stretches between the lateral ridges of the theca and the borders of the groove. At its upper end it is intimately fused with the theca so that no movement is possible between them. On the upper half of its posterior surface there is a thin chitinous expansion, projecting backwards into the cavity of the theca, and reaching almost to the posterior wall, which gives origin to an important pair of muscles. This expansion, when seen in profile, has the shape of the keel of a racing yacht, and corresponds exactly to the similar structure in *Stomoxys*. At the lower end of the labial gutter the sides are produced downwards a little beyond the bottom of the trough and terminate in gently rounded knobs which converge slightly towards one another. In this way a simple socket is formed, into which, as will appear later, a pair of labellar rods is articulated. (Plate II, Fig. 7.)

The *Hypopharynx* (Plate II, Fig. 2) is a slender slip of chitin arising from the base of the labial gutter and terminating in a fine attenuated point. It lies at the bottom of the gutter throughout and terminates just above its lower end, being slightly shorter than the labrum-epipharynx. It is pierced throughout by the salivary duct. When seen in cross section it is found to consist of two distinct laminæ, separated by a small amount of cellular tissue. The inner lamina is circular, and constitutes the duct, being directly continuous with the salivary duct in the rostrum and head. The outer lamina is flattened at the tip, but becomes rounded as it passes upwards in such a way as to accommodate itself to the bottom of the trough in which it lies. The base of the hypopharynx is enlarged into a thick knob of densely pigmented chitin, which projects upwards a little above the upper end of the theca, to which and to the superimposed labrum-epipharynx it is closely attached.

The *Labrum-Epipharynx* (Plate II, Fig. 3) is a lanceolate slip of chitin, flattened at its apex, but expanding gradually in an antero-posterior direction towards its upper end, so that at its base its depth is almost as great as its width. It is attached, so loosely that it is easily bent forward in dissection, to the thick mass of chitin at the upper end of the hypopharynx and labial gutter. As it passes downwards it closes in the open side of the labial gutter, its bluntly rounded tip lying in the hollow formed by the two projecting lateral tubercles. On its under surface there is a deep groove, the overlapping sides of which gradually converge

backwards and inwards towards one another from the apex to the upper fourth, where they meet and so form a closed canal. On cross section the labrum-epipharynx, like the hypopharynx, is seen to consist of two distinct laminæ. The outer of these composes the anterior surface and the posterior surface as far as the edges of the groove, and in the upper fourth, where the groove has become a canal, presents a continuous contour, convex in front and behind. The internal lamina forms the wall of the groove and canal. At its tip it is semi-circular and concave backwards, but as the edges of the groove close in it becomes more circular, until, about the upper fourth, it forms a complete canal, the lumen of which is continuous with that of the pharynx in the rostrum. The inner and outer laminæ are united with one another at the edges of the groove throughout, and are also firmly attached to one another by a strong band of fibres lying in the middle line behind the groove. In this way two lateral spaces are formed, one on each side of the central canal; these are roughly triangular in shape, and contain a series of muscles and some cellular tissue. The upper end of the inner tube projects a little above the outer lamina and terminates in a thickened flange.

On each side of the groove of the labrum-epipharynx there is a row of minute oval flattened tubercles, projecting into the lumen; three similar ones are situated on the posterior surface of the flattened tip of the organ. These tubercles recall the similar structures found in *Stomoxys*, but they do not bear spines, and no suggestion as to their function can be offered.

The interval between the inner and outer laminæ of the labrum-epipharynx is occupied by a series of muscle bundles passing, in a somewhat fan-shaped manner, from the outer to the inner wall. They probably function as an accessory pump, by dilating the lumen of the groove and canal.

The labral apodemes pass from the two upper angles of the labrum-epipharynx upwards, and slightly forwards, into the rostrum. Each is a deeply pigmented slightly sinuous rod, about two-thirds the length of the labrum-epipharynx. The lower end is shaped like an arrow-head with a single barb, and is fitted into a small round socket on the lateral edge of the labrum-epipharynx, where it contracts sharply at the base. The upper end is flattened and expanded for muscle attachment.

The relations of the labial gutter, hypopharynx and the labrum-epipharynx to one another are best studied in serial transverse sections. At its lower end (Plate IV, Fig. 14) the labial gutter encloses a horseshoe-shaped space, at the bottom of which the hypopharynx, which here is very small and circular in outline, is seen. The front of the space is closed in by the flat tip of the labrum-epipharynx. A little higher up (Plate IV, Fig. 15) both the labrum-epipharynx and the hypopharynx are much enlarged, and the groove on the posterior surface

of the former has become well marked, so that its lateral edges curve inwards, fitting inside the labial gutter, which has now become more V shaped. About the middle of the labial gutter (Plate IV, Fig. 16) the edges of the groove are seen to have approached still nearer to one another, so as to almost touch the hypopharynx, which is now triangular in section, the rounded posterior angle fitting into the bottom of the groove, the slightly concave base being opposite to the groove in the labrum-epipharynx. At this level the inner and outer laminæ of the labrum-epipharynx are firmly attached to one another by the median strand of fibres. At the level of the " keel " of the labial gutter (Plate II, Fig. 7) the labrum-epipharynx is considerably broader from side to side, and edges of the groove are almost in contact with one another. The gutter is now much contracted in its posterior half, forming a recess into which the hypopharynx, now also enlarged and more distinctly concave on its anterior surface, is fitted. The anterior half of each lateral wall of the gutter is bent outwards as well as forwards, so as to form with the anterior surface of the hypopharynx, an even surface on which the labrum-epipharynx, now broader than the labial gutter, rests.

Near the base of the labial gutter (Plate III, Fig. 8), where the keel is becoming narrower, the labrum-epipharynx appears as a closed canal with a double wall, the inner circular tube being continuous with the groove. The hypopharynx has become an oval tube of thick chitin with a circular lumen, and lies between the now contracted sides of the gutter. The theca is much reduced in its antero-posterior diameter, so that the upper end of the keel approaches close to the median limb of the Y shaped ridge on its anterior surface. At the extreme upper end of the haustellum (Plate V, Fig. 19) the labial gutter and the hypopharynx are completely fused to form a dense mass of chitin, which extends from the theca to the labrum-epipharynx, and to which the posterior surface of the food canal is fused. The salivary duct runs through this expansion, towards its posterior border, as a simple round tube.

It will be seen from the foregoing description that the food channel is formed in the lower part by the labial gutter and the flattened tip of the labrum-epipharynx ; in the middle portion, by the apposition of the edges of the groove in the posterior surface of the labrum-epipharynx and the concave anterior surface of the hypopharynx ; in the upper portion, by the closed canal in the labrum-epipharynx. There is no system of interlocking teeth such as that found in *Stomoxys*, the continuity of the channel depending on simple apposition of the parts. It will be noticed that the extreme tip of the hypopharynx projects into the lumen of the canal ; the tip is extremely attenuated and ill-defined, and, as suggested by Stephens and Newstead, it may function as a valve to prevent the blood being drawn up the salivary duct.

The Labella.

The *Labella* are joined to form a single organ, the distinction between the two being indicated by a deep median groove on the anterior surface. The external wall, forming the aboral surface, consists of membrane, strengthened in certain areas by thin plates of chitin. It is supported by a horse-shoe shaped rod, the *furca*, which also functions as a joint between the labium and labella. The internal or oral surface, which when the labella are in use is expanded to form a globular end to the proboscis, is formed by a simple pseudo-tracheal membrane. The sides of the groove on the anterior surface are specially modified to form the cutting organ of the fly.

The *Furca* (Plate II, Fig. 6) lies immediately below the Y fork at the lower end of the theca, and encircles the posterior and lateral walls of the organ. Its distal ends are thickened into small tubercles, just behind which there is on each side a small spur projecting upwards and backwards, so as to form a small notch. The projecting arms of the fork at the end of the theca rest in this notch, which form the joint on which the labella are swung backwards and forwards.

The *External wall* of the labella is attached to the furca ; in addition there are three special plates, one posterior and two lateral, developed to give the furca, in its movements, more control over the loose membrane. The posterior plate is heart-shaped, and arises from the posterior part of the arch, running downwards almost to the edge of the pseudo-tracheal membrane and ending in a blunt point. The lateral plates are triangular in shape, the base arising indefinitely from the membrane near its edge about the middle of the external surface on each side. The apex terminates in a fine hook, which is attached to the tubercle at the extremity of the lateral arm of the furca.

Besides these plates, which are definitely chitinized and do not bear hairs, the external wall is stiffened in other less definitely outlined areas. There are two heart-shaped ones as the extreme anterior end of the labella, the apices of which are attached to the ends of the labellar rods, and two on the posterior surface, on either side of and below the posterior plate of the furca. The lateral area between these plates is thickened along the extreme edge, where it joins the pseudo-tracheal membrane. Except on the posterior and lateral plates, the external surface of the labella is loosely covered with large and small pigmented hairs, arranged in an irregular manner, some forming a loose fringe on the lower border. At the extreme edge of the external surface the ordinary epidermal membrane is replaced by a narrow band of scales. (Plate II, Fig. 8.) These are of three kinds. Immediately below the fringe of hairs there are rows of small irregularly rounded scales, loosely and irregularly set on the membrane, and about seven deep. These are succeeded by a definite row of larger semi-circular scales, the straight edge of which projects

downwards. Below these there is another row of larger scales, resembling in shape axe-heads with the basal part somewhat expanded. The broad ends of these scales overlap the pseudo-tracheal membrane; from the narrower upper end of each there arises a small hair, which projects downwards towards the pseudo-tracheæ.

The *Pseudo-tracheal membrane* constitutes the oral surface of the labella. When the organ is extended for use the membrane presents a globular convex surface, traversed by the pseudo-tracheal channels, which converge from the periphery to the region of the teeth in the anterior median fissure. When at rest the oral surfaces of the two sides are in contact with one another, the lower margin of the organ being formed by the narrow scaly membrane of the external surface. The membrane resembles that of the non-blood-sucking muscids. It is homogeneous, transparent, and apparently structureless. The channels are minute folds, horse-shoe shaped in cross section, the edges being contracted so as to enclose about three-quarters of a circle. The lumen is maintained by a series of fine chitinous rings, closely set side by side, the extremities of each ring being turned outwards and backwards, so that when seen flat the edges of the channel have a beaded appearance. There are twelve channels on each side arranged as follows. Each channel arises from the edge of the pseudo-tracheal membrane, being overlapped at its origin by one of the hair-bearing scales of the external surface. The anterior set of four converge towards the middle line to form one large trunk, which dips inwards anterior to the teeth, at the lower end of the groove on the anterior surface of the labella. The next five channels remain separate and run to the middle of the oral pit. The posterior set of three unite to form a single larger channel, which dips inwards posterior to the teeth. Finally all those from one side unite to form a single channel, which, as it passes upwards, gradually looses its chitinous rings and becomes replaced by a short duct with cellular walls.

The Biting Apparatus.

The remarkable biting apparatus of this fly lies in the groove on the anterior surface of the labella, and is developed from their internal walls. It consists of two sets of strong teeth, four on each side, certain serrated scales, two lateral rods, which, for convenience in description, will be termed the *labellar* rods, and a median piece of chitin which connects the rods and also functions as a tooth. These structures are most conveniently described from above downwards.

The *Labellar rods* are of strong and deeply pigmented chitin. Each rod is about one-third the length of the labial gutter, somewhat flattened from side to side, and has its upper end turned slightly outwards and forwards. At the junction of the upper and middle thirds there is on the posterior surface a small tubercle,

posterior to which the rod is considerably reduced in diameter and tapers to a blunt point. The lower end of each rod is expanded and hollowed out so as to form a shallow cup for the reception of the bases of the teeth. These rods lie on either side of the bottom of the groove on the anterior surface of the labella, and are attached throughout to the membrane forming the labellar wall. The tubercles on their posterior surfaces fit into the end of the labial gutter, and, when the labella are erected, press against the projecting tubercles of the lateral walls of the gutter, the arrangement forming, in fact, a simple ball and socket joint. The posterior thirds of the rods project upwards above the lower end of the gutter.

The *Axial apophysis* (Plate II, Fig. 4) is situated behind the lower ends of the labellar rods, and binds them firmly together. It is shaped like a shield, the lower end being produced to a sharp point, which lies a little below the bases of the teeth. It thus forms the floor of the labellar groove at the lower end ; above it, the labellar rods are united by a tough membrane.

The *Teeth* (Plate III, Figs. 9 and 10) resemble rose thorns in shape except that the apex is blunt, and the borders serrated near the apex. They are arranged side by side in the antero-posterior axis of the labellum, arising from the internal wall by expanded bases which lie immediately below the lower end of the labellar rod. Their pointed ends project downwards in the lower end of the anterior groove. The two middle teeth are larger than the other two, and are inserted a little higher up, so that the upper limit of the bases of the four teeth shows a curved contour, corresponding to the cup-shaped end of the labellar rod. The short interval between the bases of the teeth and the labellar rod is occupied by a band of strong fibrous tissue, which serves to retain them in position.

The *Serrated blades* (Plate III, Fig. 9) are minute leaf-like organs with deeply serrated margins, which lie below the teeth. Each blade is a narrow lanceolate slip of chitin, about 20 μ long by 5 broad, and with about seven serrations on each margin, each incision going nearly to the middle line. They are arranged as follows. There are ten tufts consisting of five or six blades each, the blades arising at different levels and being superimposed. Each two tufts are carried on a common bifurcated stalk, which arises between the teeth at the level of the upper limit of their bases, and bifurcates at the lower limit. The tufts arising from each common stalk diverge from one another below the teeth, and turn upwards superficial to the pseudo-tracheæ. The whole of the blades are thus collected into twenty bunches, ten on each side, all of which turn outwards at the orifice of the labella, forming a sort of brush at the tip of the proboscis.

Other Structures.—In addition to the teeth and serrated blades there are certain minor structures to be noted. On the stalk of each of the serrated blades there are three pairs of short broad spines (Plate III, Fig. 11) which project downwards

and slightly forwards. At the point of bifurcation each stalk bears a pair of leaf-like scales, resembling the serrated scales, but having an entire margin and a granular surface.

The *Muscles of the Haustellum* (Figs. 17, 18 and 19) are well developed, and fill up the cavity of the labium. Their main function is to bring the biting apparatus into action.

The *Extensors of the Labellar Rods* (*M'*) arise from the sides of the keel of the labial gutter, and run directly downwards, occupying the middle area of the theca. They are inserted into the posterior third of the labellar rods.

The *Retractors of the* Furca (*M''*) arise from the sides of the theca throughout its extent, and from the thickened chitin at its upper end. The upper fibres run downwards, the lower ones obliquely downwards and inwards to the furca, and are inserted along its upper border and into the tuberosities at the end of its lateral arms.

In addition to these muscles there is a small bundle of fibres arising in the upper part of the theca which pass downwards on either side of the labial gutter, in contact with the membraneous anterior surface of the haustellum. These are inserted in the membrane, some distance above the theca, and probably act as accessory retractors.

Cellular Structures.—The membraneous and chitinous walls of the proboscis are lined throughout by an indefinite layer of the small round cells, the hypodermis. In certain regions, chiefly on the posterior surface of the labial gutter and at the bases of the teeth, this layer is replaced by a definite row of cubical chitinogenous cells, usually separated from the pigmented chitin by a layer of fibrous non-chitinized tissue. This fibrous layer is very distinct at the lower end of the labial gutter.

In sections of the labella there is, if the organ was in the extended position, a considerable interval between the cellular walls on each side. This space represents the hæmatocœl. It has no definite boundaries, being, strictly speaking, an intercellular space. It is in this space that the blood collects when the labella are distended.

The *Labial Salivary Gland* resembles that of *Musca*. It lies behind the lower end of the labial gutter, and is enclosed in a thin membraneous capsule. It consists of large granular uninucleated cells, round or oval in shape, each containing a large vacuole with a chitinous lining. The ducts leading out of these cells have not been traced.

The *Tracheæ* in the haustellum are continuations of the air sacs in the rostrum. There are two small lateral tracheæ of the ordinary type, lying among the muscles

and sending small branches to them and to the labial salivary gland. In the labella there are only a few very small trachea in the external walls.

The Mechanism of the Proboscis.

As has already been stated, *Philæmatomyia* possibly feeds both on dung and on blood, and the structure and mechanism of its proboscis are adapted to both these methods of feeding. So far as the first is concerned, there are no notable differences between this fly and the house fly. The proboscis is extended chiefly by the distension of the large air sacs in the rostrum, and by the contraction of the extensor muscles of the haustellum. The oral lobes are distended by blood, and the fluid sucked up the pseudo-tracheal channels. The mechanism of extension can be readily demonstrated in a freshly-killed insect, in which the proboscis is withdrawn, by laying it on a slide and compressing the front of the head, above the lunule, with a pair of needles. The rostrum at once distends and shoots out from the under surface of the head, and the haustellum straightens itself on the rostrum. The labella are then erected, and can be seen to fill up with a yellowish fluid, which pushes out the pseudo-tracheal membrane of the oral surface, and renders the pseudo-trachea visible. That it is fluid and not air which distends the oral lobes is readily shewn by continuing the pressure: the tracheæ can then be ruptured, and small bubbles of air collect in the fluid in the labella, floating to whichever surface happens to be uppermost. By further pressure on the rostrum from above downwards one can sometimes rupture the pseudo-tracheal membrane; the labella then collapse and a small drop of fluid escapes.

The labella when extended for use are converted into a bag filled with fluid. The upper portion of the bag, formed by the external walls, is stiffened by the chitinous plates to give a certain amount of rigidity to the organ; the lower part, limited by the flexible pseudo-tracheal membrane, is readily adapted to the surface on which the fly is feeding, the pseudo-tracheal channels being kept intact by the chitinous rings, and opened out as the membrane is stretched.

The proboscis is withdrawn by the contraction of the retractor muscles in the haustellum, and by the relaxation of the tension in the air sacs. The folding of the labella on the haustellum appears to be brought about by the elasticity of the membraneous walls, which, when the air sacs are no longer distended, and the muscles in the labium relaxed, drives out the blood.

Before discussing the mechanism by which the insect obtains blood it is necessary to consider the position of the labella, relative to the labium, in the open and

closed positions. When the labella are not in use, the oral surfaces are contracted and in contact with one another, the lower limit of the organ being formed by the scaly border of the external surface. The labella are rotated backwards, the heart-shaped sclerite in the posterior surface coming to lie in contact with the posterior surface of the theca. The labellar rods rotate backwards on the fixed point provided by the attachment of their tubercles to the end of the labial gutter, carrying the teeth and the serrated blades with them. The rods continue to lie in the long axis of the labella as they are turned backwards, so that, when the labella are closed, the upper ends of the rods project forwards and slightly downwards.

The method by which the wound is made is best studied by the dissection of freshly killed flies, the actions of the muscles being tested by pulling on them with a needle. The anterior or mesial sets are found to erect the labellar rods and to bring them into line with the labial gutter. The posterior muscles pull the furca upwards, and so exercise a tension on the labellar walls to which the furca is so intimately attached, pulling the pseudo-tracheal membrane away from the teeth, and by traction on the membrane to which they are attached rotating them into a horizontal plane. When this occurs their cutting edges are turned upwards. What appears to occur when the fly commences to feed is this. The labellar rods are erected and the tip of the proboscis pressed against the skin of the host with the teeth in the closed position ; the labellar rods being fixed in this position by their muscles, the furca and the walls of the labella are pulled upwards so that the pseudo-tracheal membrane is drawn away from the teeth, which by a continuation of the traction are rotated through a right angle into a horizontal plane, their cutting edges being pressed against the skin of the host. This is repeated with very great rapidity, and imparts to the head of the fly a vibratory motion which can often be observed at the commencement of feeding. At each successive contraction the teeth are thrust a little further into the skin, until eventually blood is reached. The action is rather a scarification than " biting." Whether the blood once it begins to flow is sucked up through the medium of the pseudo-tracheal membrane or whether it goes directly into the mouth it is difficult to say, but I am inclined to think that the membrane is drawn entirely out of the way, and that its function as a filter is performed by the remarkable serrated blades. These structures, like the teeth, are attached to the membrane, and must be drawn upwards in the same way, but in advance of them, and will therefore sweep away the cellular debris produced by the teeth, each time they are drawn through the wound, and will prevent the ingress of large particles into the mouth. When the teeth are drawn up the axial apophysis becomes the lowest part of the proboscis, and projects beyond the teeth ; it probably materially assists in the cutting operations by fixing the distal ends of the labellar rods.

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Explanation of Reference Letters.

ap.	Labral apodeme.
a. p. h.	Anterior plate of pharynx.
a. pm.	Anterior membraneous wall of pharynx.
ax. p.	Axial apophysis.
c.	Chitin of head capsule.
d. ph.	Dilator muscle pharynx.
ds, ds′, ds″.	The sclerites of the external wall.
ex. h.	Extensor muscle of haustellum.
f. h.	Flexor do. do.
fr.	Furca.
fu.	Fulcrum.
hy.	Hypopharynx.
j.	Joint on the fork of the theca.
l. d. m.	Dilator muscle of labrum-epipharynx.
l. ep.	Labrum-epipharynx.
l. g.	Labial gutter.
l. gl.	Labial salivary gland.
l. k.	Keel of the labial gutter.
l. r.	Labellar rod.
l. s. d.	Lateral sclerite of pharynx.
l. t.	Fibres from the lateral margins of the theca.
m.	Membraneous portion of the wall of the proboscis.
m′.	Extensor muscle of the labellar rods.
m″.	Retractors of the furca.
m″′.	Accessory retractors.

p.	Palp.
pt.	Pseudo-trachea.
ptm.	Pseudo-tracheal membrane.
r.	Spines of the stalk of the serrated blades.
r'.	Rod like hairs.
r. h.	Retractor muscles of the haustellum.
s.	Stalk of the serrated blades.
s'.	Leaf-like scales.
s".	Serrated blades.
s. d.	Salivary duct.
t.	Teeth.
t. f.	Fork of the theca.
th.	Theca.
tp.	Expanded end of labellar rod forming a socket for the teeth.
tr.	Trachea.

Plate I.

Fig. 1.—The proboscis in profile, drawn from a potash preparation. The labella are in a semi-erected position; when fully erected the labellar rods come into line with the labial gutter. × 33.

Plate II.

Fig. 2.—The hypopharynx, torn from the base of the labial gutter. × 44.

Fig. 3.—The labrum-epipharynx, posterior surface. × 44.

Fig. 4.—The labellar rods and axial apophysis as seen from the front. The distal end is expanded and ill-defined, forming a cup for the reception of the teeth. × 80 about.

Fig. 5.—The fork at the lower end of the theca. × 44.

Fig. 6.—The furca; the ends of the thecal fork ride in the notches at the end of the furca. × 44.

Fig. 7.—The distal end of the labial gutter. × 250.

Fig. 8.—The edge of the external wall of the labella. × 250.

Plate III.

Fig. 9.—The teeth and connected structures of one side, as seen from the inner side of the labellum. Note how the bases of the teeth fit against the expanded end of the labellar rod. × 250.

Fig. 10.—One of the lateral teeth seen in profile, detached. × 250.

Fig. 11.—The spines on the stalk of the blades (r. in figure 10). Very highly magnified.

Fig. 12.—One of the small rod-like hairs. r' in figure 10. Very highly magnified.

Fig. 17.—Section through the haustellum in the region of the keel. Note the concave surface formed by the labial gutter and the hypopharynx, on which the labrum-epipharynx rests. × 250.

Fig. 18.—Section at the upper end of the haustellum. The labrum-epipharynx has here become a closed canal; the keel of the labial gutter is approaching the theca. × 250. The tracheæ are large and shew an irregular contour, indicating that they are capable of distension.

Plate IV.

Fig. 13.—Oblique section through the labella and lower end of the labium. The labella were in a semi-erected position in this preparation, so that the end of the labial gutter and the teeth appear in the same section. The pseudo-tracheal channels are seen turned inwards on the internal surfaces of the labellæ, beneath the serrated blades. The appearance of a space below the pseudo-trachæ is due to the presence of an indentation on the posterior surface of the labella. Note also the fibrous tissue separating the labial gutter from the subjacent chitinogenous cells. × 250.

Fig. 14.—Oblique section through the lower end of the labium and the labella; from the same series as Fig. 13, but a little higher up. The pseudo-tracheæ, now only one on each side, are seen terminating in a duct with a cellular lining, cut here almost in longitudinal section. The labrum-epipharynx and hypopharynx are cut in section at their tip. × 250.

Fig. 15.—Transverse section through the lower end of the labial gutter. × 250.

Fig. 16.—Transverse section through the lower end of the labial gutter, in the region of labial salivary gland. Note the thickness of the walls of the labrum-epipharynx, and the incurvation of the edges of its groove. × 250.

Fig. 20.—Transverse section of the lower end of the pharynx in the rostrum. Note the membraneous anterior wall, and the salivary duct, lying in a mass of cells and inter-cellular fibres. The wall of the duct is not chitinized. × 250.

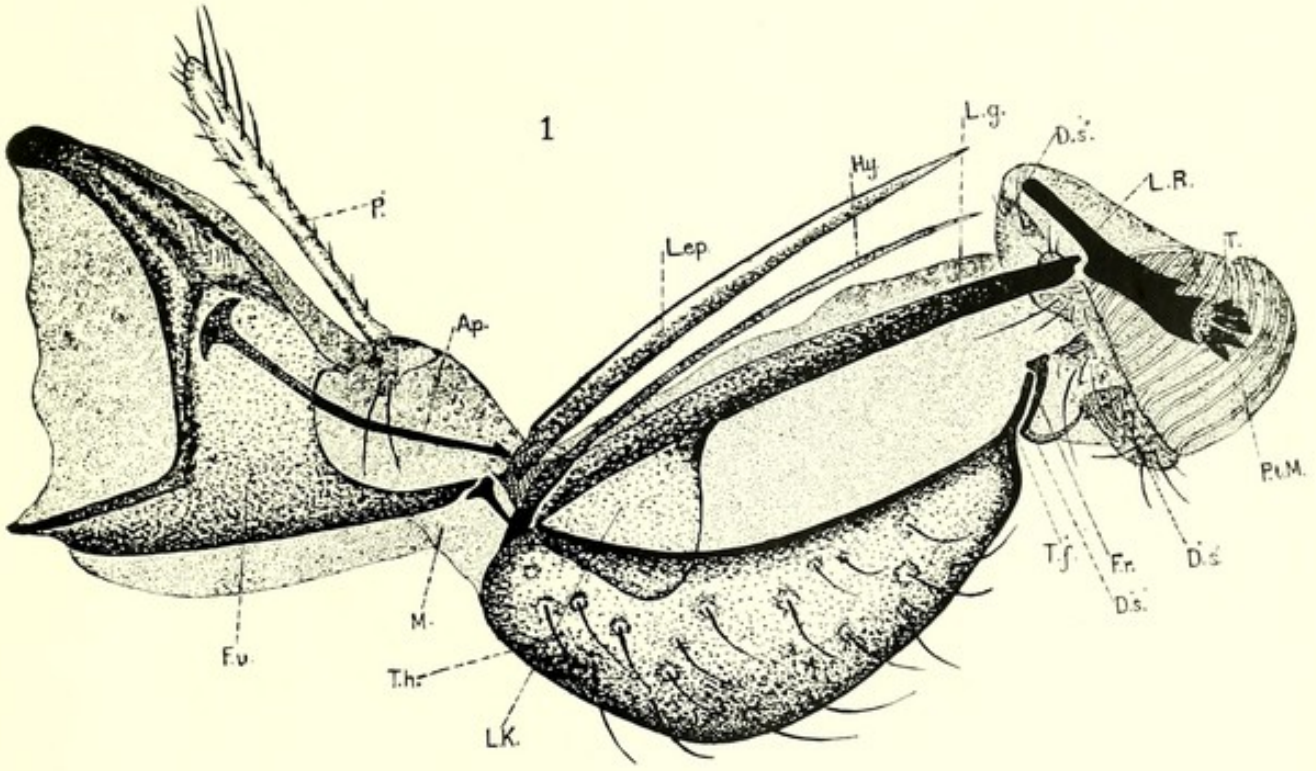
Plate V.

Fig. 19.—Transverse section through the labium at its extreme upper end. The labial gutter and hypopharynx are fused in a dense mass of pigmented chitin, which is pierced by the salivary duct. The labrum-epipharynx is adherent to the central chitinous mass. × 250.

Fig. 21.—Transverse section through the lower end of the pharynx in the rostrum, showing the lateral sclerites and the mass of cells in which the salivary duct is embedded. × 250.

Fig. 22.—Oblique section through the rostrum when partially withdrawn beneath the head. Note the infolding of the lax membrane, and the wrinkled contour of the contracted air sacs (tr.). The salivary duct is here definitely chitinized. × 250.

PLATE I.



P. W. O. - DELET.

Photo.-Engraved & printed at the Offices of the Survey of India, Calcutta, 1912.

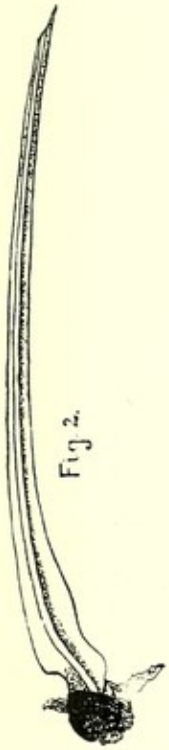


Fig. 2.

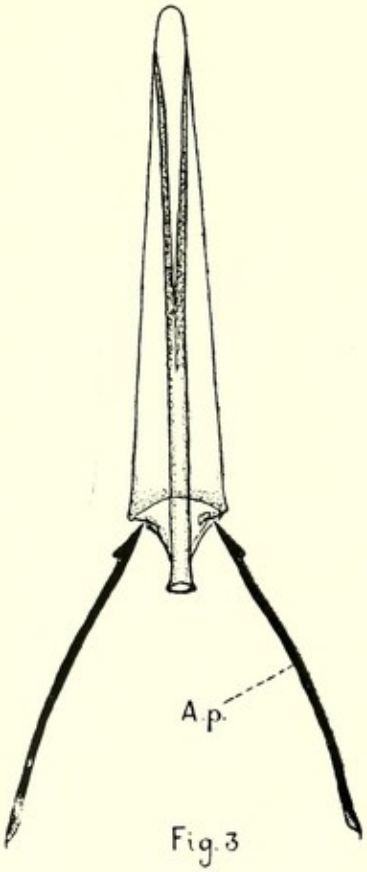
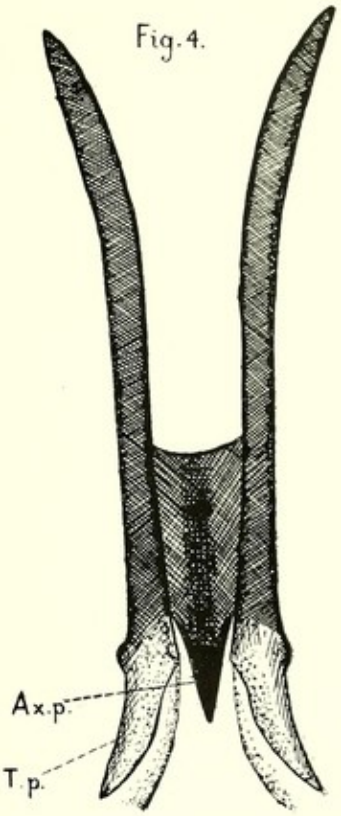
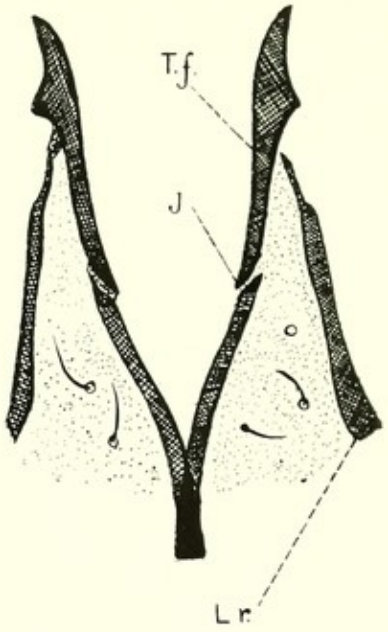


Fig. 3

Fig. 4.





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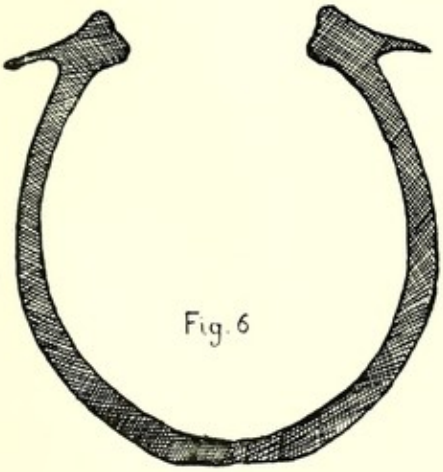

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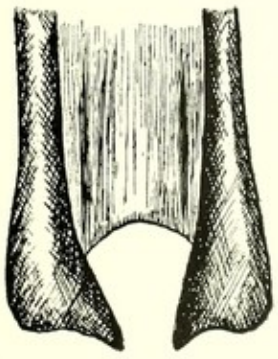

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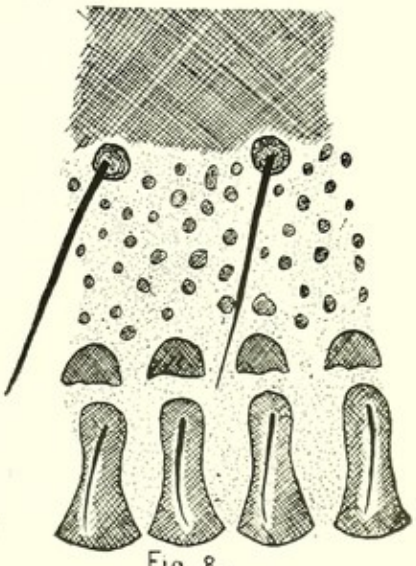

Fig. 8.

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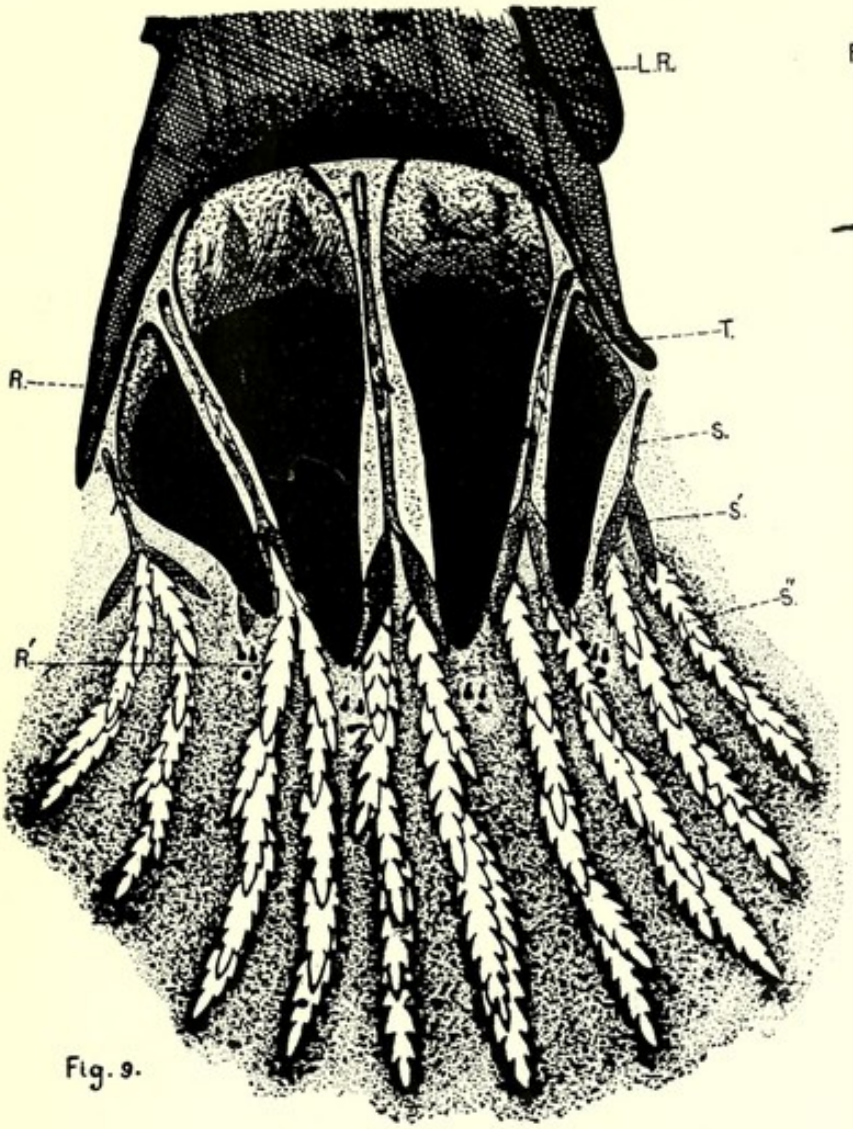

Fig. 9.

Fig. 10.

Fig 11.

Fig. 12.

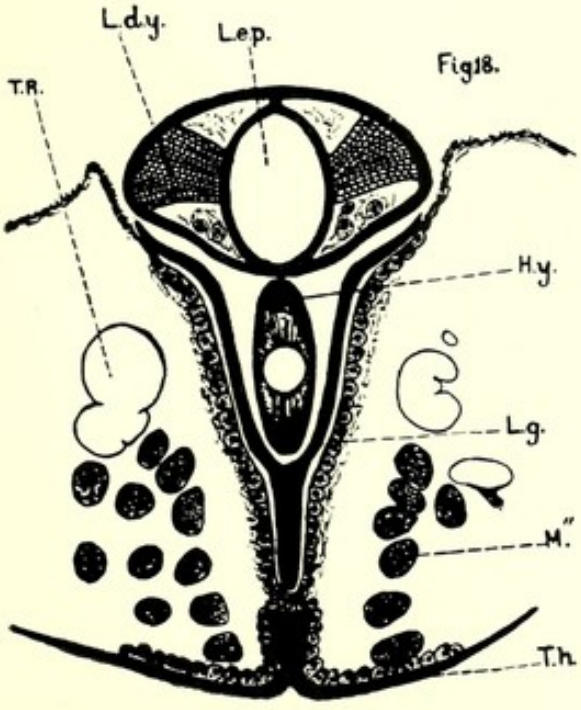

Fig18.

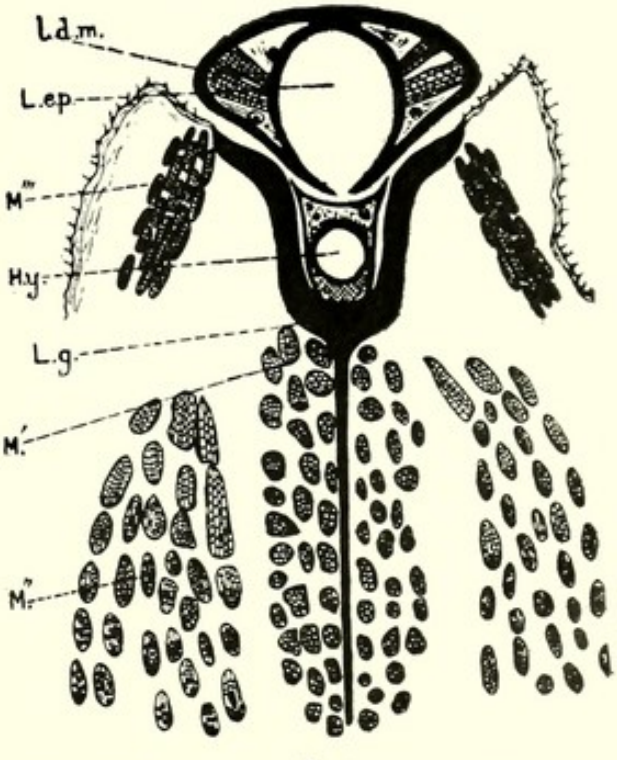

Fig.17.

W. C.- DELET.

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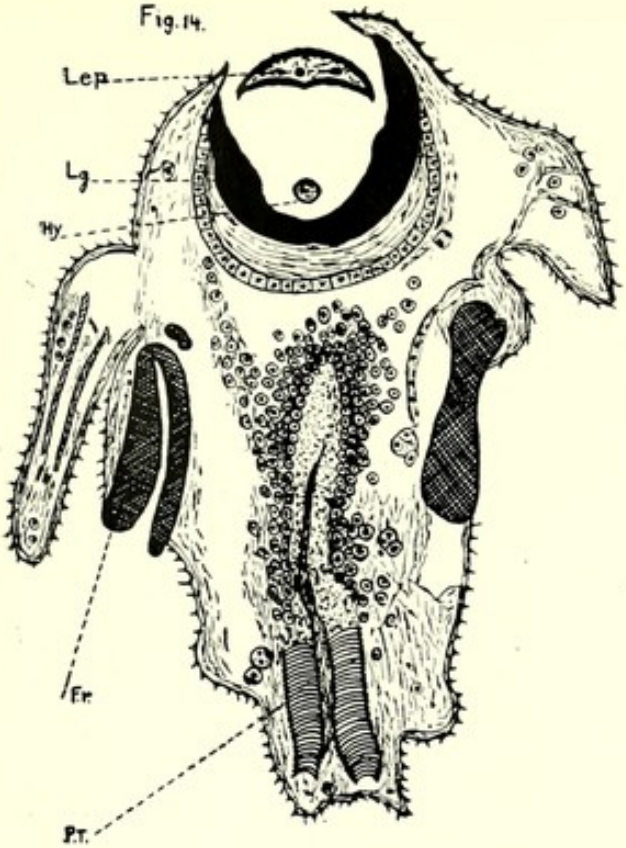


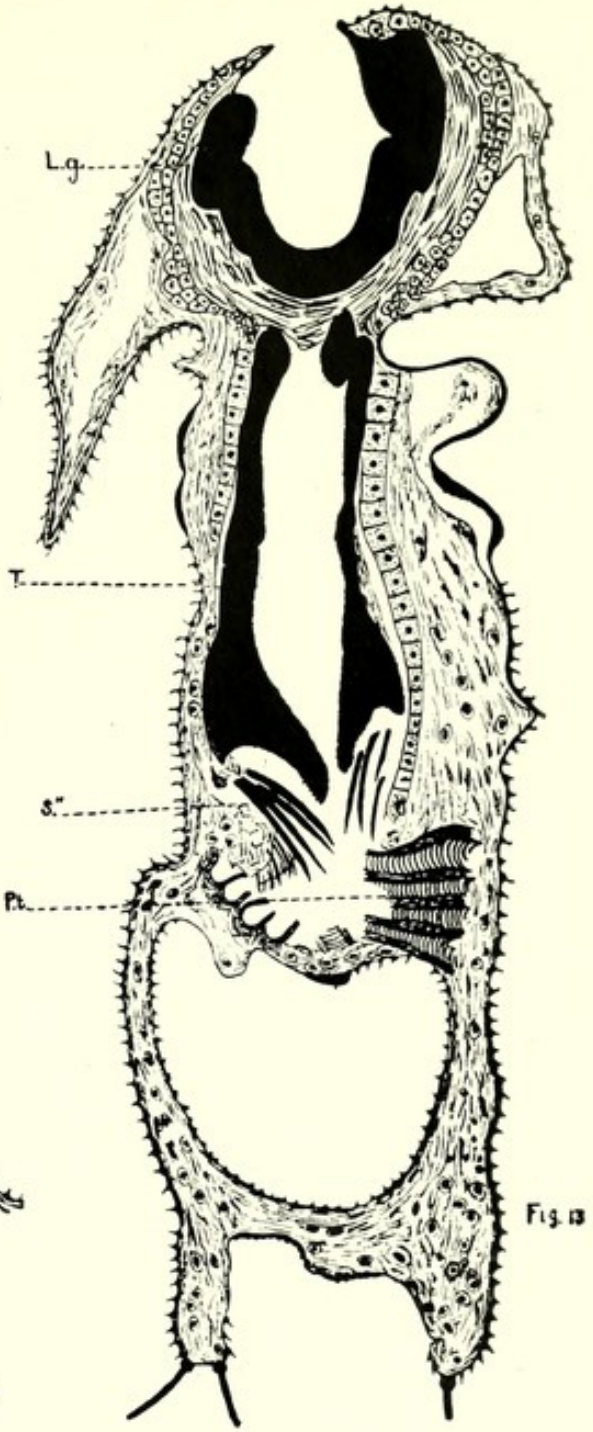
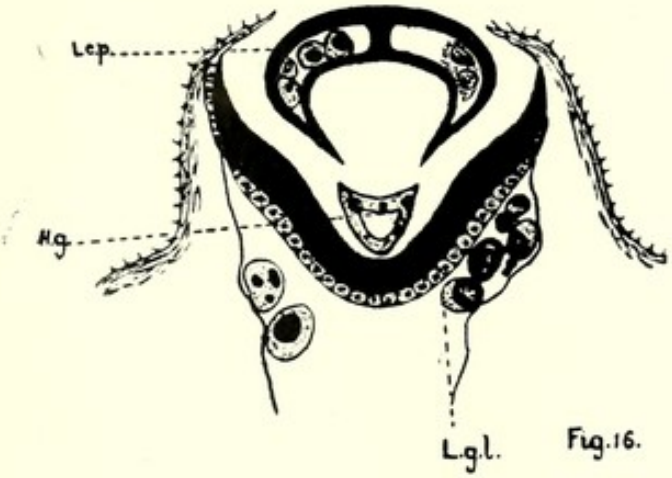


Fig. 13



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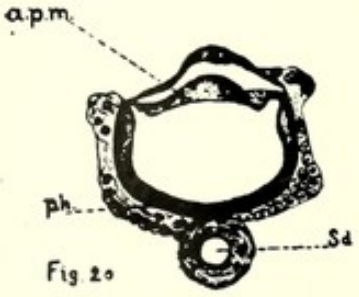

Fig 20

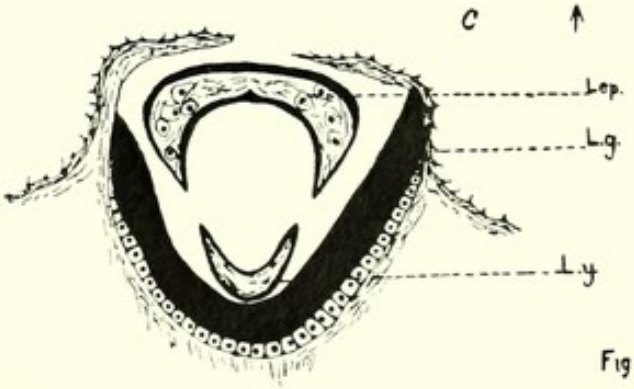

Fig 15

P. W. C.-DELHI.

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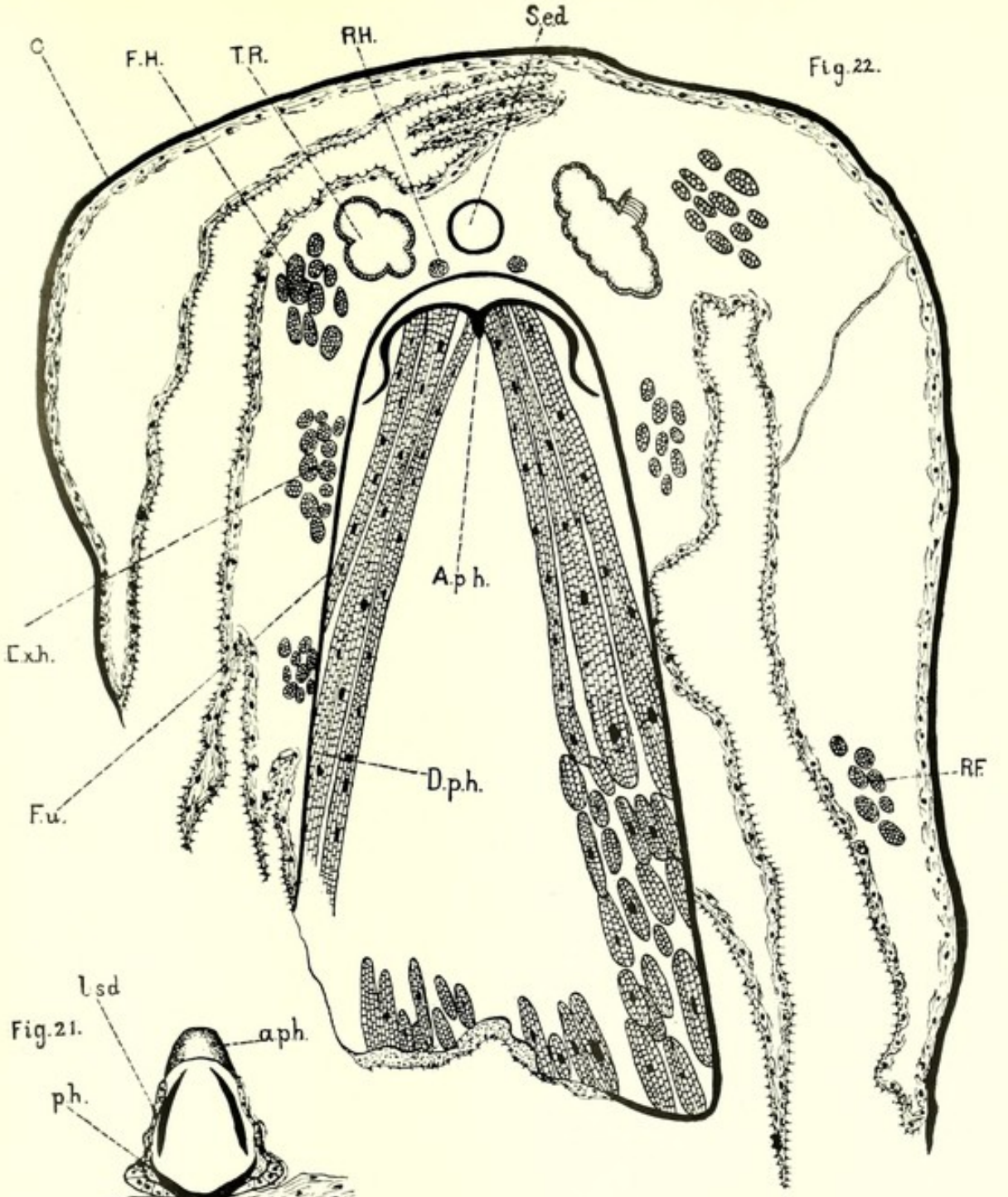

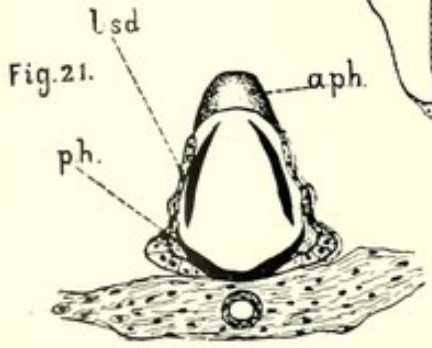

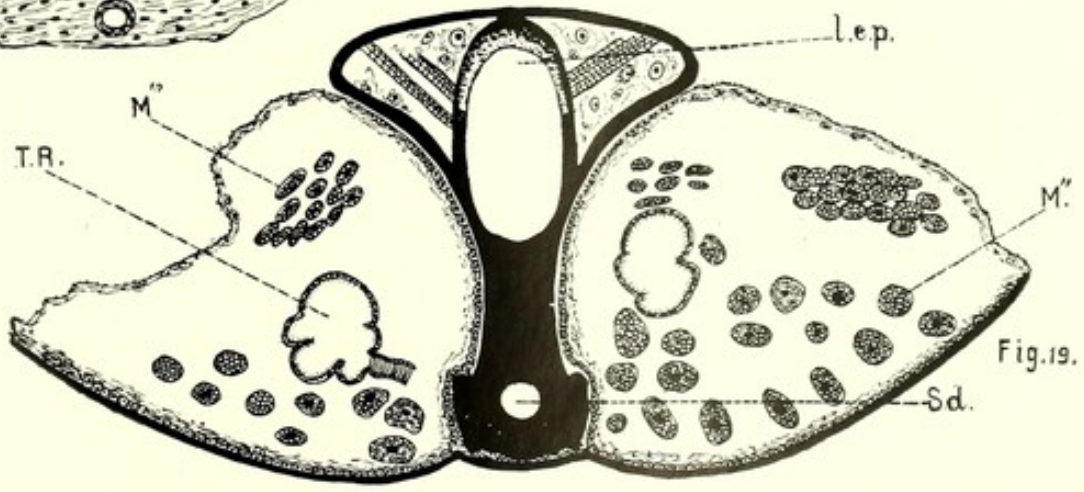

P. W. C. - DELET.

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