On Arhynchus hemignathi, a new Genus of Acanthocephala.

By

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With Plate 12.

Anatomy.

In the summer of 1894 I received from Mr. Perkins, of Jesus College, Oxford, seven small parasites which he had noticed adhering lightly to the skin around the anus of a species of bird, Hemignathus procerus, which he collected in the island of Kauai, one of the Sandwich Island group. Each of these parasites was divided into three regions,—a head, a collar, and a trunk; and, in fact, they have an almost ludicrous resemblance to a young Balanoglossus with one or two gill-slits (figs. I, II, and III). On investigating their anatomy it at once became evident that the animals belonged to the group Acanthocephala, and, further, that they differed from the other members of the group in the absence of what is perhaps their most characteristic organ,—from which, indeed, they take their name—the hooked proboscis or introvert. The absence of so characteristic a structure, and the fact that the parasites were found outside the body, i.e. not as an endoparasite, but as an ectoparasite, lightly attached to the skin, made me think that perhaps the hooked introvert had been left behind in the intestine of the host, and that the body of the parasite had passed out of the alimentary canal of the bird. However, careful inspection failed to reveal any trace of a scar or mark where the introvert might have been broken off; and although in

the absence of hooks and introvert sheath, &c., the anterior part of the body which I have called the head is as unlike the typical introvert as possible, still in its relation to the lemnisci and to the ligament it occupies the position of that organ, and until we can get further information I think the best plan is to regard this part of the body as equivalent to the eversible part of more normal forms.

The second of the three regions into which the body is externally divided is shorter than the head and smaller in diameter; it may be termed the collar. The third or posterior region, which may be called the trunk, is the longest and the most slender of the three; behind it tapers to a point where the orifice of the genital duct is situated, and this end of the animal is always a little turned up (figs. I, II, III, and VII). The exterior of the collar and trunk are smooth or lightly wrinkled, but the head is covered with a number of small depressions or pits which give it a very characteristic appearance, and which are well seen in sections. The head is attached to the collar by a narrow neck, which is surrounded and concealed by the edge of the collar. It is obvious in sections (figs. V and XIII). All the specimens were somewhat shrivelled and apparently distorted. The largest measured 3·5 mm. in length, the smallest 2·5 mm.; had they been fully distended they would probably have been 1 to 1·5 mm. longer. The body-cavity of the head is continuous with that of the neck, and the latter opens freely into the cavity of the trunk (fig. 13). The first-named space is by far the largest. The lumen of the collar region is reduced by the great thickness of the walls of this part of the body, and both here and in the trunk much of the internal space is occupied by the lemnisci and the reproductive organs.

The skin is one of the most characteristic features of the Acanthocephala, and as far as I know is only paralleled by that of the Nematodes, but it possesses certain features not found in the last named group. The whole body is covered by a thin cuticle which does not vary much in thickness in the different regions of the body, and which is invaginated a short

distance into the genital pore. Beneath this is the true epidermis, or subcuticle as it is called; this has in my specimens the usual structure met with in the group so well described by Hamann, and consists of a matrix of a fibrillar nature, the fibrils being as a rule arranged radially, in which are embedded a certain number of amœboid nuclei (figs. VI and X). This tissue is much thicker in the region of the collar than elsewhere, and it is thicker in the trunk than in the head. It is pierced in all directions by a series of tubes or lacunæ which have no definite lining, but which seem to be mere splits in the fibrillar matrix. The lacunæ—except in the head—have a general circular direction which is very well marked in the trunk region where each runs into a lateral longitudinal split (fig. X). They contain a small amount of coagulum, the remnant of the fluid which circulates in them; during life this fluid, in other species, holds in suspension fat and coloured oil globules. If these are present in my species they must have been dissolved out in the processes which precede embedding. The circular lacunæ of the trunk not only communicate with one another by means of the two longitudinal lateral lacunæ (fig. XIV), but they open into one another by numerous small branches which have an oblique or longitudinal direction. In the head the lacunæ have a general longitudinal course; they are not, however, straight, but twist in and out between the pits on the surface; they anastomose freely (fig. IV). Thus in a transverse section of the head the lacunæ appear as round holes more or less uniformly arranged in the skin, and the same effect is produced by a longitudinal section of the trunk.

In the collar region the subcuticular tissue is much thickened, and the lacunar system forms a single more or less definite ring which gives off numerous branching anastomosing twigs (fig. V).

Although the above account attempts to give the general course of the lacunæ in the skin, it should be mentioned that there is considerable irregularity in the arrangement, and one is almost inclined to believe that the canals do not remain permanent, but that they sometimes close up and

new ones appear. As they have no lining of any kind, such a closing would leave no trace.

As Schneider,[1] Hamann,[2] and Kaiser[3] have shown in the species investigated by them, the lacunar system of the introvert is completely shut off from that of the neck—if it be present—and of the trunk by a fold inwards of the cuticle which cuts the subcuticular tissue in two. I have not been able to find any such cuticular ring in the species in question, but the state of preservation of my specimens does not allow me to say definitely that it does not exist.

The lemnisci are two elongated sac-like prolongations of the subcuticular tissue which are attached anteriorly to the skin at the junction of the head and collar. They extend backwards to the extreme posterior end of the body, and are slightly bent so that a longitudinal section may cut them in two or three places (fig. XIII). Histologically they are composed of the same substance as the subcuticle in direct continuity with which they arise, and they are traversed by a similar system of canals. Physiologically they seem, as Hamann suggests, to act as reservoirs for the fluid of the canal system of the introvert; when the fluid they contain is forced into the spaces of the introvert the latter is everted. It is withdrawn again into the body by special muscles. In most species the canal system of the lemnisci opens into that of the introvert in front of the cuticular ring, and is thus completely independent of that of the trunk. If we assume that the head of my species corresponds with the introvert of other forms which have lost its introvert sheath, the lemnisci open into the same region of the skin as they do in other Acanthocephala.

The nuclei of the subcuticle and of the lemnisci are very remarkable; they correspond in structure with those described by Hamann in Neorhynchus clavæceps, in which species according to this observer both the skin and the lemnisci retain in the adult their embryonic condition. As in Neorhynchus

[1] 'Arch. Anat.,' 1868, p. 584.

[2] 'Die Nemathelminthen,' Hefte 1 and 2, Jena, 1891 and 1895.

[3] 'Bibl. Zool.,' Heft 7, 1892, p. 1.

the number of nuclei is very small, some twelve to twenty seem to suffice for the whole of the subcuticle, and perhaps two to four for each lemniscus. The structure of the nucleus shows a most striking resemblance to an amœba with rather short pseudopodia (figs. x, xiii, and xiv). No single nucleolus can be detected, but numerous chromatin particles are present, and in some a distinct vacuole can be observed. These nuclei are scattered about in a most irregular fashion; not one may be seen in a number of consecutive sections, and then perhaps three or four may appear, and from their large size persist through several sections. The nuclei lie, as a rule, embedded in the substance of the subcuticle; more rarely they are found in the lacunæ. Although there is no proof, one is tempted to believe that the nuclei wander through the subcuticle and lemnisci in an amœboid manner, and that the small number of nuclei which are found in these tissues is compensated for partly by the large size of each, but more especially by their mobility. Similar amœboid nuclei undoubtedly move about, fuse with one another, and undergo fission in the subcuticle of the larval forms of Neorhynchus clavæceps.

Within the subcuticle and completing the skin on the inner side, is a layer of circular muscles, and still more internally a layer of longitudinal muscles (figs. vi and xv). The muscles of these layers are but a single fibre thick, and they are not very uniformly present. The circular layer is most complete in the region of the trunk, and I have figured a section to show this (fig. xii). The longitudinal layer is even less definite, but scattered fibres can be detected here and there (figs. xiv and xv). Each fibre appears to be spindle-shaped, and in the circular muscles has the striated portion only on its outer face, forming a thin band; the inner half of the fibre consists of vacuolated strands of protoplasm in which is a nucleus. The longitudinal layer of muscles alone is continued over the lemnisci (figs. ix and xiv). These muscles are not covered on their inner side by any layer of epithelial cells, neither does any such layer cover the ligament, but both tissues lie freely exposed to the fluid of the body-cavity.

In the more typical Acanthocephala the anterior end of the body terminates in a hollow eversible portion provided with rows of hooks whose number and shape have a certain systematic value. This introvert can be withdrawn, not into the general body cavity, but into the cavity of the introvert sheath, which is shut off from the general body cavity by a double (Echinorhynchidæ) or a single (Neorhynchidæ) wall. The extrusion of the introvert is believed to be effected by fluid being forced into its lacunæ by the lemnisci. It is retracted by special muscles attached to the inside of its tip; besides these, other retractor muscles run from the outside of the introvert sheath, and these serve to retract the whole sheath and its contents into the trunk. The chief nerve ganglion lies as a rule on the posterior end of the introvert sheath, usually in the middle line, but in the Gigantorhynchidæ it is placed to one side. From the posterior end of the introvert sheath, and having its origin between its two walls when they are present, the ligament runs backward, traversing the body cavity, and ending in the funnel-shaped internal opening of the oviduct in the female and in the vas deferens in the male.

Owing to the absence of an introvert and its sheath, the relations of the ligament in the present species is somewhat altered. It takes its origin from the anterior end of the head, and at first seems to consist of a few strands of muscular fibres which arise from the muscles of the skin (fig. XI). All my specimens but one proved to be mature females, whose ovaries had broken up into the egg masses which are characteristic of the Acanthocephala. These egg masses consist of packets of a dozen or more cells of which the peripheral layer develop into ova at the cost of the central cells which serve them as a food supply (figs. VI, XI, and XIII). These packets coexisted in my specimens with ova in various stages of development, some without any egg shell, whilst others were provided with a thick deeply-staining membrane. The whole lumen of the head was crowded with these ova. In the region of the collar the ova were confined by a thin-walled membrane, and in the trunk there were two such masses of ova, which,

however, seemed less mature than those lying in the head. Lying amongst the various organs in the body-cavity were a number of very finely granular masses, which I take to be the masses of spermatozoa (figs. VI and X). Of the complex system by means of which the ova leave the body, little could be made out beyond the fact that a well-marked funnel is present opening into the posterior end of the body-cavity of the trunk (fig. IX). I failed, however, to find a second opening near the narrow end of the funnel such as occurs in other forms, but this may have been due to the poor state of preservation. The funnel leads into a duct which opens on the posterior end of the trunk.

The testes are two in number, and lie one behind the other in the ligament, though owing to its looping both may appear in the same transverse section. The spermatozoa do not escape into the body of the male as the ova do into that of the female, but pass down a duct in the ligament which opens at the end of the body. Traces of accessory glands were seen, but the details were not clear.

The brain lies on or in the ligament just behind its point of attachment to the skin of the head (figs. XI and XIII). Owing to the disruption of the ovaries in my female specimens the ligament could not be traced very far, but in the only male it reached from one end of the body to the other. The brain consists of a few large ganglion cells with a clear homogeneous cytoplasm and deeply-stained nuclei; the divisions between the cells were very sharp and straight (fig. XI). In the females this mass of cells lay in the ligament; in the male, on the other hand, it occupied the centre of the fibrous and muscular strands which compose that body (fig. XV). In the former I could trace no nerves leaving the brain, but in the male two nerves surrounded by muscles pass backward; these obviously correspond with the retinacula of other forms.

Classification.

Until recently the group Acanthocephala included but one genus, Echinorhynchus, which comprised several hundred

species. Recently, however, Hamann[1] has pointed out that these species present certain differences which enable him to divide the group into three families, each with a corresponding genus. To these I venture to add a fourth, to include the remarkable form above described. This family may, I think, be called the Arhynchidæ, and the new genus Arhynchus, which name refers to the absence of the eversible introvert; and, inasmuch as it is convenient in naming a parasite to have some indication of its host, I think the specific name may be hemignathi.

If these terms be adopted, the classification of the Acanthocephala will be as follows, the characteristics of each of the first three families being taken from Hamann's papers.

ACANTHOCEPHALA.

I. Family Echinorhynchidæ. The body is elongated and smooth. The introvert sheath has double walls, and the introvert is invaginated into it. The nerve ganglion is in the introvert sheath, mostly embedded in it and central in position. The hook papillæ are only covered with chitin at their apex, and the hooks have a process below.

Genus Echinorhynchus, with the characters of the family.

The vast majority of Acanthocephala belong to this family; a few may be mentioned. E. proteus, found in many fishes and varying in size with its host; its larval forms inhabit the Amphipod Gammarus pulex, and are also found in the body-cavity of numerous fresh-water fishes. E. clavula occurs in many fishes and in the intestine of a species of Bufo. E. angustatus is found also in fishes, with its larval form in the Isopod Asellus aquaticus. E. moniliformis is said to attain maturity in the human intestine; its usual host is a mouse, and its larval host the larva of a beetle, Blaps mucronata. E. porrigens invests the intestine of the rorqual and E. strumosus that of a seal. There are many others.

[1] Loc. cit., and 'Zool. Anz.,' Bd. xv, 1892, p. 195.

II. Family GIGANTORHYNCHIDÆ. Large forms, whose body is ringed and flattened during life like that of a Tænia. The hooks are like those of a Tænia, the hook-papilla being entirely covered with chitin. There are two root-like processes to each hook. The introvert is muscular, has no lumen and the introvert cannot be retracted into it, but the whole retracts into the body-cavity. The ganglion is excentrically placed to the side, behind the middle of the so-called sheath. The body-cavity is enclosed in a structureless membrane, and is traversed by membranes stretched transversely. The lemnisci are long, coiled, with a central lacuna.

Genus Gigantorhynchus, with the characters of the family.

Hamann includes three species in this family—G. echinodiscus, G. tænioides, and G. spira; and points out that E. gigas agrees with them in all points but that of the external annulation. The first of the above-named species occurs in the intestine of anteaters, and has been found in Myrmecophaga jubata and Cycloturus didactyla. G. tænioides has been found in a species of Cariama, Dicholophus cristatus; and G. spira lives in the king vulture, Sarcorhampus papa. E. gigas in the adult stage occurs in the small intestine of swine, and its larval host is believed to be the grubs of Melolontha vulgaris and Cetonia aurata in Europe and of Lachnosterna arcuata in the United States.[1] It is recorded once from the human intestine.

III. Family NEORHYNCHIDÆ. Sexual maturity is reached in the larval state. The introvert sheath has a single wall. A few giant nuclei only are found in the subcuticle and in the lemnisci. The circular muscles are very simply developed, and the longitudinal muscles only present in places.

Genus Neorhynchus, with the characters of the family.

This genus includes but two species, N. clavæceps and N. agilis. They both present interesting cases of pædogenesis, the large embryonic nuclei of the young larva do not break up into numerous nuclei as they do in the com-

[1] C. W. Styles, 'Zool. Anz.,' Bd. xv, 1892, p. 52.

moner species. N. agilis is found in Mugil auratus and M. cephalus; N. clavæceps in the Carp, Cyprinus carpio, its larva form according to Villot[1] in the fat bodies of the Neuropterous insect Sialis niger; it has also been found in the alimentary canal of the leech Nephelis octocula, and specimens of the water-snail Limnæa have been articially infected with it.

IV. Family Arhynchidæ. Short forms, with the body divided into three well-marked regions,—head, collar, and trunk. The head is pitted, the collar smooth, and the trunk wrinkled, not annulated—in spirit specimens. There is no eversible introvert, and no introvert sheath and no hooks. The sub-cuticle and the lemnisci have a few giant nuclei, and the lemnisci are long and coiled.

Genus Arhynchus, with the characters of the family.

This family in the length and curvature of its lemnisci resembles the Gigantorhynchidæ, and in the persistence of the embryonic condition of the nuclei in the sub-cuticle and the lemnisci, the Neorhynchidæ; but in the shape of the body, its division into three well-marked regions, the absence of eversible introvert, introvert sheath, and hooks, it stands alone, though to some extent nearer to the Neorhynchidæ, in which the introvert is relatively small, the introvert sheath simple, and the number of hooks reduced, than to either of the other families.

The single species Arhynchus hemignathi was found attached to the skin around the anus of a Sandwich Island bird, Hemignathus proceros. This bird is a member of a family Drepanididæ, which is entirely confined to the Sandwich Island group. Professor Newton tells me that it is probable that the "food of Hemignathus consists entirely of insects which it finds in or under the bark of trees;" hence it is probable that the second host of this parasite, if such exists, must be looked for amongst the Insecta.

The Zoological Laboratory, Cambridge;
March, 1896.

[1] 'Zool. Anz.,' Bd. viii, 1885, p. 19.

DESCRIPTION OF PLATE 12,

Illustrating Mr. A. E. Shipley's paper on "Arhynchus hemignathi, a new genus of Acanthocephala."

In some cases the names of the various structures are written on the figures, in others the following abbreviations have been adopted. *circ. mus.* The layer of circular muscles in the skin. *gen. d.* Genital duct. *gen. p.* The external opening of the duct. *lac.* The lacunæ in the skin. *lat. lac.* The large lateral lacunæ of the trunk. *lem.* The lemnisci. *lig.* The ligament. *long. mus.* The longitudinal muscles of the skin. *mus.* The muscles from which the ligament arises. *nuc.* The amœboid nuclei of the skin and the lemnisci. *sperm.* Coagulated masses of spermatozoa in the body-cavity of the female.

FIGS. I, II, and III.—Three views of three different specimens of Arhynchus hemignathi. Each × 20. The division of the body into three regions is well marked. The details are shown in Fig. I. Figs. I and II are rough sketches.

FIG. IV.—A transverse section through the head of a female, crowded with ova and egg-masses; the ligament is shown in section. × 40.

FIG. V.—A transverse section through the same, just below the edge of the collar. In the centre is the neck, which fuses with the collar a few sections further back. The big circular canal of the collar is shown at *lac.* × 40.

FIG. VI.—A transverse section through the trunk of the same. The uppermost lemniscus is cut in two places. The ovary is double, and shows egg-masses as well as eggs; some coagulated masses of spermatozoa are lying in the body-cavity. × 40.

FIG. VII.—A surface view of the external opening of the genital duct. × 40.

FIG. VIII.—Some developing ova, highly magnified.

FIG. IX.—A transverse section through the trunk near the genital pore, taken from the same series as figs. IV, V, and VI. It shows part of the funnel-shaped internal opening of the genital duct, *gen. d.* × 40.

FIG. X.—A transverse section from another specimen taken behind the opening of the genital duct. This shows the arrangement of the lacunæ and their communications with the lateral lacunæ, *lat. lac.*

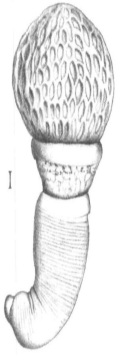
FIG. XI.—A longitudinal section through the central part of the skin of the head, showing the origin of the ligament and the ganglion cells of the brain, lying in a mass of ova and egg-masses.

FIG. XII.—A small portion of the skin in section, showing the single layer of circular muscle-fibres. × 40.

FIG. XIII.—A median longitudinal section through a female. The whole body-cavity full of ova and egg-masses. The ligament is seen in the head, and the genital duct near its opening in the trunk. The left lemniscus, cut twice, is alone seen. × 30.

FIG. XIV.—A transverse section through the trunk of a male, showing one of the testes. This section shows also the longitudinal muscles on the lemnisci and the large lateral lacunæ, *lat. lac.* × 40.

FIG. XV.—A transverse section through the head of a male, showing the brain in the ligament, and the longitudinal muscle-fibres very well developed. × 40.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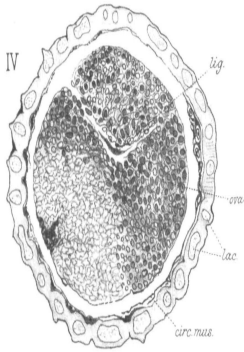
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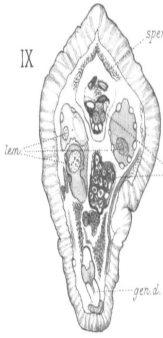
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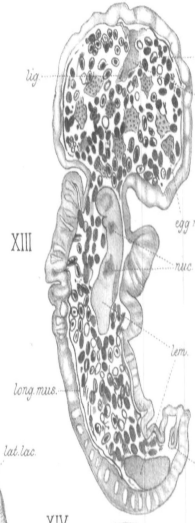
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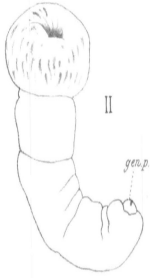
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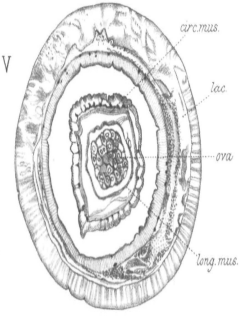
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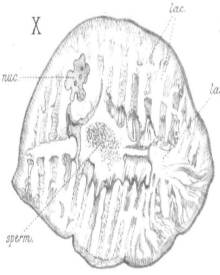
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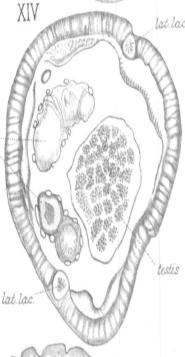
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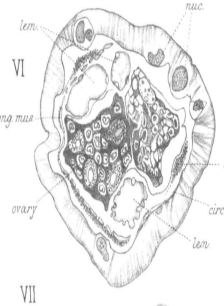
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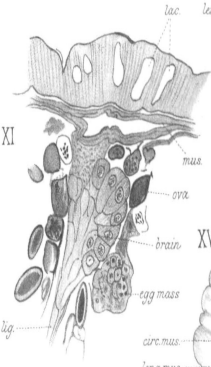
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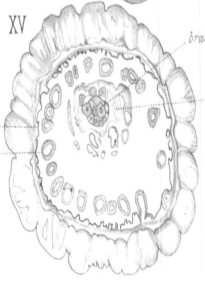
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