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T H E S I S

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on

THE STRUCTURE of HAEMATOPOTA PLUVIALIS

[Meigen]

BY

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HAEMATOPOTA PLUVIALIS. o [Meigen.]
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I N T R O D U C T I O N .

In reviewing the progress of medicine during the last two or three decades, one cannot but remark on the enormous widening in the field of investigation which has taken place. To the old methods of pathological investigation there have been added a host of new methods, and many branches of science, formerly un-connected with medicine, have been brought to bear on the problems of disease. It is perhaps characteristic of the modern period, that progress is being made, not so much by new and startling discoveries, but by the application of new methods of study to old problems, and by the adoption of new points of view. There is hardly a branch of medicine in which this is not the case, and it is in none more marked than in the study of the diseases peculiar to the tropics. The discovery of the malarial parasite, and the subsequent demonstration of its developmental cycle in the mosquito, gave a new impetus to the study of the parasitic protozoa, and it has become year by year more evident how large a proportion of the diseases which the practitioner in tropical climates is called upon to treat - and to investigate - are due to these organisms./

organisms. Ross' discovery was an epoch making one, not only because it made clear the way for rational methods of dealing with malaria as an endemic disease, but because it led to a close study of the parasitic protozoa as a whole, and was the starting point for an enormous amount of research work, much of which has already been brought to a successful issue.

There is good reason to suppose that the parasites of mammalian blood, and those of the blood of birds, are normally transmitted from the infected to the non-infected animal by means of an intermediate host, usually a blood sucking arthropod, and that in many cases, if not in all, the parasite undergoes in the body of the intermediate host certain developmental changes, which are essential to its continued propagation. The study of the structure and life history of these intermediate hosts has therefore become a matter of primary importance, both for the elucidation of the life history of the pathogenic agent, and for a rational prophylaxis against the disease. In this way a knowledge of entomology, particularly as regards the biting flies, has become an essential part of the equipment of those engaged in the study of tropical diseases, and the/

the subject has received considerable attention of late, accounts of the structure and natural history of most of the arthropods actually incriminated as carriers of disease having been published.

The fly which is the subject of this thesis may be taken as a fairly typical member of the Tabanidae, a family of Diptera which is universally distributed, and in which the blood sucking habit is almost universal in the female sex. Up to the present it has not been demonstrated that any member of the group acts as an intermediate host, in the strict biological sense, to any parasite of mammalian blood. There is, however, a considerable amount of evidence that certain Tabanidae can act as transmitting agents in various trypanosome diseases, notably Surra and the allied conditions. Rogers, (1) in 1901, showed that "horse flies" can transmit Indian surra if the flies are made to bite an uninfected animal within twenty-four hours of biting an infected one, and the brothers Sergent, (2) working with Atylotus tormentosus and A. nemoralis, obtained similar results in the disease Debab, which affects dromedaries in the Soudan. More recently these results have been confirmed by Fraser and Symonds (3), in the Federated/

Federated Malay States, positive results being obtained with Tabanus fumiger, partitus, vagus, and minimus, in Surra. Certain Tabanidae are also suspected in Mbori, in the trypanosomiasis of horses in Annam, and in Mal de Caderas, Souima, and Mal de Zusfana, though in many of these cases the suspicion appears to rest more on the local prevalence of the fly and on popular opinion, than on experiment.(4)

In considering the results of the large number of negative experiments recorded, one must never lose sight of the fact that in the cases of Sleeping Sickness and Malaria, it has been conclusively proved that only particular species of the respective groups can act as transmitting agents. The number of species of Tabanidae in most tropical countries is very large, and it is possible that the results of many experiments may have been negative simply because the observer was not fortunate enough to use the proper species of fly. On the other hand one must regard simple mechanical transmission, by trypanosomes adhering to the mouth parts of the fly, and being injected into the next animal on which it feeds, as possible. A developmental cycle in the intermediate host is not essential in trypanosome infections, since, by simple hypodermic injection/

injection, the organisms can be passed through laboratory animals for an indefinite period. The chances of infection by such mechanical transmission are of course very small, since the number of trypanosomes in the blood of naturally infected animals is not usually great, and it is probable that something else occurs in most cases.

In this connection there is a somewhat neglected observation of Roubard's (5) which, if confirmed for any of the Tabanidae which have been proved capable of transmitting trypanosome diseases would offer an explanation of the constancy of the results, even if it does not establish a developmental cycle. He found that immediately after feeding on an infected animal, the proboscis of glossina palpalis contains numerous actively motile trypanosomes. In a short time the organisms attach themselves to the walls of the proboscis, and undergo a structural change, becoming Herpetomonas like organisms, the flagellum being thickened and used as a stalk by which the organism is attached. They then commence to multiply rapidly, and form little colonies in the walls of the labium. The trypanosomes when in this stage are motionless in salivary fluid, but become actively motile in physiological salt solution. He found these "cultures" present in/

in probosces for 48 hours with Trypanosoma brucei, and for 5 - 6 days with Trypanosoma gambiense, dimorphon and cazabouli.

It is evident, then, that the Tabanidae must, in the present state of our knowledge, be regarded with grave suspicion, and it is indeed probable that before long one or other of the members of the group will be proved to be the intermediate host of some haematozoon. The question of fly borne disease is one of the gravest now receiving the attention of scientists, and in order that accurate and reliable results may be obtained, the study of the intermediate hosts must progress pari passu with the study of the protozoa.

Apart from the immediate connection of the Tabanidae with disease, the study of a typical member of the group is of considerable interest from the comparative point of view. The Tabanidae are of a relatively simple type, showing the minimum of structural modification consistent with a blood sucking habit, and by a comparison with the Muscidae on the one hand, and the Culicidae on the other, a most interesting and instructive demonstration of the process of adaptation to function is obtained. On account of their larger size and simpler structure the/

the relation of the anatomy to the function is much more readily made out than in *Anopheles*, and the comparison is most useful as a contrast in the interpretation of observations in other blood sucking flies. The following account of *Haematopota pluvialis* should be compared with Hewitt's (6) description of *Musca domestica*, and with Nuttall and Shipley's (7) account of *Anopheles Maculipennis*.

A word is necessary with regard to the name *Haematopota*. Until recently this name was accepted without dispute, but recently an old paper by Meigen, of which only two copies are known to exist, has been unearthed, and from this it appears that, previous to the adoption of the name *Haematopota*, the genus was named by Meigen *Chrysozona* (8). A strict adherence to the established rules of zoological nomenclature would therefore necessitate the substitution of the name *Chrysozona* for the well known one of *Haematopota*. The matter is still in dispute, and it remains to be seen whether the change of name will be universally accepted. The old name is used in this paper pending a settlement, since Mr Austen is kind enough to inform me that he has not adopted the name *Chrysozona* for official use in the British Museum.

FIELD NOTES.

Under various local names, such as "cleg", "gadfly", "horse fly", the female *Haematopota pluvialis* is well known in most parts of the British Isles, and is much the commonest member of the Tabanidae found in this country. It is on the wing from early June to the end of August or even later, and frequents damp pastures and country lanes, being seldom found far from water, or near houses. Its appearance depends to a remarkable extent on favourable conditions, viz. abundance of sunshine and an absence of wind, and, even in suitable weather, it varies greatly in numbers in different years, from no ascertained cause. Its flight is at times swift, but usually, when about to feed, it is rather deliberate and hovering, and is accompanied by a faint hum. So far as is definitely known, the fly is exclusively a blood-sucker, and attacks indifferently horses, cattle, or man, choosing those which are stationary or moving quietly about, and not selecting any particular part of the victim, the piercing organs being able to penetrate even the thickest parts of the skin.

The method of feeding, as observed on one's own hand, is as follows. After a short preliminary/

preliminary investigation, in which the labium appears to be used as a tactile organ, the piercing styles are inserted by a series of short sharp forward thrusts of the thorax, the labium being retracted and the labellae everted behind the rest of the proboscis, and the maxillary pulps extended in front. As the wound is deepened the fly elevates itself on its hind legs, till the abdomen is tilted up at an angle of 45° or so, the forelegs being meanwhile extended in front of the proboscis, with their tibiae held parallel to the surface. While in this position the abdomen gradually distends, and slight peristaltic movements can be seen in it. In a short time a clear fluid begins to exude at the anus, and this goes on as long as the insect feeds, the fluid becoming tinged with blood towards the end of the meal, and even, in some cases, appearing to consist of unaltered blood. Several times during the process the mouth parts are withdrawn a little and again thrust in; finally they are withdrawn by a few sharp jerks, and the fly, after resting a moment to clean its proboscis with its forelegs, flies away. A small drop of blood usually oozes from the puncture, and a faint ring of hyperaemia/

hyperaemia, and usually some slight irritation, mark the site for a day or so. The pain caused by the bite is usually trifling, less than that of a mosquito bite. Some individuals, however, appear to be remarkably sensitive, and suffer for days, even a week or longer, from local irritation and inflammation.

The fly takes about three minutes to obtain a full meal, and while feeding it is not readily disturbed; the process can be watched, on one's hand, through a pocket lens.

The habit of defaecating while feeding, usual in blood sucking insects, has an important bearing on the question of the normal parasites of the fly, for it is obvious that any encysted phases of such parasites which may be free in the hind gut at the time of feeding will be deposited on the skin of the host, and will be in a position to be taken up by another fly. In the case of the Tabanidae it is easy to see how such parasites might be caught in the everted labellae, and so find their way into the pharynx as the insect feeds.

This species is not gregarious, except in the sense that large numbers may be found feeding on the same host, and they do not appear to collect in particular localities in/

in the evening, as described by Hine (9) for certain American Tabanidae. In view of their habit of defaecating on the skin of the host, it does not appear to be necessary to assume that parasites are transmitted from one fly to another, as described by Patton (10), by the uninfected fly, inserting its proboscis into the faeces of an infected fly, in their evening resting places.

The male of this species is extremely seldom met with⁺, even in localities in which the female is common enough to be a nuisance. During two months in ~~the~~ district where the females could be seen almost every day, only two males were caught, and both of these were obtained early in the season. The male is a flower feeder, and does not suck blood. A suggestion as to the cause of its remarkable scarcity will be made when considering the reproductive organs of the female.

METHODS.

The parts were studied by the dissection of fresh specimens, and by the preparation of serial sections. Dissections of the various organs, after fixation in sublimate alcohol, were stained in various ways, chiefly with borax carmine and Delafield's/

+ Vide Bruce, Report on Sleeping Sickness. Com. Proc. Roy. Soc. B. Vol. p. 565

Delafield's Haematoxylin, and mounted as permanent preparations. The chitinous parts were dissected after treatment with caustic soda solution for varying periods, with or without decolorization with chlorine gas. The proboscis, head, thorax, and abdomen were separately embedded and cut in serial sections by the combined paraffin and celloidin method, and the sections, though showing a good deal of shrinkage as a result of the long time required for complete penetration of the fluids, were very useful in checking the result of dissection.

For the study of the mouth parts and of the complicated structures at the base of the skull, it was found convenient to embed the whole head, after prolonged treatment with a weak solution of caustic soda, in paraffin, and then to cut away by hand the portions not required. The paraffin was then dissolved off in clove oil, and the preparation mounted, with or without further dissection, in a hollow slide. Similar preparations were made of the sides and lower part of the thorax, and were found to be much more satisfactory than simple dissections.

The separate organs were fixed and preserved/

preserved after dissection in Bles' fluid*, and subsequently embedded and cut in sections. This is a most convenient method of fixation when one is away from a laboratory and the tissues, even after preservation for several months in the fluid, stain quite well.

In the description of the parts, the terms superior, anterior, etc, are used in their strict anatomical sense, with reference to the fly in a resting position on a horizontal surface. It is important to note this in the description of the head, since the mouth parts are almost perpendicular to the long axis of the body. The term proboscis is used to include all the protruding mouth parts.

* Formalin.	7 Parts
Alcohol, 70%	90 "
Glacial Acetic Acid.	3 "

EXTERNAL ANATOMY.

(1) THE HEAD.(a) External Appearance (Plate III Fig. 10)

The head has the shape of a somewhat flattened dome; it is rather more than twice as broad as it is long, and is a little broader than the thorax. The antennae project forwards from the apex of the dome, and the proboscis hangs downwards from the lower surface. The base of the dome, forming the posterior surface of the head, is concave to correspond with the convexity of the prothorax. The outer thirds of the head, as seen from the front, are occupied by the large compound eyes, the space between them being filled in by a square shaped piece of the Epicranium. This piece is light fawn colored, is covered with fine hairs, and has on it three pigment spots, two large and anterior, the third much smaller, mesial and behind the other two. There are no ocelli. The posterior border of this epicranial plate, constituting the vertex of the head, is hollowed out into a shallow groove, which is continued on to the posterior surface of the head. Bounding this groove there are two/

two ill defined sutures, which pass from the posterior and internal angles of the eyes to the posterior surface of the head, converging towards the occipital foramen.

In front of the above piece, at the apex of the dome, there is a shining black transverse band, elevated somewhat from the surface, which bears the antennae. This band occupies almost the entire space between the eyes, and is separated from the epicranial plate behind and the clypeus below by definite sutures.

The Clypeus is an oblong plate, rather narrower above than below, which stretches from the antennal plate to the labium. It is light fawn in color, and is speckled with fine pigment spots, and covered with fine hairs. There are two pigment patches, resembling those on the superior epicranial plate, in its upper half. The anterior openings of the intracranial tunnels, to be subsequently described, lie in the lower third of the sutures bounding the clypeus on each side. The Genae, as seen from the front, fill in the triangular areas between the eyes and the clypeus; there is no suture intervening between them and the posterior surface of the head. They resemble the clypeus in coloring, and/

and are dotted over, especially in the upper parts, with coarse pigment spots, and have a dense coating of long fine hairs, which project inwards to merge with those in the maxillary palps.

The posterior surface of the head is vertical, and slightly concave. The occipital foramen is situated near its lower border; in front of this opening, there is on each side a small stirrup shaped aperture, the posterior end of the intracranial tunnel.

The Eyes are conspicuous for their large size and beautiful coloring. The ground color is a bright iridescent greenish gold, which unfortunately fades rapidly on the death of the insect. Running transversely across the eye there are five irregular bands of reddish brown; these markings are retained, though somewhat faintly, in specimens preserved in alcohol. The facets of the eye are hexagonal, with rounded angles, and are of approximately equal size and shape throughout. There are a few minute hairs scattered over the surface.

The Antennae, (Plate III Fig.12), are situated on the antennal plate already noted. They consist of three joints, the distal one being about as long as the first and second together. The first /

first joint is cylindrical, the second short and round. The third joint is ringed, having upon it three constrictions, which divide it into four segments. The first of these segments resembles the basal joint, but is more slender; the second and third segments are equal, and short and round; the terminal segment, which is rounded at its apex, is a little longer than the two preceding ones together. The first joint is rather sparsely covered with large black forwardly directed bristles; the second joint has a set of similar bristles arranged in a whorl, and a few similar but smaller hairs are arranged about the constrictions on the distal joints, and in a loose whorl round the middle of its first segment.

(b) The Mouth Parts.

These consist of two paired organs, the Mandibles and maxillae, three single mesial styles, the labrum, epipharynx, and hypopharynx, and a large fleshy labium, in the groove on the anterior surface of which the piercing styles lie when at rest.

The Mandibles, (Plate II, Fig.9), are the most powerful of the piercing organs. The blade has/

has the shape of a short, broad, pointed and slightly recurved sabre. The internal edge is armed, in its distal half, with a regular row of extremely minute serrations; the proximal half of the edge is extremely fine and attenuated. The external edge is sharp only at the distal end. Proximally it broadens out, so that the blade becomes triangular in cross section, and two stout strands of chitin are developed along its margin, one of which crosses the surface of the blade, while the other runs directly upwards to the base of the mandible. These two strands are produced into two cornua, and the horseshoe shaped arch between them is further strengthened by thick fibres. The external horn articulates with a projecting angle of the epicranium, the joint corresponding to the ginglymus of mandibulate insects. The internal horn is free, and lies on the membrane which completes the base of the skull in this region.

The Maxillae, (Plate II, Fig. 1 & 2), are remarkable in that the several parts of a primitive first maxilla, viz. cardo, stipes, galea, lacinia and palpus, can be readily recognised.

The Lacinia, or blade, is a stout slip of chitin, the same length as the mandible. It is quadrilateral/

quadrilateral in section at its tip, but becomes flattened proximally, and at the base merges with the stipes, the yellow chitin characteristic of the piercing parts giving place to that of the ordinary skeletal type. The tip is armed with a covering of minute flat teeth or rasps, arranged in a somewhat imbricate manner, with their points projecting upwards. These teeth are continued along the edge of the blade as it becomes flattened, for about half its length on the inner side, not quite so far on the outer side. The blade is strengthened by the development of two strands of chitin, one of which, the larger, runs down the middle, and merges with the stipes, while the other, lying nearer the internal edge, is produced into the galea.

The Maxillary Palp, which rises from the outer side of the stipes some distance above the base of the lacinia, is two jointed and antenniform. The first joint is short and cylindrical, the second conical and pointed, and much larger than the first. Both joints have a dense covering of long fine hairs, many of which are pigmented. The two palpi turn inwards and forwards from their origin, and so come to lie in contact with one another, in front of the basal piece of the labium, in such a way as to close in/
in/

in the groove in which the piercing organs lie when at rest.

The Galea, is a short peg-shaped projection arising from the inner edge of the lacinia at its base. The two galeae project inwards opposite to one another at the level of the articulation of the mandible, and assist in supporting the membrane at the base of the skull.

The Stipes, which is directly continuous with the lacinia, is a much convoluted piece, lying behind the pharynx, and extending upwards to a point about midway between the base of the mandible and the occipital foramen. It may be described as consisting of a vertical rod, flattened transversely, and bent outwards in its lower third, then inwards and again outwards at its upper end, where it articulates with the cardo. The lower third of inner edge is turned forwards, and there is a blunt projecting spur on the middle of the outer edge. On the posterior surface of this plate, at its lower end, there is a well marked ridge, into which the palp is attached.

The Cardo, is a small wedge shaped piece which connects the maxilla with the cranial wall. Its base articulated with the stipes, while its apex which/

which is turned outwards, rests in a notch in the thickened edge of the epicranium bounding the central space (Plate III, Fig. 13). The cardo lies behind the base of the intracranial tunnel, and is crossed by the attachment of this tube to a curved rod, to be subsequently described.

The Labrum (Plate II, Fig. 7) is a thin spatulate slip, which is fused, except for a short interval at its upper end, with the epipharynx. When the two are separated by dissection, it is seen that the labrum does not extend quite to the tip of the epipharynx and that its margins are extremely thin and illdefined. It is attached to the clypeus by a narrow and Yshaped slip of brown chitin.

The Epipharynx (Plate II, Fig.7) is shaped like a broad two edged sword. It is directly continuous at its base with the anterior of the two chitinous plates which form the pharynx & has on its posterior surface a deep groove, the edges of which are incurved so as to include about $\frac{4}{5}$ of a circle. This groove, when opposed to the hypopharynx, forms the canal up which blood is sucked. The tip of the epipharynx is blunt, and is occupied by three small tubercles, two of which are lateral and anterior, while the third is situated at the extreme/

extreme tip. These tubercles consist of a large number of small blunt teeth, arranged in rows in a radiating manner. The edges of the epipharynx are fine and sharp, and show an oblique striation. Internal to the edges, - there is on each side a strong supporting band of fibres running in a longitudinal direction, and internal to this, between it and the canal, there is a small amount of cellular tissue, well seen in cross section. (plate II. Fig. 4).

The Hypopharynx (Plate II fig.8).

resembles the epipharynx in shape, but is more slender, and tapers more towards its point. It is pierced throughout its length by the salivary duct, which opens at its tip. The edges of the blade contract sharply at the base, where the duct opens into the salivary reservoir. The hypopharynx consists of two laminae, which are readily separated in dissection. The anterior and larger of these is continuous with the posterior plate of the pharynx and with the salivary reservoir, while the posterior lamina is attached to the cornua of the labium.

The Labium. (Plate II Figs.4 & 6) has a somewhat complicated structure. It is partly composed/

composed of thin chitinous plates, and partly of a flexible membrane, which connects the chitinous parts so as to enclose a tubular space, in which there are contained certain muscles and cellular structures. The distal half of the labium is divided into two labellae, on the opposing surfaces of which the anthrodial membrane is replaced by a pseudo-tracheal membrane, similar to that of the house fly. The loose connection of the chitinous plates, by means of the membrane, permits of a considerable degree of movement of the labellae on the labium and on one another. The anterior surface of the labium is deeply grooved for the reception of the piercing mouth parts. The main support of the upper half of the labium is a large shield like plate, aptly termed by Meinert the Scutum. This piece is concave forwards, and forms the posterior and lateral walls of the upper half of the organ. The narrow upper end is produced into a pair of cornua, which lie behind the salivary receptacle and are attached to the non-chitinized membrane, which, as will be seen subsequently, completes the base of the skull. The arched upper border of the scutum has, in each side, a row of six long black macro setae. In the middle of this border/

border a pair of stout, pointed processes, called by Meinert the Cardines, project downwards.

In front of the scutum, and, of course, separated from it by the muscles lying between the membranous folds, there is a somewhat ill-defined chitinous plate, which forms the floor of the groove in which the piercing parts lie. This plate is also concave forwards, though its contour differs considerably at different levels. The membrane which completes the wall of the labium in this region is attached to the sides of this trough like piece and to the corresponding sides of the scutum, and is folded forwards, to a degree varying in different preparations, over the groove on the anterior surface. In this way the membranous wall of the labium, together with the maxillary palps, which lie in front of the upper part of the labium, entirely conceals the rest of the mouth parts. Below the level of the scutum, and external to the cardines, there is on each side an oval plate, called by Meinert the Stylus Extensoris labellae, and by Hansen the Lamina articuli secundi labii. On the internal surface of this plate there is a thick dentate ridge, which curves slightly inwards, so as to rest in the/

the angle on the lower border of the scutum, external to the cardo. The pointed lower end of the plate fits into a notch in the chitinous framework of the labella, when the latter is brought parallel to the surface on which the insect rests.

The Labellae are oval lobes, attached to one another behind, but diverging in front. They are set on the labium at an angle of about half a right angle, so that their long axis points upwards and backwards from the labium. Their outer surfaces are mainly membranous, but are stiffened by the development, on each side, of two thin plates of chitin along the border. The upper one of these plates lies in the projecting posterior angle of the labella, & is square shaped. Its lower side is produced into a narrow spur, which runs forward across the outer surface & bears a row of six or seven short but stout black setae. The anterior side of the plate is incurved below this spur, so as to form a notch for the reception of the "stylus". The lower plate is about twice the size of the upper, & lies in the long axis of the labella. Its upper & anterior arch is thickened & ridged for muscle attachment. Many short, stout, black setae are scattered over the outer surfaces & posterior borders of the labellae; they are especially numerous on the larger chitinous plate. No special sense organs have been found in connection/

connection with these setae, although, from the manner in which the insect uses its labellae, one would expect to find something analogous to the tactile organs in the proboscis of the house fly. The membrane attached to the scutum is produced downwards, and holds together the various chitinous plates described. It is continued for a short distance round the anterior and posterior borders of the labellae, but is replaced, in their inner and opposing surfaces by a pseudo-tracheal membrane. This membrane is clear, transparent, and apparently structureless. Its surface is traversed on each side, by twenty six deep grooves, which converge from the posterior border inwards, so that, accommodating themselves to the oval shape of the labella, the upper ones run downwards and inwards, the lower ones upwards and inwards, while the middle ones are directly transverse. These grooves lead to, but do not actually communicate with, a short but broader longitudinal groove which runs along the inner border of each labella. When examined under a high magnification, it is seen that these grooves are lined with, and presumably kept open by, a series of minute incomplete chitinous rings, set side by side, transversely to the axis of the groove. Each ring/

ring is about three quarters of a circle, & each end is thickened into a little knob, so that the edge of the groove has a beaded appearance.

The labellar muscles arise from the scutum, and are inserted into the lower chitinous plates. They consist of three pairs of muscles, not definitely separated at their origin. The most posterior bundle runs directly downwards to the "stylus", that is, the oval plate lying external to the cardines. The other fibres are inserted into the upper and lower chitinous plates of the labellae, some fibres being traceable almost to the tip. Contraction of all these bundles together will retract the labellae, while contraction of the anterior fibres only will bring the labellae more parallel to the surface on which the fly is resting.

Two trachea enter the base of the labium. They expand at the region of the scutum into two comparatively large air sacs, from which the trachea can be traced downwards for a short distance. There is also a pair of small nerves, lying internal to the muscles.

Cellular Structures. The membrane, and the chitinous plates developed in it, are lined throughout by an indefinite layer of small round cells./

cells. The anterior plate which forms the floor of the groove in which the piercing mouth parts lie is lined by a single layer of small regular cubical cells, which extends forwards to the junction of the plate with the membrane. The pseudotracheal membrane is lined throughout by a single layer of similar, but larger, cubical cells. There are a few fat cells scattered about the interstices of the organ.

The space between the pseudotracheal membrane and the outer wall of the labella is almost entirely filled up by a large mass of cells, which probably represents a labial salivary gland (Plate II, Fig. 3 & 4.). These cells are remarkably large, averaging about 40 μ m. in their long axis. They are oval or pear shape, and are arranged with their narrow ends pointing towards the pseudotracheal membrane, the innermost ones lying in contact with the cubical cells. The nucleus is round or oval, and is situated at the broad end of the cell. The chromatin appears to be separated into a large number of small rods, mainly aggregated about the periphery. In many cells there is a second nucleus, usually very small, situated at the narrow end of the cell. The protoplasm contains many fine granules, and is, in a small proportion of the cells/

cells, vacuolated. In each cell there is a crescentic or sickle shaped area, near the nucleus, where the protoplasm is non granular and does not stain well, being only faintly tinged by eosin. In a few cells a distinct vacuole can be made out inside this area.

It is evident from its structure that the labium exercises other functions as well as the obvious one of protecting the other mouth parts. The pseudotracheae differ in no essential particular from those of the house fly, except that there is no direct communication between them and the alimentary canal. This is not, however essential. If fluid is drawn inwards along the pseudotracheae by capillary attraction, it will come to lie in contact with the hypopharynx and epipharynx, the distal ends of which lie between the two internal longitudinal pseudo-tracheae. It may, then, either by capillary attraction or by contraction of the pharyngeal muscles, be drawn into the pharynx. I have never myself seen Haematopota drink, but it appears to be generally agreed that Tabanidae do so. Austen, (13) quoting Pontschinsky, states that in Russia house flies are destroyed in large numbers by pouring petroleum on the pools to which they resort.

There are no ducts to be made out in connection/

connection with the labial gland cells. Their secretion is probably exuded by means of the cubical cells lining the pseudotracheae membrane.

(c) THE INTRACRANIAL TUNNELS.

These remarkable structures lie in the lower part of the head. Each consists of a stout hollow chitinous tube, which opens on to the anterior and posterior surfaces in the positions already indicated in the description of the external characters. The two tubes lie in a horizontal plane, and converge somewhat towards one another from before backwards. The main portion of the tube is cylindrical, and is narrowest about its middle. The anterior end is funnel shaped, and has a wide attachment to the epicranium in the region of the clypeus and gena. The posterior end, which lies in front of the cardo of the maxilla, is more irregular, and is produced into three tubercles. One of these projects inwards, while the others are firmly attached by strands of chitin to the thickened lateral edge of the epicranium, and to the curved rod which extends from the region of the orifice to the occipital foramen.

From the upper surface of each of these tubes/

tubes there arises a thin trabecular membrane. This is triangular in shape, and is attached in front to the epicranium at the junction of the clypeus with the gena, extending as high as the antennal socket. The free upper margins of the two trabecular plates separate off a median compartment in this region of the head, in which the pharynx and the pharyngeal dilator muscles are contained.

These intracranial tunnels resemble those described in *Chironomus* (14) and in *Anopheles* (7). They are of the nature of supporting buttresses, and the fact that they are hollow has probably no more significance than that, weight for weight, a hollow cylinder is stronger than a solid rod. Their special functions will be discussed in relation to the mechanism of feeding.

(d) THE STRUCTURE OF THE BASE OF THE SKULL.

(Plate III, Fig.13)

The chitin of the head capsule is deficient in a space extending from the occipital foramen to the bases of the mandibles, this area being completed by a flexible non chitinized membrane. The space is bounded in front by the cornua of the mandibles and the galeae of the maxillae, and laterally by the thickened edge of the epicranium, and by a specially developed curved rod. The central part of the space is occupied by the pharynx, on each side/

side of which lie the stipes of the maxillae.

The lateral curved rods, previously referred to, extend from the posterior orifices of the intracranial tunnels to the occipital foramen. They are flattened, and shaped like boomerangs. The lower end of each rod is produced into a tubercle which projects inwards into the central space, while the upper ends are produced inwards in front of the occipital ring, and are united by a few strands of fibres, so as to form the anterior boundary of the foramen. About the middle of each rod there is a constriction, and above this the rods are fused with the epicranium.

The upper and posterior border of the occipital foramen is formed by a thickened arched ridge, continuous with the posterior wall of the head capsule.

(e) THE HOMOLOGY OF THE HEAD.

It is, of course, somewhat difficult to assign the component parts of the head to their respective segments with precision, from a study of the adult insect, especially when, as in this case, few of the sutures marking the lines of fusion of the segments can be made out. The parts in Haematopota, however, represent/

represent a comparatively early stage in the adaptation to the suctorial habit, and by comparison with other insects of more elementary form it is possible to define the extent of the various somites with some degree of certainty. The detailed exposition of the present views on the segmentation of the insect head given in Berlese's recent work(15) is adhered to in the following description. Berlese regards the insect head as derived from six segments, the third of which is wanting in the adult stage, except in Campodea. The first somite is the pre-oral one, and bears the eyes. The labrum and clypeus belong to it. The second segment bears the antennae, and is well demarcated in this insect as the elevated antennal plate. The sternite of this segment is represented by the anterior parts of the intracranial tunnels and trabecular plates. The fourth segment bears the mandibles. Its tergite lies behind the antennal plate and extends, between the eyes, to the vertex. The sternite is represented by the genae, the posterior border, and an indefinite area of the posterior surface of the head; its extent may be inferred from the area of attachment of the mandibular muscles. The mandible itself shows the least possible differentiation from the mandibulate type which is consistent with a blood sucking/

sucking habit. It is articulated to the gena, and, as will be seen later, the arrangement of its muscles indicates that it is capable of a relatively wide range of movement. Comparing it with Blatta and Anopheles, it illustrates very prettily the process of adaptation to function. The fifth segment bears the maxillae. Its tergite occupies the lateral areas on the posterior surface of the skull, external to the sutures; the sternite is represented by the bases of the intracranial tunnels. The primitive form of the maxilla has already been discussed. The tergite and sternite of the sixth segment are not separated. The tergite occupies the median area of the posterior surface of the head, between the sutures, and encloses the occipital ring above. The sternite has undergone considerable modification in the development of the membranous area at the floor of the skull. The palatal membrane, representing the gular region of other insects, and the cornua and scutum of the labium, representing the submentum and mentum, belong to the sixth sternite. The cardines of Meinert, and the stylus, may represent the cardines and stipes of a primitive second maxilla.

(2) THE THORAX.

The head is attached to the thorax by a short/

short neck, which, on account of the concavity of the posterior surface of the head, is not easily seen on the living insect. There are no definite sclerites in the neck.

The Thorax, as seen from above, is ovoid in shape, the pointed scutellum projecting backwards above the first abdominal segment. It is rather narrower than the head, and is continuous with the abdomen without any "waist". It is dark tawny brown in color, with a dorsal median light stripe, continuous with that on the abdomen, and two lateral stripes, the inner of which extends only through the anterior half. It is covered throughout with short downy hairs, which are aggregated into little tufts on certain of the sclerites, especially about the neck and sides.

There is no differentiation of the thorax into three regions, and the separate parts, as described, can only be satisfactorily studied by dissection.

(a) THE PROTHORAX.

The sclerites of the prothorax close in the convex anterior end of the thorax, and can only be satisfactorily seen after removal of the head. There are seven paired and two unpaired sclerites.

On the ventral aspect, immediately behind the thoracic inlet, there are three pairs of sclerites which/

which belong properly to the neck. These "jugulares" lie in a loose anthrodial membrane, and are not united directly to one another in the middle line. The first, which is the largest, is dome shaped, and bears a tuft of dense hairs. It is free in the anthrodial membrane. The second piece is a transverse oblong slip, attached externally to the epimeron; it bears no hairs and is not recognizable on the external surface of the thorax. The third jugular resembles the second, except that it bears hairs, and is attached also to the episternum. It lies in front of the articulation of the foreleg. The looseness of the thoracic wall in this region permits of considerable distension during the act of feeding.

These remaining sclerites are readily homologized with those of a primitive thoracic segment. The ventral sclerite is divided into a pair of praesterna, a sternum, and a sternellum. The praesterna lie on the inner sides of the spaces in which the forelegs are articulated, and behind the jugulars. They are quadrilateral in shape, and are firmly united by their inner borders, from which a thick ridge projects upwards into the thoracic cavity. Their anterior borders form a continuous thickened arch, to which the anthrodial membrane is attached.

The Sternum is a small semicircular plate, which is wedged in between and behind the praesterna, which/

which project backwards on each side of it. The sternellum is heart shaped, and is inset between the diverging inner borders of the sterna of the meso-thorax. The sternum and sternellum do not bear hairs, and are easily recognizable on the external surface of the thorax.

The Episternum lies external to the articulation of the foreleg, and is firmly attached to the meso-thorax. The Epimerum lies in front of the episternum, & is closely adherent to it and to the praesternum. Both lateral sclerites are rounded and convex, and are conspicuous on the external surface, having dense tufts of hairs. The Pro-notum is represented by two small convexities on the outer edges of the praescutum; they are continuous with the epimera.

Passing between the ventral and lateral sclerites there is a somewhat complex arrangement of fibrous bands, representing an antefurca, which serves both to compensate for the laxity of the thoracic wall in the region of the jugulares, and to provide for muscle attachments (Plate IV, Fig. 14). It consists of two parts, arising from the sternum and sternellum respectively. The anterior fibres arise from the arched border of the sternum, from the posterior fourth of the median ridge between the/

the praesterna, and from a thick transverse strand which separates the sternum from the sternellum. The fibres are collected into a broad arched transverse band, which, as it runs outwards, contracts to form a stout round cord. The posterior fibres arise from the thickened and ridged lateral borders of the sternellum, and run outwards and forwards. All these fibres run towards the junction of the epimerum and episternum, and are mainly attached to the recurved anterior margin by the latter sclerite. They form a strong supporting buttress for this part of the thorax.

(b) THE MESOTHORAX.

This constitutes the main part of the thorax. The tergite, which occupies the whole dorsal surface of the thorax, is separated into a Praescutum, Scutum, Post scutum, and Scutellum. The two former pieces together make up the greater part of the tergite, and the separation between them is only indicated by a short lateral furrow anterior to the wing base. The post scutum is a very thin transverse slip, tightly wedged in between the scutum and scutellum, and not easily seen. The scutellum is a stout triangular piece, with rounded margins, which overlaps/

overlaps the first abdominal segment, and conceals the meta thorax from above.

The Sternum is divided into two quadrilateral plates, which are united along the middle line at an angle, thus giving the thorax a keeled appearance. The episternum lies directly above the sternum, and resembles it in shape. Both these sclerites are united to the adjacent plates, and to one another, the lines of junction being marked on the internal surface by prominent ridges. The epimerum is a narrow and irregular vertical plate, extending from the wing base to the middle line below. The upper third of its anterior margin is separated a short distance from the episternum, the interval being filled in by anthrodial membrane on which the anterior series of wing sclerites lies. The middle third of the margin is united with the mesosternum, and below this the two diverge, leaving an interval in which there lies a conical coxal plate, with which the middle leg articulates. The upper third of the epimerum is concealed, from within, by the wing sclerites. Its posterior margin is ill defined, and merges into the membrane to which the squama is attached. The middle third is produced backwards, forming a dome shape expansion which lies below the squama, and which gives origin to the mesophragm.

The/

The posterior thoracic spiracle lies in a membranous interval below this expansion. The lower third of the epimerum tapers to a blunt point; it is partially fused with the meta thorax.

The Mesophragma is a funnel shaped expansion, which projects backwards and inwards into the thorax, materially diminishing the size of the thoracic outlet. It arises from the upper and lower borders of the dome shaped expansion on the epimerum. From these borders thin sheets of chitin are reflected upwards and downwards into the cavity of the thorax, those from the two sides meeting above and below, so as to form a sort of inner chamber in the thorax. This funnel, which is more extensive above than below, extends backwards as far as the first abdominal segment, and contains all the organs passing from the thorax to the abdomen. In cross sections of the posterior end of the thorax it appears as an isolated ring of chitin, giving attachment to the longitudinal muscles of the thorax. Between the Scutum and Praescutum above, and the episternum below, there is a narrow longitudinal interval, filled in by arthrodial membrane. This is prolonged downwards to separate the episternum from the epimerum. The anterior thoracic spiracle lies at the anterior end of this space.

(c) THE SCLERITES OF THE WING BASE.

These are arranged in two sets. The anterior set consists of three wedge shaped rods, which are attached to one another and to the adjacent sclerites by their expanded upper ends, their pointed apices hanging down internal to the episternum and the arthrodistal membrane. The largest rod is situated between and internal to the other two. The pointed anterior angle of its base is attached to the praescutum, near the lateral furrow separating it from the scutum, by a strong band of fibres. The anterior rod is attached at its base to the largest rod. The posterior wedge is shorter and stouter than the others, and is attached by the anterior angle of its base to the first rod, and by its apex to the anterior margin of the epimerum, by stout cords.

This set of sclerites, by virtue of the elasticity of the fibrous cords connecting them with the dorsal and lateral walls of the thorax, and by means of the muscles attached to them, will antagonise the longitudinal muscles, by reducing the vertical diameter of the thorax.

The posterior set of sclerites is directly associated with the wing, and forms a series of levers by which the wing can be folded and unfolded. They/

They are five in number, and are of too irregular a shape to be accurately described. Their arrangement is indicated somewhat diagrammatically in the figure (Plate V, Fig. 19). The costal vein terminates in a round knob, produced downwards into a fibrous cord. The Radial vein terminates in a very complex sclerite, which lies upon the upper end of the epimeron, and receives, in its anterior border, the fibres from the costal vein. Co-relation between the two important veins of the wing is thus secured. The posterior margin of the wing terminates in a conical sclerite, which lies behind the radial sclerite but is not connected with it. The squama is closely connected with a curved rod lying in the membrane at its base, and this rod is attached above to the base of the sclerite which terminates the posterior border of the ring. Below these four rods there lies a Y shaped rod, which is the governing part of the mechanism. This rod is horizontal, the fork of the Y being anterior. The lower limb of the fork is received into a little pit in the epimeron; the upper limb is bifid, and interlocks with the bifid lower end of the radial sclerite. The posterior long limb of the Y is attached to the curved rod at the base of the squama.

If one bears in mind that when the wings are folded on the abdomen the squamae are folded on the/

the wings, the mode of action of these levers becomes obvious. When the long arm of the Y is pushed up, the radius, and with it the costa, are pressed backwards, while the squama is pushed in the reverse direction.

The Mediafurca is composed of two large lateral expansions, set on a Y shaped stalk. It lies in the angle between the mesosterna, and is attached, somewhat loosely, to the posterior part of the ridge between them. These lateral expansions are formed from two plates of chitin, lying one above the other. The plates are roughly oblong in shape, but with their external anterior angles produced forwards; they are united along their inner and anterior borders, but diverge from one another behind, and are separated posteriorly by a small vertical plate, so that they enclose a boat shaped cavity. Behind this expansion there is another about one fourth the size, and formed in the same way, from two triangular plates. These are attached in front to the plate representing the stern of the boat, and converge to meet one another behind. The fork of the stalk is much thickened and ridged, to resist the strain which falls on it during the contraction of the transversely acting muscles attached to/

to the apodeme.

(d) THE METATHORAX.

The metathorax is much reduced in size, and the separate segments are difficult to recognise. The mesophragma passes backwards through the metathorax.

The Meta-notum is a narrow thickened arched ridge, which lies beneath the scutellum, where it articulates with the tergite of the first abdominal segment. The pleural sclerite is undivided, and forms a narrow plate extending from the insertion of the halter to the middle line. It is attached to the metanotum above and behind, and to the epimerion of the mesothorax in front. The meta-ster-num is a small oval plate, fused with the pleural sclerites. It bears the post furca, and its posterior borders are deeply excavated for the reception of the coxae of the hind legs.

The post furca lies on the metasternum, anterior to the coxae. It consists of a pair of pointed wing like expansions, united with one another and supported by stout ribs. It is attached to the median ridge between the two lateral halves of the metasternum. Each expansion is supported by a Y shaped rib, the inner limb of which runs to the extreme/

extreme tip of the apodeme. These ribs converge inwards and backwards, and those of the two sides are connected by a sheet of chitin. They do not meet posteriorly, but diverge again, and terminate in a pair of stout hooked processes, which lie between the coxae, and are closely connected with the median ridge on the meta-sternum.

(e) THE WINGS.

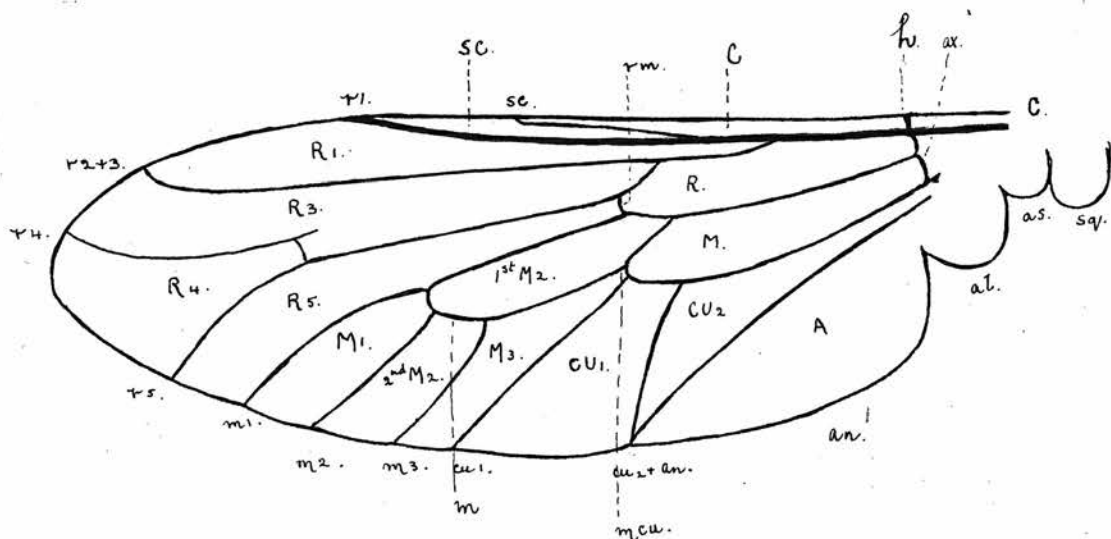
The wings, when in the resting position, extend a little beyond the tip of the abdomen, and are held in a tectile manner. Their general shape is indicated in the figure (Plate I). They are light brown in color, and are mottled with patches of a lighter tint. The inner half of the posterior border of the wing is indented, so that a large anal lobe, a smaller alula, and a still smaller antisquama, can be distinguished. The Squama is specially differentiated, and is relatively rather large and conspicuous. It lies in a plane almost at right angles to the wing when the latter is moderately extended, and, as the wing is folded backwards, the squama is folded in it so that it lies in contact with the antisquama. The special mechanism by which this is accomplished has already been/

VENATION OF WING.

c. Costa, sc. subcosta, r. 1, 2, 3, 4, 5, the four divisions of the radial vein. m. 1, 2, 3, the three divisions of the median vein. cu, 1 & 2 the two divisions of the cubital vein. a. n., anal vein. h. humeral cross vein. ax., axillary cross vein. rm. radial median cross vein, m. median cross vein. mcu. median cubital cross vein. A, an', anal lobe. al. alula. as. antisquama. sq. squama. R, R1 etc. the radial cells. M. M', etc. the median cells. Cu 1 & 2, the cubital cells.

been described. The squama is somewhat thicker than the rest of the wing, and has a thickened margin, which bears a fringe of fine hairs.

The distribution of the wing veins is sufficiently indicated in the text figure. The terminology employed is that of Conistock and Needham (16). The Costa extends to the tip of the wing and is continuous with the thickened posterior border. It bears four rows of small spines, which extend all round the wing. The Radial vein divides into four branches, of which the second represents



Text Figure 1. Venation of Wing.

the fused second and third radial veins. The first radial vein, the stoutest in the wing, bears a single row of small spines. At its termination there is a small oval area of dark pigmentation, the "stigma". The division between the fourth and fifth radial veins/

veins is peculiar. The fourth vein turns forwards and then outwards, from its origin, and from the angle so produced a stout spur projects inwards, in line with the vein. At first sight it appears as if an adventitious cross vein had been developed, but a comparison of other Tabanidae indicates that an obtuse angle is by no means uncommon at this junction. The peculiarity is the projecting spur.

(f) THE LEGS.

The legs are composed of five joints, as in other Diptera. The joints differ somewhat in the three legs. The coxa of the foreleg is long and cylindrical, and articulates with the thorax at a comparatively wide membranous interval external to the praesternum. The femur resembles the coxa, but is longer, and is covered with stout black setae. The tibia is shorter and stouter than those of the other legs, and is covered with setae. The coxa of the middle leg is much reduced in size; it articulates with the coxal plate which lies behind the mesosternum. The femur resembles that of the foreleg, except that the setae are restricted to a small area just above the lower end. The tibia of this leg has two stout conical spines at its lower end. The/

The coxae of the hind legs are broad and oval, and lie almost in contact with one another, on the metasternum. The femur and tibia resemble that of the middle leg, except that the hind tibia does not bear spines. The metatarsus is the same in the three legs. There are five joints, the first of which is much longer than the rest. The next three joints are short and conical. The terminal joint bears two large symmetrical curved claws, and three pulvilli with glandular hairs.

The fore tibia is colored yellow in its proximal half; the mid and hind tibiae are yellow throughout, except at the lower end, & in small areas about the middle and the upper end.

(g) THE HALTERES.

These are situated on the anterior edge of the metathorax, just behind the posterior spiracles. Each consist of a somewhat flattened ovoid knob, borne in a slender stalk, which terminates in an expanded base. The upper and lower surfaces of the halteres are pigmented, and are covered by extremely fine hairs. The proximal expanded end of the stalk, and a small elevated cushion lying behind it, have on them a large number of minute shallow pits, on the margins of which there/

there are a few small hairs.

(3) THE ABDOMEN.

The abdomen is the same breadth as the thorax, and is about twice as long. It consists of 7 visible segments which decrease in width from before backwards, so that the last is about two thirds the breadth of the first. The posterior segments are flattened from above downwards. The coloration resembles that of the thorax. The median light stripe is continued down the abdomen, and in addition there is on each segment a round spot on each side, and a narrow area on the posterior margin, of the same fawn colour. The whole abdomen has a scanty covering of downy hairs, and there is a small fringe of short stout setae on the posterior border of the last segment. A pair of small oval anal lobes projects from under cover of the last segment.

The pleural membrae which unites the tergites and sternites, and which bears the spiracles, is capable of considerable distension, and is conspicuous in a recently fed insect.

Under cover of the seventh segment there are several small sclerites, which, with the anal lobes, may be taken to represent four reduced segments/

segments. Dorsally there is a plate resembling the seventh tergite, but about one fourth the size; behind this there are two pairs of small pieces, and the two anal lobes. On the ventral aspect the several pieces are fused into one, which is roughly square shaped, with the posterior half of its lateral borders expanded. These sclerites are situated in an anthrodial membrane, and when they are drawn out, it is seen that the anterior margin of the first piece is attached to the posterior margin of the seventh segment, so that they form a continuous but retracted part of the abdominal wall. The arrangement probably represents, and functions as, an ovipositor.

I N T E R N A L /

INTERNAL STRUCTURE.

(1) THE ALIMENTARY CANAL.

This consists of the following parts:-

Pharynx.

Cesophagus, with its diverticulum.

Proventriculums.

Midgut.

Hind Gut, divisible into-

Ileum, with the Malpighian tubes

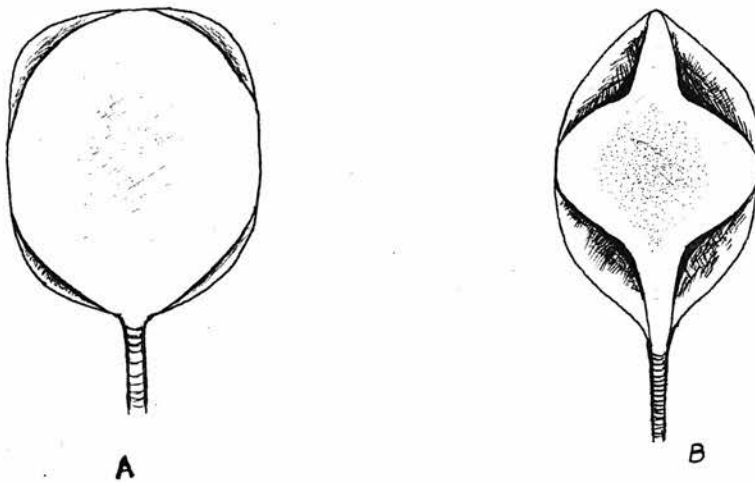
Colon

Rectum, with its papillae.

The Pharynx is the most important part of the sucking apparatus of this insect. It consists of two oblong vertical chitinous plates, the anterior of which is continuous with the epipharynx, the posterior with the hypopharynx. These plates are concave forwards, and are closely opposed to one another in a state of rest; they are united to one another by their lateral borders, and the pouch so formed opens below into the canal between the epipharynx and hypopharynx, and above into the first part of the cesophagus. The upper lateral angles of the pharynx are produced into two long cornua, which project upwards, and slightly forwards, into the cranial cavity. The pharynx lies on the palatal membrane, in front of and between the stipes of the maxillae. (Plate 3 fig. 13).

The/

The Oesophagus consists of two parts, differing in structure and in function. The first part is accessory to the pharynx, and might perhaps, be more correctly described as part of it, since it plays an important part in the mechanism of feeding. (17).



Text Figure 2. The Chitinous plate of the Oesophagus. A. when the pouch is dilated. B. when empty.

It is a dilatable chamber, situated between the cornua of the pharynx, and lying in a horizontal plane, that is, at right angles to the pharynx and proboscis. The superior and lateral walls of this pouch are formed by a quadrilateral plate of chitin/

chitin. This plate is concave downwards, and its four angles are turned downwards towards the pharynx, and are connected with it by a thin membrane which completes the chamber. This membrane is attached to the margins of the chitinous plate above, and to the cornua of the pharynx and to the upper margins of the two pharyngeal plates below. The second part of the oesophagus runs directly backwards from the posterior angle of the first part, through the brain, occipital foramen, and neck, into the thorax. It terminates just behind the thoracic inlet in a small dilatation, in the dorsal aspect of which there is an aperture, by which the oesophagus communicates with the proventriculus. The intra-cranial portion of the oesophagus has a thin semi membranous wall, but as it passes backwards the chitin thins, and is replaced by a layer of small round cells, set on a basement membrane.

The Oesophageal Diverticulum is a small bilobed sac, which lies in the second abdominal segment, to the left of the middle line. It is connected with the oesophagus by a fine duct, which arises from the posterior end of the terminal dilatation/

dilatation of the cesophagus, and runs backwards beneath the proventriculus and between the salivary glands. The walls of the diverticulum are composed of delicate interlacing fibrils, in the meshes of which there are many round cells. The duct has the same structure as the thoracic part of the Oesophagus, with which it is directly continuous, the distinction between them being only marked by a narrowing of the lumen.

The cesophageal diverticulum is usually distended with gas. Some-times it is found to contain blood, but it apparently does not function in the same way as the corresponding organs of the mosquito, since it is frequently found to be empty in specimens dissected immediately after feeding.

The Proventriculus extends throughout the thorax, lying between the lateral expansions of the mediafurca and on the mesophragma, and terminates in the second segment of the abdomen by joining the midgut. Its anterior portion is broad, flat, and has a mammillated surface; the posterior portion contracts to form a simple narrow tube. At its anterior end there is on each side a wide wing like expansion, the prominent anterior angle of which is produced forwards and outwards with a small pointed/

pointed tubercle. It should be noted that the proventriculus lies throughout on a higher level than the oesophagus and its direct continuation, the oesophageal diverticulum; the opening into the oesophagus is on the ventral surface of the proventriculus, a little behind its anterior end. The mammellated appearance of the surface is produced by folds in the wall; these are arranged somewhat irregularly, but there are usually two rows of small elevations to each of the surfaces, and one row on each lateral margin. The lumen of the proventriculus is a transverse slit, which becomes rounded in the posterior portion. The wall of the proventriculus is composed of a layer of round or oval cells, attached to a stout basement membrane. These cells, however, have the power of forming a large amount of secretion, which is collected in the cells towards their free margins, and eventually extruded into the lumen. The appearances seen on section consequently differ widely at the various stages of this process. When the secretion is fully formed but not yet thrown off, the cells are elongate, and are arranged in rather indefinite rows. The nuclei are round or oval, and stain deeply. The borders of the cells adjoining the lumen/

lumen are converted into a structureless hyaline eosinophil mass, in which the distinction between adjacent cells is lost. This hyaline layer is carried into all the folds of the wall, and renders the mammillation of the surface more marked. At a later stage this secretion is thrown off, and the lumen is found to be filled with a coarse granular mass, which takes up the eosin stain only faintly. The cells are flattened, and their nuclei lie close to the basement membrane, with their long axes parallel to it. The surface of the proventriculus is then not so mammillated & the lumen is less flattened. At a still later stage the lumen is found to be empty, and the wall closely resembles that of the oesophagus, being composed of a simple layer of round cells, the inner ends of which project into the lumen. These remarkable changes are related to the feeding of the fly, and are of the same nature as those described by Schaudinn (18.) in the mosquito.

The Midgut is the chief digestive part of the alimentary canal and is the only part in which blood is found in a recently fed insect. It lies in the second and third segments of the abdomen, and is embedded in a mass of fat body, to which, and to the adjacent coils of the Malpighian tubes, it is closely/

closely bound down by a rich supply of tracheae. It is oval or pear shaped, the narrow anterior end, which is generally a little dilated when the gut is full of blood, merging indefinitely with the proventriculus, while the posterior end is sharply demarcated from the rest of the gut by the insertion of the Malpighian tubes. The wall of the gut consists of a single layer of long cylindrical cells, arising from a thin basement membrane, and two thin layers of muscle fibres, the inner layer being circular, the outer layer longitudinal. The cells, with their basement membrane, are collected throughout the cavity into small villi, so that the mid-gut has a stellate appearance on cross section. The cells lying between the villi are typically columnar and are regularly arranged, while those on the sides of the villi are more elongate, their attached ends being compressed. The appearance of the protoplasm between the nucleus and the free border of the cell varies in different preparations. In some it is clear, hyaline, and eosinophil, while in others it is vacuolated, and the border of the cell is frayed out, the cells having discharged their secretion after the manner of goblet cells. The/

The lumen of the gut often contains large numbers of degenerated free nuclei, evidence of the degeneration of the epithelium. There are many small round cells, by means of which the columnar layer is regenerated, lying between the attached ends of the cells; these are most conspicuous when the large cells have discharged their secretion.

The Hind Gut commences at the origin of the Malpighian tubes and is continued backwards as a simple narrow tube. The first part, immediately behind the mid-gut is somewhat dilated; the succeeding narrow portion is bent upon itself, passing first from left to right, then to the left again, bending upwards. The gut then dilates to twice its previous diameter, and runs directly backwards to join the rectum. The wall consists of a single layer of short cubical cells, on a basement membrane, and a few scattered bands of circular and longitudinal muscle fibres. Although there is no difference in structure, the anterior narrow portion may for convenience be termed the Ileum, the dilated posterior portion the Colon. The dilated anterior portion of the Ileum, in a considerable proportion of cases, has been found distended by two or three large gregarine cysts. The Colon frequently contains many large/

large reddish granules, the remains of blood.

The Rectum is separated from the colon by a slight constriction of the gut. It is pear shaped the narrow end opening beneath the anal plates. The structure of the wall resembles that of the preceding portions of the hind gut, except that the circular muscle fibres are more numerous. There are six rectal papillae inset in the wall, They are small curved wedge shaped bodies, projecting into the lumen of the rectum, their apices being directed towards the anus. They are composed of a single layer of large cells, arranged around a central lumen, down which there runs a small tracheal twig, which enters the papilla from the outside.

The Malpighian Tubes are four in number. Each tube, when dissected out, is about the same length as the whole alimentary canal. They are arranged in complicated loops, chiefly in the posterior part of the abdomen, and are closely bound down to the other organs by tracheal twigs. A long loop passes forwards in each side of the mid-gut. The tube is of uniform diameter throughout, and tapers to a blunt point which lies near the rectum. In fresh dissections this end of the tube has an orange/

orange red colour. The tube is composed of a single layer of large flattened cells, with large oval nuclei, which are folded round the lumen and cemented by their edges. They are inserted into small expanded evaginations of the gut, where the large flattened cells become replaced by small round cells.

The Salivary Apparatus consists of a pair of glands, a duct, and a reservoir. The glands lie in the thorax, extending to its junction with the abdomen. They lie beneath the proventriculus, and on either side of the duct of the oesophageal diverticulum. They are long, simple, and tubular, and dilate gradually from before backwards, the posterior portions being curved outwards. They are composed of a single layer of cubical cells, and a stout basement membrane. The lumen generally contains a mass of small granules. Towards their anterior ends the glands narrow, and the basement membrane is reinforced by a series of coarse, closely set, chitinous rings, while the cells become flattened. The two ducts which are thus formed unite just before entering the neck, and the common duct, lying below the nerve cord, runs to the salivary reservoir. This salivary reservoir is a small chitinous pouch situated in the lower half of the posterior surface of the pharynx; it opens below into the/

the duct in the hypopharynx.

(2) THE RESPIRATORY SYSTEM. (Plate V fig.20)

The Head. Two small tracheae from the anterior thoracic spiracle enter the head, and at once break up into branches, too minute to be traced. There are minute tracheae in the labium and antennae, which expand at the base of the organs into small air sacs. The large space above and in front of the brain and pharyngeal muscles is entirely filled up with small air sacs, of which as many as twelve can be counted in some sections of the head. They are closely adherent to the epicranium and to the brain, and are most formidable obstacles in the dissection of the head. They have very tough and thick walls, and obviously can have little or no function in the respiration of the insect. They serve as elastic cushions to protect the cerebral ganglia from the changes of intra-cranial tension during feeding, and have also a function, as will be seen later, in relation to the mechanism of feeding.

The Thorax. The anterior thoracic spiracle is situated at the anterior end of the membranous interval between the dorsal and lateral walls of the throat. The posterior spiracle lies just in front of the halter. It should be noted that the spiracles/

spiracles are not orifices in the chitinous wall of the thorax, but are situated on the membrane joining adjacent sclerites. Each spiracle is a dumbbell shaped slit, with a chitinous margin, on each side of which there is a row of short comblike spires, to guard the orifice. The tracheae which arise from them break up at once into numerous small branches distributed to the muscles and viscera. There are several small air sacs, resembling those of the head, around the thoracic ganglion.

The Abdomen: There are seven spiracles, resembling those of the thorax, situated in the pleural membrane. The first one lies immediately behind the metathorax, the others being situated rather in front of their respective segments, and diminishing in size from before backwards. The arrangement of the tracheae within the abdomen is somewhat complex. The trachea from the first spiracle, after a short backward course, ends in a smaller air sac, which leads by a short connecting trachea to a second and larger air sac. These air sacs are entirely different to those of the head. Their walls are composed of a thin white opaque membrane, which, when ruptured, spreads out in water, like a very thin paraffin section. It is very difficult to dissolve the air out of these vesicles, and sections/

sections of this part of the abdomen are difficult to prepare. Four small trachea arise from the second air sac. The first runs inwards, and breaks up at once into fine filaments for the supply of the adjacent fat body; the second trachea communicates with the second spiracle; and the third runs along the dorsal wall, ventral to the heart, communicating with its fellow of the opposite side. The fourth and largest of these trachea runs directly backwards to the end of the abdomen as the main lateral trachea. This gives off six dorsal branches, which communicate with those of the other side, ventral to the heart, and many small branches to the viscera and to the ventral wall of the abdomen, and receives communicating branches from the third to the seventh tracheae. Each trachea as it passes inwards from its spiracle gives off a number of small twigs to the surrounding parts; the fourth trachea supplies most of the mid-gut; the fifth, which is of considerable size, constitutes the main supply of the ovary, which it enters along its posterior border.

(3) THE MUSCLES OF THE HEAD.

The muscles associated with the mouth parts have been elaborately described and figured by Meinert (11) and Hansen (12), in *Tabanus*, and some of/

of Meinerts' figures are to be found in most text books on Entomology. The arrangement of the parts in *Haematopota* does not differ materially from that described in *Tabanus*, but since the works of the above authors are in Danish, and are not readily accessible, an account of the parts will be given here. It will be necessary to go into considerable detail in order to facilitate the subsequent description of the mechanism of feeding. The muscles were studied by dissection and in **serial** sections taken at various planes.

Labial Muscles: The intrinsic muscles, acting on the labellae, have already been described. There is also a pair of small retractor muscles, which arise from the tubercles at the base of the intra-cranial tunnels, and are inserted into the cornua of the labium..

Mandibular Muscles: There are two adductor muscles attached to the inner cornua of the mandible. The internal of these, the adductor rectus, arises from the inner side of the trabecular membrane and from the intra-cranial tunnel. The oblique adductor arises from the floor of the head cavity, near the posterior border. The abductor muscle arises near the oblique adductor, and is inserted in the external cornu. It has a long tendon.

The /

The Maxillary Muscles are also three in number. The adductor rectus arises from the inner side of the trabecular membrane, in common with the corresponding mandibular muscle, and the oblique adductor arises above and behind the oblique mandibular muscle. The two adductors run almost directly in the line of the maxilla, and are inserted into the lower end of the stipes. The abductor muscle of the maxilla arises from the gena, external to the anterior orifice of the intra cranial tunnel, and runs upwards and backwards to the upper end of the stipes.

The Depressor Labri lies between the two lateral halves of the dilator muscle of the pharynx. It arises from the internal surface of the clypeus and after a short course downwards and backwards is inserted into the tongue shaped upper end of the labrum.

The Muscles of the Pharynx. The dilator of the pharynx is the largest muscle in the head. It passes from the sides of the clypeus to the anterior plate of the pharynx, and encloses the depressor labri. It should be noted that the line of action of this muscle is not directly forwards, but forwards and outwards.

The Retractor Muscles of the pharynx arise from/

from the epicranium between the eyes, just above the large pigment spots. They are of small size, and have long tendons, which are inserted into the cornua of the pharynx.

Hansen describes in Tabanus a "laxator" muscle of the pharynx, passing from the clypeus to the upper end of the pharynx. I have not been able, in Haematopota, to distinguish this muscle from the dilator.

The Protractor of the Pharynx arises from the inner sides of the trabecular membrane, and passes upwards and forwards to the cornu of the pharynx. It is short and stout, and has no tendon.

Muscles of the Oesophagus. The Dilator muscle corresponds to that of the pharynx. It is broad and fleshy, and lies in a vertical plane, being attached to the epicranium in front of the vertex, and to the whole of the upper surface of the chitinous plate of the first part of the oesophagus.

The Lateral Dilators of the oesophagus arise from the epicranium in the region of the antennal sockets and from the adjacent parts of the trabecular membrane. They run inwards and backwards and a little upwards, and are inserted without tendons into the down turned edges of the oesophageal plate. These muscles are called "Compressors" by Hansen/

Hansen.

The Sphincter Muscles are composed of circular and oblique fibres, which support the membranous wall of the first part of the oesophagus. There are two bands, separated by the cornua of the pharynx, which run transversely between the lateral edges of the chitinous part of the wall, that is, on the inferior surface of the oesophageal pouch. The posterior bundle contains many oblique fibres, and is larger than the anterior one.

There is also a circular sphincter, attached to the cornua of the pharynx, which encircles the short duct between the pharyngeal and oesophagus pouches.

The Retractors of the oesophagus arise from the sides of the occipital Foramen, and are attached to the second part of the oesophagus as it leaves the brain. There are two small bundles on each side, arising above and below the foramen.

The salivary reservoir is surrounded by a fan shaped muscle, which is attached to the posterior plate of the pharynx. Hansen also figures a mesial muscle, lying between the adjacent borders of the lateral halves of this muscle.

(4) THE MECHANISM OF FEEDING.

The sucking of blood is accomplished, after the insertion of the proboscis, by the alternate dilatation and contraction of the pharyngeal and oesophageal pouches, and the whole structure of the head is adapted to this function. The anatomy of the parts, considered with due regard to general mechanical principle, and to the observed habits of the living fly, provides an explanation of the exact mechanism. The process may be considered in three stages, the insertion of the piercing parts, the sucking of the blood, and the passage of the blood onwards into the gut.

The insertion of the piercing parts is accomplished, not by a movement of the parts themselves, but by a forward thrust of the whole body of the fly. Since the proboscis has only a slight inclination forwards from the perpendicular, it is necessary, in order to obtain the greatest mechanical advantage, that the proboscis should be brought more into line with the long axis of the body. This is accomplished by bending of the neck, and by the elevation of the fly on its hind legs; this manoeuvre brings the convex end of the prothorax in contact with the concavity in the posterior surface of/
of/

of the head. While in this position the fly, taking a firm hold in the skin of the host by means of the large claws on the metatarsi, gives a series of short jerks forwards. The wound is made by the mandibles and maxillae, both of which have firm attachments to the chitinous wall of the head. The epipharynx and hypopharynx take little or no part in this process, since the pharynx, with which they are continuous above, has only membranous and muscular connections with the rest of the head, and there is no rigid line through which the pressure can act. Moreover, the epipharynx has a blunted tip, and the slender hypopharynx falls a little short of the other mouth parts.

The mandibles and maxillae, after their insertion, can perform lateral and to and fro movements, by which the wound is enlarged and kept open. The nature of the movement of their muscles is correlated in a remarkable manner with the nature of the armature, in each case. By the alternate contraction of its adductor and abductor muscles, the mandible rotates on its fixed point, the ginglymus, through a short arc, and at each contraction of the abductor muscles the saw like edge is brought into play.

By similar alternate contractions of its muscles the maxilla is alternately bent and straightened/

straightened, the movement taking place at the joint between the cardo and stipes, and in this way the rasps on the end of the blade are forced up and down in the wound. During the making of the wound, the pharynx, carrying with it the labrum-epipharynx and the hypopharynx, is retracted by contraction of the retractor muscles attached to its posterior cornua; this is facilitated by the retractor muscle of the labrum, which pulls upwards and forwards on that part of the upper end of the labrum which is not fused with the epipharynx. When the wound is made, the pharynx is thrust into it by the contraction of the protractor muscles.

The second part of the feeding process is the dilation of the pharynx. This is accomplished by the contraction of the powerful dilator muscles, which pull the anterior plate forwards, and reduce its concavity.

At first sight it is a little difficult to understand why the pharynx is not drawn forwards as a whole, since there is no muscle or firm chitinous attachment to directly oppose the dilator muscles. This is prevented by the combined action of the protractors and retractors of the pharynx. When these two muscles act together, the vertical element in the force of each will be neutralised by the/

other, so that the resultant pull, the protractor muscle being the larger, will be backwards. The lower end of the pharynx is meanwhile steadied by the clypeus, against which the labrum epipharynx rests.

During the dilatation of the pharynx the sphincter muscles of the oesophagus are contracted; when the pharynx is full, they relax, and the blood is drawn from the pharynx to the sacular part of the oesophagus by the contraction of the dilator muscles of the oesophagus. The sphincter muscles then again contract, and so drive the blood backwards into the gut, the second part of the oesophagus being held taut by its retractor muscles. The pharynx now dilates again, and the process is repeated until the insect has had a full meal.

The intra-cranial tunnels have an important relation to the mechanism of feeding. They are nearly parallel to the dilators of the pharynx, which lie, in fact, in the chamber formed by the trabecular plates arising from their upper surfaces.

The chitin in the region of the clypeus is very thin, and were it not that the intra cranial tunnels support it and distribute the strain on to the thicker parts at the base of the skull, would be unable/

unable to resist the powerful dilators.

It will be noticed that the pharynx has no sphincter muscle to bring the two plates into opposition when the blood flows to the oesophagus, and that the muscles which close the oesophagus are very much smaller than the dilators. The collapse of these chambers is usually attributed, in the mosquito, to the elastic recoil of the plates, elasticity being assumed as a property of this variety of chitin. Whether this be the case or not, it is highly probable that the air sacs in the head play an important part in the mechanism. When the pharynx is filled with blood, the sphincter between it and the oesophagus being contracted, the intra-cranial pressure must necessarily be increased. This will result in a compression of the air in the sacs, and, when the sphincters are again relaxed, the positive pressure will be used up in bringing the plates once more into contact. Increased pressure is to a certain extent allowed for by the palatal membrane.

The mechanism of the salivary apparatus is simple. The saliva is forced from the glands into the reservoir by the contraction of the thoracic muscles/

muscles in which they lie, and is ejected from the reservoir by the contraction of its fan shaped muscle.

(5) THE REPRODUCTIVE SYSTEM.

This consists of paired ovaries and accessory glands, an oviduct, a genital bursa, and three spermathecae.

The Ovaries lie in the last three or four segments; unlike the mosquito's, that do not, even when the ova are ripe, produce any considerable distension of the abdomen. They are white pear shaped bodies, in which the separate ova can be readily distinguished. The apex of each is produced forwards as a delicate filament, which can be traced to the fat body on the dorsal wall of the abdomen in the second segment. The ovary is invested by a few scattered muscle fibres, continuous with the oviduct and with the apical filament. The rich tracheal supply enters along the rounded posterior border. Each ovary consists of 54 short ovarian tubes, each of which contains a single large oval ovum. Above the ovum there is a small conical cap of undifferentiated cells, the apex of which runs forwards to join the apical filament. Below the ova, the tubes enter a common duct, which runs in the/

the outer and posterior borders of the organ, and which is continuous with the oviduct. This duct is well seen in transverse sections of the ovary, in which it appears as a narrow slit, extending about one fourth the circumference of the organ. The oviducts are short, and unite to form a common duct, opening into the genital bursa. They are composed of muscle fibres arranged in circular and longitudinal layers. The fibres are attached behind to the chitinous frame work of the genital bursa; above they are continuous with the thin wall of the common duct of the ovarian tubes.

The Accessory Glands lie between the ovaries, extending as far forwards as the midgut. They are long and tubular, and open into the genital bursa by short constricted necks. In fresh dissections they are a dirty yellow colour, owing to the granular secretion which they contain. The walls/

walls of the gland are thrown into four or five longitudinal folds. They are composed of short cylindrical cells, on a thin basement membrane.

The Spermathecae are three long chitinous tubes, bent sharply on themselves about the middle, so that the proximal and distal halves lie parallel to one another. They open by a very short common duct into the genital bursa. The blind end of the tube is dilated and oval, and is bound down to the genital bursa by a few fine filaments. The chitinous wall of the tube is thickest in the distal half; from the bend it thins gradually and can only be distinguished with some difficulty towards the base. It is striated transversely, and appears to consist of a large number of circular fibres of chitin. It is covered externally by a layer of small round cells, external to which, in the proximal part of the tube, where the chitin is thin, there are a few bundles of muscle fibres. At the base of each spermatheca, just above the point at which the three unite to form a common duct, there is a remarkable funnel-like structure developed in the wall of the tube. This consists of a central hollow cylinder of thick/

thick chitin, slightly curved, and tapering to a point below. This is enclosed in a series of thin transparent rings of chitin, somewhat loosely arranged, and apparently spiral. They project a considerable distance from the surface of the cylinder, and support the layer of round cells. In front of the tube, and slightly separated from it, there is a short but wide flange of chitin, shaped like a short funnel. The whole structure closely resembles a short, hollow and slightly bent screw. (Plate VII Fig.34).

The Genital Bursa is the continuation of the common oviduct & into it open the accessory glands and the spermathecae. Its wall is supported by an incomplete framework of delicate chitin, consisting of one transverse and two lateral plates. The lateral plates are oblong, and concave upwards, and lie mainly in the horizontal plane, but are inclined towards one another. The transverse plate lies in front of them, and is connected with the lateral plate on each side by a thick rib of chitin, which is continuous with its thickened anterior border, and with a ridge near the inner border of the lateral plate. The anterior plate is also concave, and the three together/

together form a support for the lower wall of the bursa.

The posterior end of the bursa is partly closed in by two thick curved ridges of chitin, which arise from the lateral plates, and converge backwards and inwards towards one another. Each of these ridges has a row of peculiar spines, (Plate VII.fig. 26), which project inwards and so further close in the aperture. This arrangement constitutes a sort of valve, and suggests an explanation of the extraordinary scarcity of the males of the species, late in the season. On anatomical grounds it is unlikely that the male will be able to disengage unharmed after copulation and it may be that, as in the case of the bee (19), copulation is fatal to the male fly.

(6) THE NERVOUS SYSTEM.

This consists of a compound ganglion in the head, thoracic and abdominal ganglia, and their connectives and nerves. It shows a moderate degree of concentration. The optic lobes, cerebral ganglia, and the suboesophageal ganglia, are fused into one mass, which lies in the posterior part of the head, and envelopes the
second/

second part of the oesophagus. It is shaped like a short stout cylinder, the transverse diameter being about four times the width. The anterior surface is indented at approximately equal fourths, indicating the lines of fusion of the optic lobes and central bodies; the posterior surface is similarly indented in thirds, the nerve cord which passes through the neck arising by two branches from the middle third. The antennal nerves arise from the outer sides of the central bodies, and pass directly forwards to the antennae, between the air sacs. Three small nerves arise on each side from the inferior surface of the central body, & break up at once to be distributed to the adjacent muscles. One small filament can be traced in serial sections to the labium. The optic nerves arise from the whole outer surfaces of the optic lobe on each side, in a conical bundle, the fibres of which spread out forwards and inwards over the wide area occupied by the eyes.

The envelopement of the oesophagus by the brain is well demonstrated in serial section parallel to the proboscis. The first part of the oesophagus lies at a slightly higher level than the brain, so that the intra-cerebral portion enters/

enters the brain towards its upper surface, and passes through with a downward inclination, emerging near the lower surface, just above the nerve cord. The parts are so much fused that the relation of the ganglia to the oesophagus, found in more primitive insects is lost.

The nerve cord lies, in the head, above the salivary duct. As the duct divides the nerve passes between them, and comes to lie on the ventral wall of the prothorax. It here gives off two small nerves, probably recurrent, the course of which has not been traced.

The Thoracic Ganglion lies in the prothorax. It is flattened from above downwards, and is shaped somewhat like a heraldic shield. It consists of three fused ganglia, the distinction between which can be readily made out in suitably stained preparations. There are two small accessory lobes, attached to the external angles of the anterior border, and projecting from the under surface. Seven nerves emerge from each side of the ganglion, and are distributed to the thoracic muscles. Two small bundles emerge from the region of the accessory lobes, and one large trunk/

trunk from the posterior border of each of the constituent ganglia. The middle one of these is much the largest, and emerges in two parts. The seventh nerve is a small filament lying just external to the emerging commissure at the posterior end. It may, perhaps, indicate the fusion of an abdominal ganglion with the thoracic ganglia.

The Abdominal Ganglia are connected with the thoracic by a comparatively long cord. There are five discrete ganglia, of which the largest represents two fused together. The first, second & third are small round masses, separated from one another, and from the fourth, by short cords. The fourth and fifth one partially fused; the fifth is larger and more oval than the rest, and, as in the case of the thoracic ganglion its constituent parts are easily recognised by suitable staining. A pair of delicate nerves emerges from each ganglion, two pairs coming from the fifth. They are of considerable length and appear to run to the lateral walls near the spiracles, but on account of their extremely small size it is difficult to be certain of their precise distribution.

(7) THE HEART and FAT BODY.

The heart lies in the dorsal wall of
the/

the abdomen. It is a simple and extremely delicate tube, and is embedded in a mass of yellow pericardial cells, which are adherent to its wall. The aorta arises from its somewhat dilated anterior end, and arches upwards in contact with the dorsal wall of the thorax. It can be traced through the neck into the head, where it divides into two minute branches.

The Fat Body is distributed throughout the body in the usual manner. A large mass of it surrounds the midgut.

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P L A T E . I .

HAEMATOPOTA PLUVIALIS. $\frac{\circ}{+}$ [Meigen]

x 12.

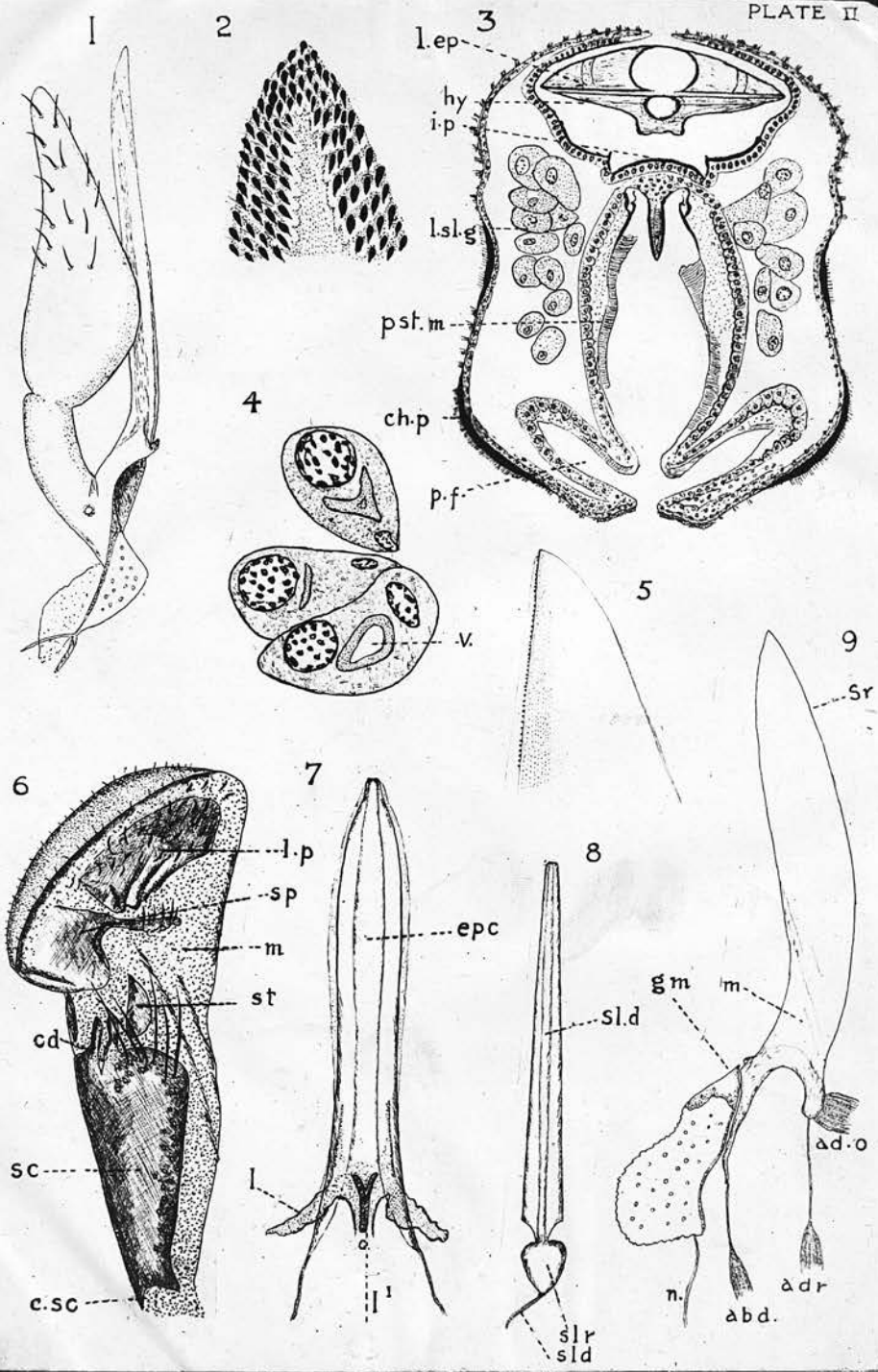
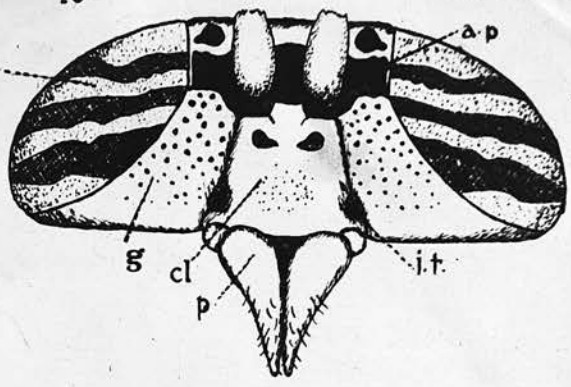


PLATE.II.

- Fig. (1). The Maxilla, with its palpus, x45.
- fig. (2). The tip of the Maxilla, showing the rasps. x1000.
- fig. (3). Transverse section through the labium, about the middle of the labellae. l.e.p., labium epipharynx. hy., hypopharynx. i.p., internal chitinous plate, lining the groove. l.sl.g., labial salivary gland. p.st.n., pseudo-tracheal membrane. ch.p., the upper chitinous plate on the outer wall of the labella. p.f., a pocket like indentation, which runs the whole length of the labella, between the posterior border and the pseudo-tracheal membrane. x 200.
- fig. (4). The labial salivary gland cells x 1000 v., vacuole.
- fig. (5). The tip of the mandible showing the serrations on its internal edge x 1000
- fig. (6). The Labium, seen from the side. l.p. lower chitinous plate. s.p., upper do. M., membrane. st., stipes. c.d., cardines. s.c., scutum. C.SC., Cornua of the scutum x 45
- fig. (7). The Labium Epipharynx. ep.c., its groove l., labrum. x 45
- fig. (8). The Hypopharynx. sl.d., salivary duct. slv. saliv. reservoir. x 45
- fig. (9). The Mandible. sr. serrated edge. M., the thickened base. ad.c. adductor obliquus. ad.r., adducta rectus. abd. abductor N., nerve. g., ginglymus.

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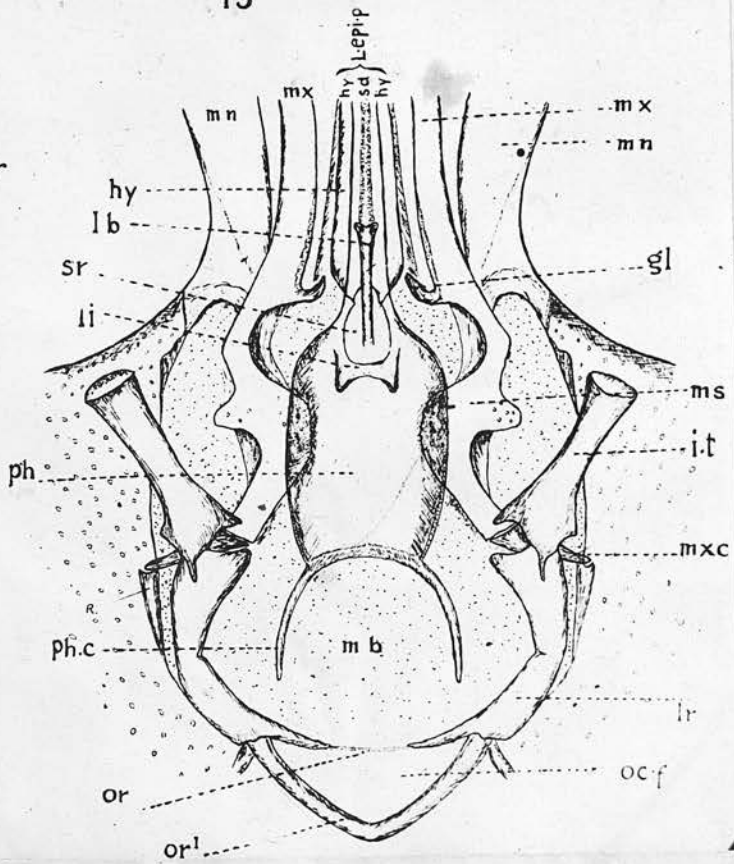


PLATE. III.

Fig. 10. The head from the front.

e: eye. a.p. antennal plate. i.t: anterior aperture of the intracranial tunnel. g. gena. cl: clypeus. p. maxillary palp. x 20.

fig. 11. Salivary gland, transverse section. x 350.

fig. 12. Antenna.

r: "rings" on the distal joint. x 45.

fig. 13. The base of the skull: (vide p.31) x 45.

l.epi.p: labrum epipharynx. mx: maxilla. gl. galea. ms: stipes of maxilla. mxc: cardo of maxilla. mn: mandible. hy: hypopharynx. lb: labrum. sr: salivary reservoir. ph: pharynx
ph.c: the cornua of the pharynx, between which the first part of the oesophagus lies.
mb: palatal membrane. lr: lateral rod. or: the fibres forming the lower boundary of the occipital foramen. or': the posterior arch of the foramen: cc.f. occipital foramen.

PLATE IV

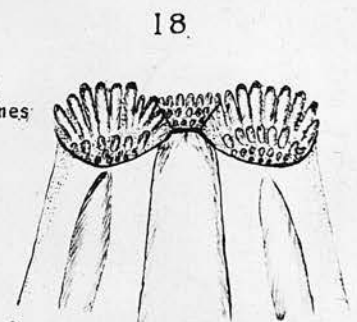
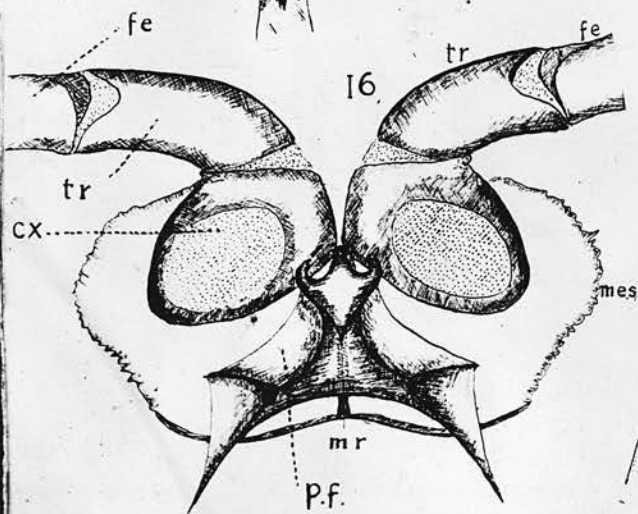
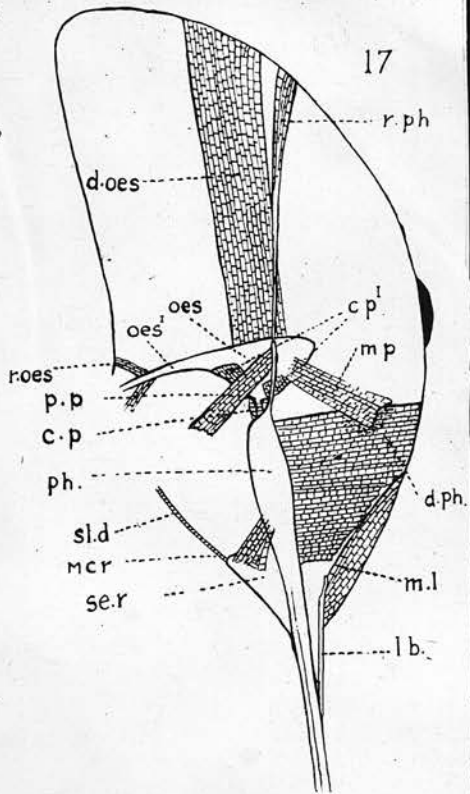
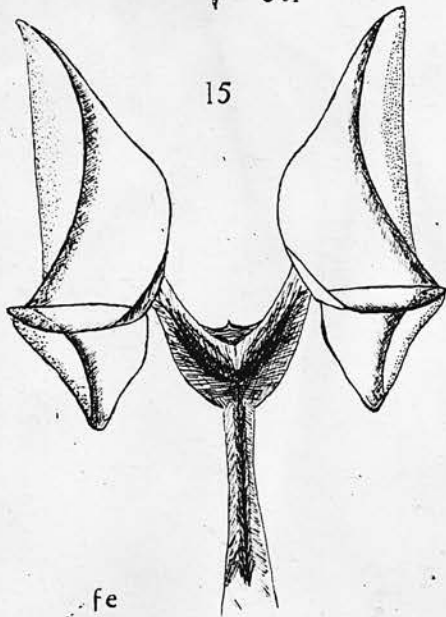
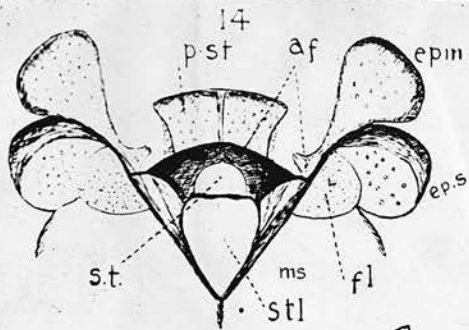


PLATE. IV.

Fig. 14. The Prothorax from above.

p.st: praesternum. st: sternum. stl: sternellum. ms: mesosternum. epM: epimeron. eps: episternum. f.l: space for articulation of the foreleg. a.f. the anterior fibres of the ante furca. x 75.

fig. 15. The Mesofurca. x 75.

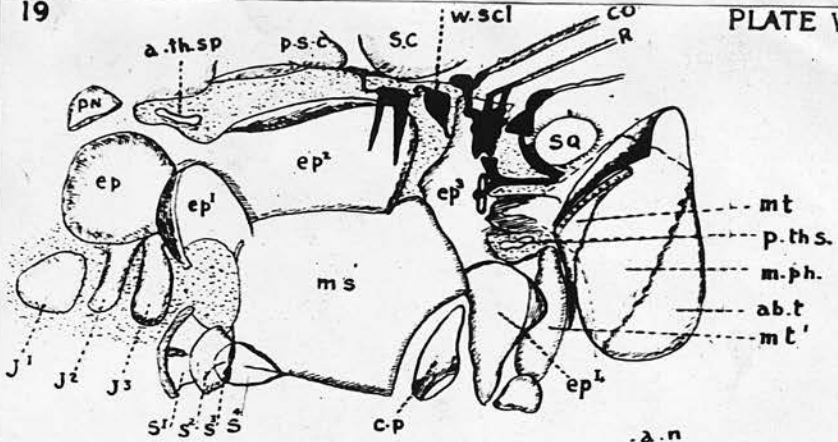
fig. 16. The Postfurca lying on the metasternum fe: femur. tr: trochanter. ex. coxa, of the hindleg. mes. metasternum. mr: median ridge between the metasternum. p.f. postfurca: x 75.

fig. 17. The Muscles of the head: diagramatic. d.ph. dilator of the pharynx. m.l: labral muscle. lb: labrum. m.p. lateral dilator of the oesophagus. c.p. the sphincter between the pharynx and oesophagus. ep: the anterior and posterior sphincters of the oesophagus. p.p. the protractor in depression of the pharynx. p.p: pharynx. ces. ces: first and second parts of the oesophagus. r.ces: retractor of the oesophagus. d.ces: dilator of the oesophagus. r.ph. retractor of the pharynx. se.r: salivary reservoir. sl.d: salivary duct. mcr: compressor muscle of the salivary reservoir x 33.

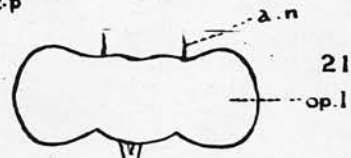
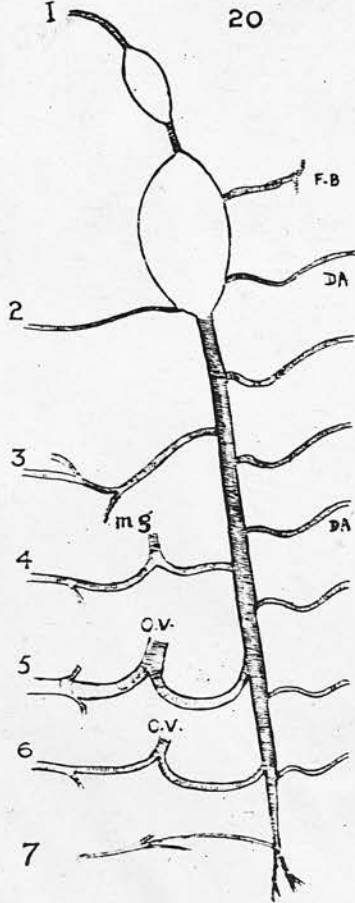
fig. 18. The tip of the Epipharynx x 1000.

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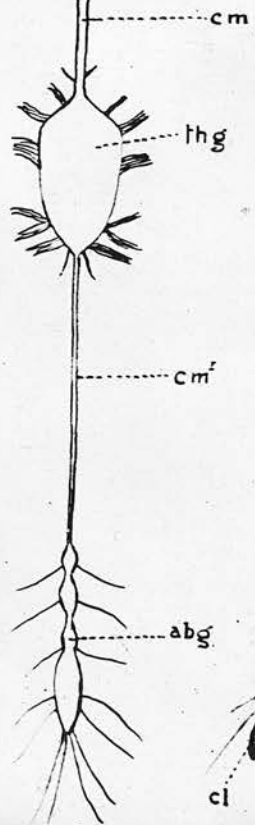
PLATE V



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PLATE. V.

Fig. 19. The thorax: the lateral wall is drawn from within, after removal of the muscles. pn: pronotum. ep: epimeron. ep¹: episternum. j¹ j² j³: the three jugulares. s: praesternum. s²: the transverse band of the antefurca. s³: sternum. s⁴: sternellum. a. th. sp. anterior thoracic spiracle, lying in the membranous interval between the dorsal and lateral walls. p.s.c: the posterior end of the praescutum. sc: scutum. W.s.cl: wing sclerites: co: costa, r: radius. s.q. squama. m.s: mesosternum. ep: episternum. ep¹: epimeron. c.p: coxal plate for articulation of middle leg. mt. meta tergum. mt: meta pleuron. m.s: metasternum. p.th.s: posterior thoracic spiracle. m.ph: meta phragma. abt. dorsal plate of the first abdominal segment. x 17.

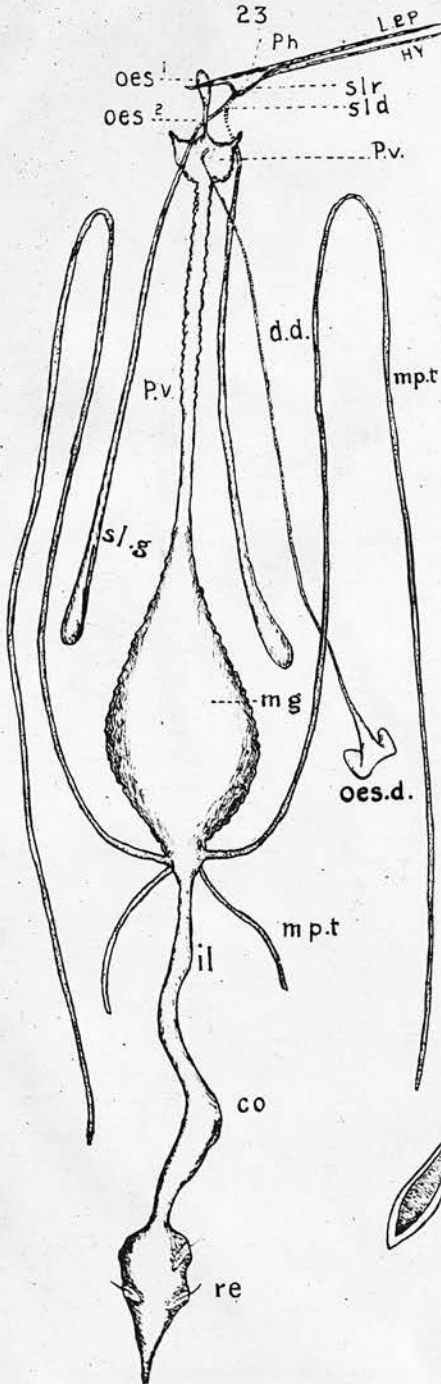
fig. 20. The respiratory system of the abdomen. 1 - 7: tracheae from the spiracles. F.B. to fat body. D.A: Dorsal branches (7) M.g. to midgut o.v: the ovary. x 17.

fig. 21. The nervous system: a.n: antennal nerves. op.l: optic lobe. c.m: commissure. th.g: thoracic ganglion. abg: abdominal ganglia. x 17.

fig. 22. The food and meta tarsus. x 75. cl: claw. pv: pulvillus.

PLATE VI

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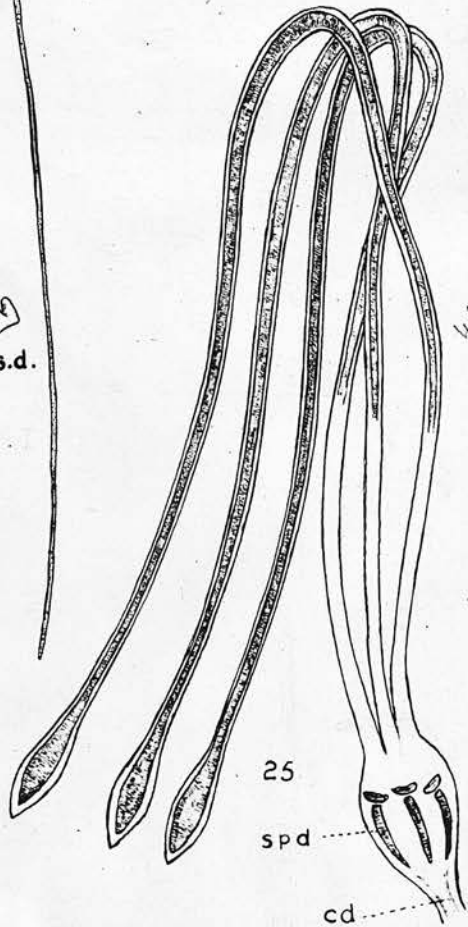


PLATE. VI.

- Fig. 23. The Alimentary Canal x L.e.p: labrum
epipharynx. Hy. Hypopharynx. P.H. Pharynx.
oes', oes": 1st. and 2nd. parts of the
oesophagus. slr: salivary reservoir. sld:
salivary duct. slg: salivary gland. oes. d:
the oesophageal diverticulum. P.v:
Proventriculus. M.g. midgut. m.p.t:
malpighian tubes. il: ileum. co. colon. re:
rectum, showing three of the papillae. x 17.
- Fig. 24. The Proventriculus. showing the develop-
ment of the intracellular secretion. x 1000.
- Fig. 25. The Spermathecae. sp.d: the funnel like
tubes at the proximal end of the spermathecae.
c.d: common duct. opening into the genital
bursa. x 40.

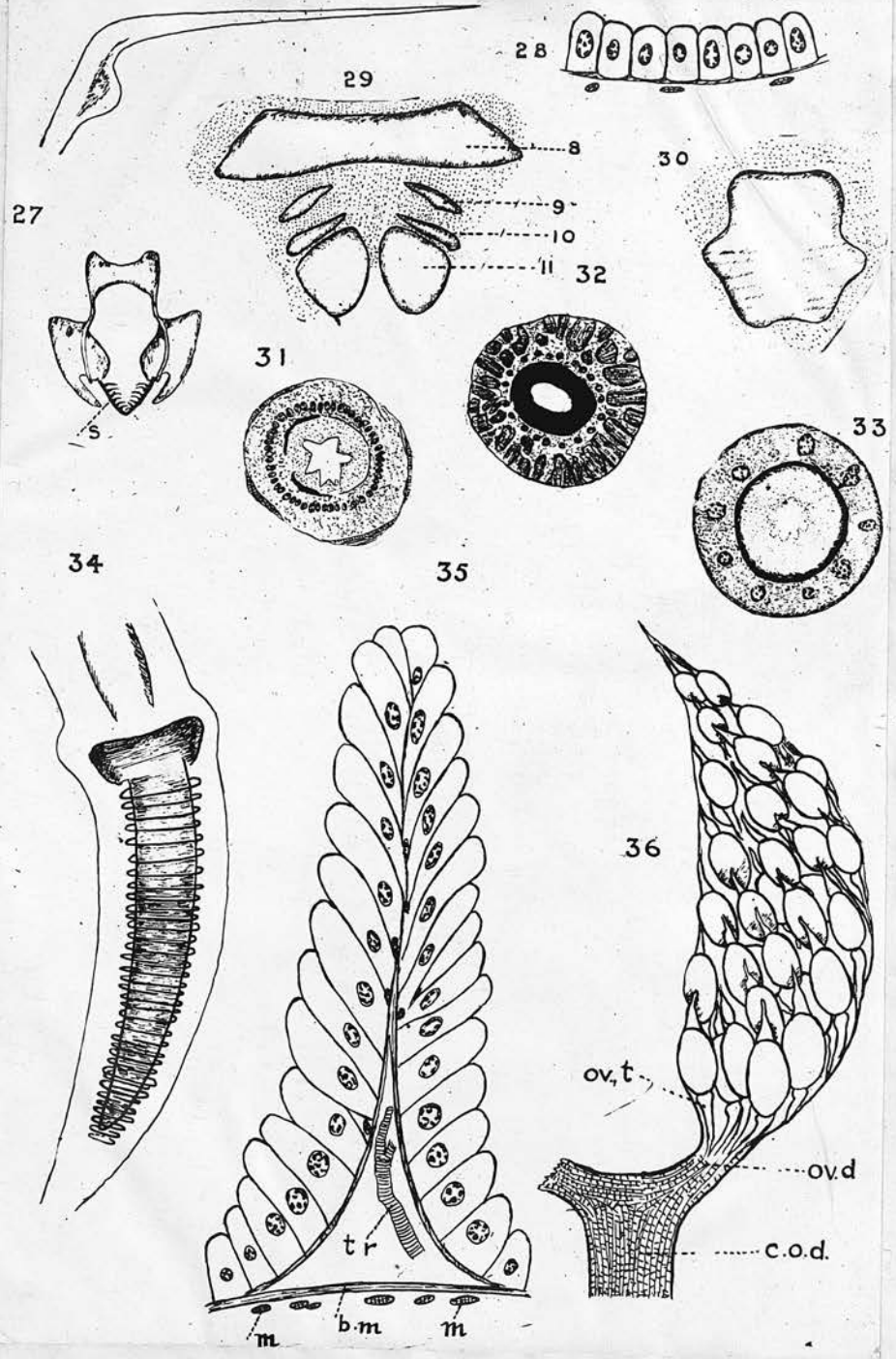


PLATE. VII.

- Fig. 26. one of the spines from the genital bursa.
x 1000.
- " 27. the chitinous framework of the genital
bursa. x 44.
- " 28. the wall of the hindgut. x 600.
- " 29. the dorsal sclerites lying beneath the
seventh segment.ll: oval lobes. x 50.
- " 30. the corresponding ventral sclerite.x 50.
- " 31. transverse section of proximal part of
spermatheca. x 450
- " 32. section through the spiral funnel at the
base of the spermatheca. x 450.
- " 33. section through the distal end of the
spermatheca. x 450.
- " 34. the spiral funnel at the base of the
spermatheca. x 400.
- " 35. a villus of the midgut x 600.
- " 36. the ovary: o.v.t. ovarian tubule. ov.d.:
ovarian duct. c.o.d: common ovarian
duct. x 27.