# B. THE ANATOMY OF SOME AQUATIC OLIGOCHÆTA FROM THE PUNJAB.

*By* J STEPHENSON, *Major, I.M.S.*

## NAIDIDÆ.

*Nais variabilis*, Piguet, var. *punjabensis*, var. nov. (Pl. xv, fig. 1.)

The form here described was found first in the tank at Shalimar near Lahore, and afterwards in other places.

*Externa' characters.*—The animals are of an indefinite light grey colour, and are fairly transparent under the microscope. The average *length* of a single individual is about 5-6 mm.; they may be only 2-3 mm., or on the other hand a fully extended specimen about to divide may reach 12-14 mm. They live for the most part crawling freely in the mud or on aquatic vegetation; but in the month of May, a considerable number were found concealed, probably temporarily, in the tubes of insect larvæ. I could not differentiate these tube-inhabiting forms by any certain means from others previously observed. Backward progression is quite easy to these animals, and is not uncommon, at least while under examination.

The *prostomium* is short, slightly extensible, rounded, and bears sensory hairs; the surface epithelium is thicker at its tip than elsewhere in the body. The *mouth* is transverse, reaching from side to side. The *eyes* are placed laterally exactly at the level of the mouth; they are ovoid or somewhat irregular masses of black pigment, with, in addition, a violet tinge; additional smaller eyes ("Nebenaugen") may be present near the two principal ones (fig. 3). In several cases (in the posterior half of an animal which was about to divide) the eyes were being formed by the deposition of a brown pigment; in one case the pigment appeared to have a violet tinge from the beginning. The body-wall is pigmented irregularly over the few most anterior segments, in one case as far back as the ninth; the pigment is of a light brown colour, and is contained in the deepest portion of the body-wall, probably in the epithelium lining the body-cavity. Behind the head the general shape of the body is uniformly cylindrical. The *anus* is posterior and very slightly dorsal.

The *number of segments* is frequently about 26; but it may apparently vary between 18 and 32, as computed from the number of ventral setal bundles; these, however, diminish gradually in size at the hinder end of the animal, and cease altogether some little distance in front of the anus (*v.* fig. 4).

*Asexual multiplication.*—There is never more than one constriction present; that is to say, the chains of three, four or five incomplete individuals formed by *Æolosoma* or *Chætogaster* are not found. Figure 5 shows the site of an approaching division;

the budding of new segments has taken place behind the sixteenth segment of the original single animal, the first five segments of the posterior animal also have been newly formed, so that the seventeenth segment of the original animal would in this way become the sixth, or first with dorsal setæ of the second. It may be mentioned that I found [8 and 9] in *Chætogaster* also that the first five segments are intercalated at the head end of the second animal; in *Pristina*, however (*v. infra*), seven are so added; and with these facts may be mentioned two others, that in *Chætogaster* and *Nais* the nephridia begin in the seventh, in *Pristina* in the ninth segment; and that in *Pristina* the position of the reproductive organs also is two segments further back than in the others. Figure 6 shows the hind end of an animal which had apparently recently divided; here the budding of new segments took place behind the fourteenth original segment; the site of the zone of budding would seem, therefore, not to be a fixed one.

The *ventral setæ* (text-fig. 1) occur in all segments from the second onwards; but those of the second, third, fourth and fifth segments differ slightly from the rest. All agree in being curved so as to resemble an elongated $\int$, in being forked distally, the proximal prong being shorter and thicker than the distal, in possessing a nodulus, and in projecting but slightly from the body-wall; their total length is at most about half the diameter of the extended body.

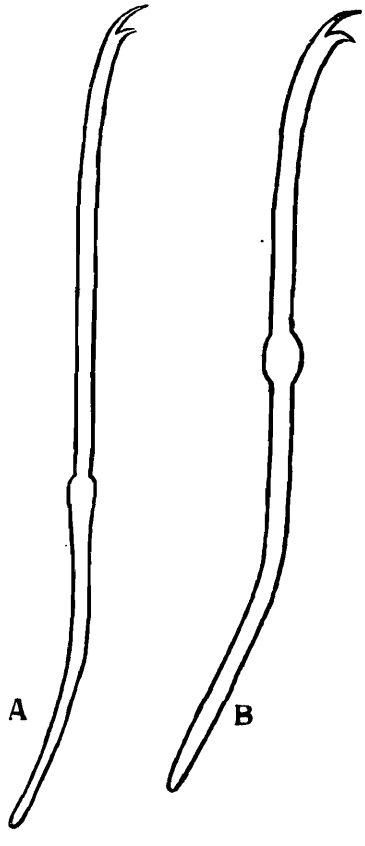


FIG. 1.—Ventral setæ of *Nais variabilis*, var. *punjabensis*—
A, of ii, iii, iv, v segments;
B, of the remaining segments.

From the sixth segment onwards, they measure ·075—·08 mm. in length, are moderately stout, and have the distal prong of the fork 1½ times as long as the proximal, though only ⅔ as thick at the base. The nodulus is distal to the middle, the proportions being—

proximal to nodulus : distal to nodulus : : 4 : 3.

A variation in the relative form of the two prongs of the fork was occasionally met with, where both were of the same length, but the proximal prong was twice as thick at its base as the distal.

The ventral setæ of the second to the fifth segments are slightly longer, *e.g.*, ·09—·095 mm. in a case where the more posteriorly placed setæ were ·08 mm. They are also considerably thinner; the distal prong of the fork is twice as long as the proximal, and is of the same thickness at the base. The nodulus is proximal to the middle of the length of the seta, the proportions previously given being about reversed, *i.e.*—

proximal to nodulus : distal to nodulus : : 3 : 4.

The usual number of ventral setæ in a bundle is 3 to 5; numbers from 2 to 7 are also met with.

The *dorsal setæ* (text-fig. 2) begin in the sixth segment; in one specimen the seventh was the first to bear them, though there seemed to be a small lobulated setal sac in the sixth; like the ventral setæ, they diminish in size towards the posterior end, and usually cease altogether a few segments in front of the ending of the ventral setæ. They may be divided into long and short, or hair-setæ and needle setæ.

FIG. 2.—Dorsal needle-seta of *Nais variabilis*, var. *punjabensis*.

The length of the hair-setæ varies; they may be equal or nearly equal to the diameter of the body, or may be only a half or two-thirds of the diameter; in some cases they have obviously been broken off short; in others they have either fallen out altogether or have not been developed. They are frequently smooth; but frequently also they may have few (fig. 8) or many extremely fine thorn-like projections, which may even be branched; to these "thorns" minute foreign particles frequently adhere; an extreme example of this condition is shown in plate xvi, fig. 9. The thorn-like processes are, when present, not arranged in definite lines or at regular distances. They seem to be due to the fraying out from the side of the seta of some of its component fibrils and to the forcible breaking back, without actual detachment, of the frayed ends. Their presence would thus be an indication of age or hard wear; and as a matter of fact they appear to be most numerous in those cases where age or hard wear are also evidenced by the irregular lengths of the setæ, by their broken condition, or even their entire absence from certain segments. It has seemed to me that the earlier specimens of a batch of material examined soon after being taken from their natural surroundings, do not show these thorn-like processes so often nor to so extreme a degree as those examined subsequently, after having been kept, perhaps, a month in the laboratory. Here, again, we have perhaps an indication that the processes are due to disintegration brought about by relatively unfavourable conditions.

In the first draft of this paper, I described the needle-setæ of the dorsal bundles as having usually a single point, and only very occasionally being bifid at the free end. During the last month or two, however, I have examined a considerable number of specimens from a different source (the river Ravi), and in these I have usually found some, at least, of the needle-setæ to be bifid; indeed I have thought it possible that all are bifid, and that the failure actually to see this depends on the fact that in many cases the prongs of the forked end are so placed under the microscope as to overlie one another and hence are not seen separately. It is possible that my earlier failure to note the bifid ends of these setæ may have been due to a lack of sufficiently close observation; on the other hand, both doubly- and singly-pointed needle-setæ may perhaps occur, as is stated to be the case in an allied form (*N. variabilis*, var *simplex*, Piguet [7]).

Describing, however, the bifid form as the typical one, these needle-setæ of the dorsal bundles are about ·06 (·058—·07) mm. long, slightly sickle-shaped, with an

indefinite nodulus about one-third of the length from the free end. The forking is always very fine, and is practically never visible without the employment of an immersion lens (*cf.* text-fig. 2 : plate xvi, figs. 10 and 11, represent my earlier views as to these setæ, the one (fig. 10) representing the usual and the other (fig. 11) what I at first considered the " abnormal," *i.e.*, bifid, variety).

What is perhaps the most typical constitution of a dorsal bundle is the presence of one long and one short seta. But the bundle may be constituted by two hair- with one needle-seta, or one hair- with two needle-setæ, or two of each, or one needle-seta alone. It occasionally happens that no dorsal setæ of any kind are visible on a segment which ought normally to bear them. When it is remembered that the hair-setæ themselves may or may not have the thorn-like processes described above, may be of various lengths, and may or may not be broken short, it will be seen that the dorsal setal bundles may vary in different cases very widely indeed; in one and the same animal almost every bundle may present differences as compared with every other.

Two varieties of *setal sacs* are shown in figs. 12 and 13; it will be seen that one is lobulated and massive, the other attenuated. The lobulated form is apparently the rarer.

The *body-cavity* contains many *lymph-corpuscles*; these are of two kinds, white and brown. The white (fig. 12) contain a large number of bright refractile spherical granules, usually indeed appearing to be made up of them. The brown ones contain a number of minute particles which appear to be droplets of a brown oily substance; they resemble those described later for *Pristina*. An animal may have only white corpuscles, or may have both white and brown; never, so far as I have seen, brown only. I did not observe any brown corpuscles till May; it is possible that their presence is seasonal, and perhaps determined by the more plentiful food-supply at the beginning of the hot weather; the brown particles appear to be of the same nature as those in the wall of the alimentary canal. I could not correlate the presence of the brown corpuscles with any other structural peculiarity.

The *septa* are well-marked; there are also strands connecting alimentary canal and body-wall.

*Alimentary tract.*—The *buccal cavity* occupies the second segment. The *pharynx* occupies the third, fourth and fifth (*v.* plate xv, figs. 1 and 2); it is mobile, but not protrusible. Surrounding the pharynx on all sides are a number of ovoid or pear-shaped hyaline nucleated cells, the masses of which give to the pharynx a somewhat nodular appearance. Occasionally a portion of this cellular mass is somewhat detached from the pharyngeal tube; in plate xvi, fig. 14, is shown such a mass, partially detached from the dorsal wall of the pharynx, the alimentary tube itself being ventrally situated, and possessing apparently no specially thickened muscular walls (*cf.* the description of the pharynx and septal glands of *Pristina*, *post.*). The *œsophagus* occupies the sixth and part of the seventh segments; it contains in its wall numbers of minute brownish particles looking like oil droplets. A dilatation, more or less defined, in the seventh and eighth segments, may be called the *stomach*; this portion of the tract

is, however, variable. Usually the stomach is fairly sharply delimited anteriorly (fig. 1), the œsophagus in some cases being invaginated backwards into it after the manner of an intussusception; the stomach is less sharply delimited posteriorly, where it is continued into the intestine; it may appear as merely a gentle fusiform dilatation on the alimentary tube; or in some cases may not be distinguishable at all. In the latter case, there is then no differentiation of the alimentary canal behind the pharynx. The *intestine* is ciliated, the cilia being obvious, and working in a postero-anterior direction; peristaltic movements throughout its extent occur constantly and with a fairly regular rhythm; these movements, like the ciliary action, proceed from behind forwards, and, borrowing a term from mammalian physiology, may for convenience be described as "antiperistaltic." It would seem, therefore, that the intestine performs a respiratory function.

*Circulatory system.*—The blood is yellowish red, and contains no corpuscles. The dorsal vessel is contractile, the contractions progressing in a postero-anterior direction; it is incorporated in the wall of the alimentary canal as far forwards as the œsophagus; the brown globules present in the wall of the intestine may be seen superficial to the vessel. The ventral vessel is non-contractile and is not incorporated in the intestinal wall; it divides about the level of the setal bundle of the third segment, and the branches join in the prostomium to form the dorsal vessel; for the relations of the blood vessels to the nerve ganglion *vide* fig. 15. There are not fewer than four, perhaps five, transverse commissures joining dorsal and ventral vessels in the pharyngeal region; they occur in the third, fourth and fifth segments, but apparently there may be more than one in a segment.

*Nephridia.*—The first nephridium is in the seventh segment. The beginning of the tube can be seen as a ciliated open mouth, or small ciliated funnel, in the preceding segment; the tube at once pierces the septum, and is then somewhat dilated for a short distance, after which it appears to maintain a uniform diameter throughout its numerous windings till it opens into a terminal ciliated dilatation which discharges to the exterior on a level a little in front of the insertion of the ventral setæ. The walls are composed of a granular protoplasm in which nuclei and cell outlines are not to be distinguished in the living animal.

*Nervous system.*—The cerebral ganglion is deeply indented behind, less deeply in front (fig. 15). The commissures join its anterior part (figs 2 and 15); the first ganglion of the ventral chain is immediately behind the mouth; the ganglia in general can be seen in a side view as swellings, situated each at the level of the ventral setæ; seen from the ventral surface the cord has an irregular lobulated outline, and the ganglionic swellings are not distinguishable from this aspect.

*Genital organs.*—The genital organs were observed in various stages of development in the months of March and April. The appearances were as follow: as to the interpretation of the appearances I am not in all cases quite clear. Both sexual and asexual reproduction may go on together; an individual that was about to divide asexually was not uncommonly found to have sexual organs in a moderately advanced stage of development.

The first sign of sexual organs is the appearance of an apparently homogeneous hyaline mass, presumably the testis, in the fifth segment, close to septum 4/5. Next (fig. 16) there is seen at the sides of the hinder end of the pharynx a sac containing mulberry-shaped masses of sperm-mother-cells, dull and hyaline in appearance; among the morulæ are large numbers of round cells, with many bright granules in their interior, similar to the lymph-corpuscles of the body-cavity. In the specimen shown in the figure (16), there is a similar sac (or probably an extension of the former one) on the right side of the sixth segment.

In a subsequent stage (fig. 17) the spermathecæ form as sausage-shaped structures, hollow, with cellular walls and with external openings at the anterior part of the fifth segment. The vesicula seminalis in the same segment contains developing spermatozoa, as does that in the sixth; another seminal vesicle has developed, perhaps as an outgrowth of that in the sixth segment, and this extends back through the seventh, eighth and ninth segments, containing developing spermatozoa. At the hinder end of the ninth segment was seen a mass of ova; the ovaries must therefore have developed.

In fig. 18 the seminal vesicles are smaller; but the ova are more numerous, and a large mass in the sixth segment probably represents the ovary; the eggs seem to develop in the body-cavity; thus there are masses of them in the fifth segment, and again a small mass in the ninth, at the hinder end of the seminal vesicle; it is quite possible, however, that the masses in the fifth segment are sperm-morulæ. In the seventh segment is seen the earliest stage of what later becomes a very prominent structure; there are seen three small masses, opaque, and composed of a number of small glancing or refractile particles aggregated together. At or about this stage the seminal vesicles may attain an enormous dilatation, as shown in plate xvii, fig. 19, for the posterior vesicle; the anterior, however, was not obvious. Genital products (either egg masses or sperm-morulæ) are sometimes visible free in the body-cavity as far forward as the third segment, or even occasionally in the second (*v.* fig. 20); and slight and unintentional violence may cause spermatozoa to burst through the body-wall and be discharged from the tip of the prostomium.

The clitellum forms as a wrinkling and thickening of the epidermis at the region of septum 6-7 (fig. 20). Later it extends over both fifth and sixth segments; the skin is finely tuberculated throughout this region ,which is sharply defined both in front and behind. The thickening and tuberculation are accompanied by considerable opacity, so that it is impossible to make out the internal anatomy of this part after the establishment of the clitellum.

The opaque granular mass or masses referred to above increase in size; if multiple at first, they appear to unite into a single mass. This mass has apparently no definitely fixed position; though it was first seen forming in the seventh segment, in another case it was found, while still of small size, to be present in the ninth. Later, however (fig. 21), it grows to such an extent as to occupy the seventh, eighth and ninth segments. It can then be easily seen with the naked eye in a living free-moving worm as a bright white particle, the size of a small pin's head. On slight

pressure it may be extruded whole from the body of the worm. When teased, it is found to consist entirely of oval particles, each homogeneous and non-nucleated, bright and highly refractile, in diameter a third or a quarter the size of a lymph-corpuscle of the animal's body-cavity. Singly these particles are transparent; in the aggregate, in the body of the animal, they are opaque, and the mass which they compose is under the microscope by transmitted light quite dark. The similarity of the particles to those included in the corpuscles of the body-cavity has been mentioned; it may be added that appearances would seem to suggest that certain of the body-cavity corpuscles are mere aggregates of such particles.

It may be conjectured that the great swelling of the body in segments v and vi of the specimen represented in fig. 21 is due mainly to the growth of the opaque body, and the consequent pushing forwards of the dilated seminal vesicles, which formerly stretched backwards as far as the hinder end of the ninth segment.

The *genital setæ* (text-fig. 3) are the modified ventral setæ of the sixth segment, and replace the setæ of ordinary type in animals with sexual organs in an advanced state of development. They are ·09 mm. or less in length, stout in build, curved

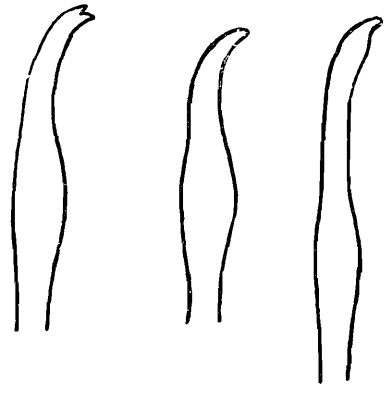

FIG. 3.—Genital setæ of *Nais variabilis*, var. *punjabensis*.

and somewhat swollen near the free end, which may or may not be bifid. If bifid, the prongs of the fork are short, blunt, and approximately equal in length; if not, the extremity is blunt and rounded. There may be two setæ in each bundle, or sometimes three, one at least in either case being bifid, the other frequently with a single point.

I cannot find any reference to a white mass of similar constitution to the one described above. Michaelsen [4] figures and describes only ova in the ovisac of *N. elinguis*; Piguet [7] figures something similar for *Pristina longiseta*, and describes the ovisac of *N. communis*, but again speaks only of ovarian cells and ova. The ordinary works of reference do not contain any allusion to a white mass of the nature of the above. It is always stated that "albumen" is found within the cocoons of Oligochæta, but its source is not mentioned; it seems possible that we have here an indication of its origin. (*Cf.* also *Pristina*, *post.*)

NOTE.—Since writing the above account I have been able to obtain a fair number of sexual individuals, with the organs in various stages of development. Unfortunately I am unable to work through this material at present, but hope to have an opportunity of returning to this subject.

*Parasite.*—In almost all cases there are a number of protozoan ectoparasites attached to the head, and in smaller numbers to other parts of the body, of these worms. Strictly speaking they are commensals rather than parasites, since occasionally they are found attached to the setæ, and hence cannot then draw any nutriment from the body of the worm. I have not identified the form, though it appears to be related to *Spirochona*. It is of a vase shape, with stiff processes projecting from the rounded angles of its free extremity; these are actively motile, performing sharp sudden movements inwards at irregular intervals; there is also a spirally coiled ciliated oral process. The animal is attached by a "foot"; the nucleus, as brought out by acetic acid, is moniliform, with a narrower central portion, or may appear as divided into two separate halves (plate xx, fig. 49 *a-e*).

The species described above has a certain similarity to *N. elinguis*, O. F. M., and agrees in most particulars with the diagnosis given by Michaelsen [3] in 1900; and I was at first inclined to consider this form as, at most, a variety of *N. elinguis*.

Through the kindness of Dr. Piguet, I have recently received a copy of his dissertation [7] on the Naididæ of Switzerland. He remarks as follows: "La systématique des *Nais* était très incomplète, les diagnoses souvent insuffisantes. La description sommaire de *N. elinguis* s'applique à au moins 3 *Nais* différentes, et le désaccord entre les zoologistes au sujet des espèces de ce genre s'explique très facilement. Une détermination exacte basée sur une description rapide des soies est impossible, et permettrait de confondre *N. communis*, *N. variabilis* et *N. elinguis*, qui ont toutes trois des aiguilles bidentées et des soies capillaires dans les faisceaux dorsaux; et cependant ces trois espèces sont parfaitement distinctes."

Of the species and varieties into which the old *N. elinguis* has thus been broken up, the one which most closely resembles the present form is *N. variabilis*. From *N. elinguis* as now defined the present form is distinguished by the constitution of the dorsal bundles, which in *N. elinguis* have a larger number of component setæ; and by having shorter terminal prongs to the dorsal needle-setæ; the distinction between the ventral setæ of segments ii-v, and those which follow them is also wanting in *N. elinguis*. From *N. communis*, Piguet, also it is distinguished by the colour, the less marked bifurcation and less obvious nodulus of the dorsal needles, the frequent bifid termination of the genital setæ, and apparently by the very definite difference in the thickness of the ventral setæ in segments ii-v and of those posterior to this.

In considering *N. variabilis*, Piguet, we have to take into account the type form, the variety of the large lakes of Switzerland, the variety with very long hair-setæ, *N. variabilis*, var. *simplex*, and a form called by Piguet "seconde forme annexe." I have gone carefully through these forms, which differ among themselves in details of colour and relative size and visibility of the prongs of the dorsal needle-setæ,

as well as in a few other details; and I cannot find in any one of them the exact counterpart of the form I have here described. Indeed it is perhaps hardly to be expected that such a highly variable species should present exactly the same aspect in such a distant region and different climate.

There is, moreover, one peculiarity of the Indian form which distinguishes it absolutely, so far as I have seen, from all forms of *Nais* hitherto described; that is, the frequent thorn-like processes on the dorsal hair-setæ. Since these are by no means always present, it would probably be better (accepting the explanation of the phenomena previously suggested) to describe this as a general tendency or predisposition to disintegration of these particular setæ.

That this characteristic has any greater value than that belonging to a geographical variety I do not for an instant suppose; it occurs also in *Pristina longiseta* and *Slavina punjabensis* (*v. post.*), and hence is in all probability connected with local or climatic peculiarities. I would therefore suggest that the present form be considered as a variety of *N. variabilis*, Piguet, to be denoted as var. *punjabensis*.

*Nais paraguayensis*, Mchlsn. (Pl. xvii, fig. 22.)

This form was first found on April 27th in water from a pond in the Zoological Gardens, Lahore. It is somewhat larger than the preceding, being from 8 to as much as 20 mm. in length. It is of a light orange colour. It may progress at the bottom of the vessel by active wriggling movements, or sometimes by undulations freely through the water. There are no eyes.

The *prostomium* is rounded, and not elongated. The anterior part of the body, as far as the sixth segment, may be much thinner than the portion that succeeds (fig. 22). There may be an immense number of *segments*; on examining fig. 22, it will be seen that the larger number, however, have probably been recently formed; rapid budding seems to have taken place after the twenty-first original segment, twenty or more new segments being indicated by the presence of small dorsal setæ, and still more by annulations and rudimentary septa, while at the extreme posterior end segments are still altogether undifferentiated. In another case this budding took place after the thirtieth segment; rudimentary septa, but as yet no setæ, were present in the newly formed portion.

The *ventral setæ* are of the previous type; the prongs of the fork are of about equal length, the proximal one being slightly stouter; the nodulus is slightly more prominent on one side than on the other (fig. 23). They are usually six in number in each bundle.

The *dorsal setæ* consist of both hair- and hook-setæ. The hair-setæ are equal in length to the diameter of the animal, or sometimes somewhat shorter than this; they are smooth, and usually one, sometimes two, per bundle; in the latter case the second hair-seta may be considerably shorter than the first. The hook-setæ (fig. 24) are slightly curved distally in a sickle-shaped manner, and are very unequally forked, the smaller prong of the fork being on the convex side of the "sickle" and much shorter and finer than the larger, which continues the axis of the curve; these

"hook-setæ" are one or two in number in each bundle. The bundles of the dorsal setæ begin in the sixth segment, and are perhaps most commonly composed merely of one hair- and one hook-seta.

Septa are well marked; the corpuscles of the body-cavity resemble the white corpuscles of *Nais variabilis*; brown corpuscles were not seen.

The remaining systems require only brief mention. The *pharynx* was seen to be ciliated; there was no differentiation of a stomach, the whole of the alimentary canal behind the pharynx having the same character throughout; its walls contained brown oil-like globules, as in the previous form. The usual "antiperistaltic" movements were observed. The *œsophageal* or *pharyngeal commissures* were plexiform and irregular. The first *nephridium* was in the seventh segment. In other points this form appeared to correspond entirely with the *Nais* previously described. The points of distinction consist in the absence of eyes, the forked sickle-shaped dorsal setæ, and the pharyngeal plexus. The sickle-shaped setæ appear to be identical in form with those of *N. heterochæta*, Benham, which species, however, possesses eyes. But the form which comes closest to the present one is *N. paraguayensis*, Mchlsn. (Michaelsen [4]), recently described from Paraguay; there appears to be a slight difference in the hooked dorsal setæ, no sickle-shaped curve being figured or described by Michaelsen for his form; the forking, however, is of the same nature, and there would hardly seem to be sufficient reason for separating the two, though my specimens appear to be considerably larger than those from Paraguay.

*Pristina longiseta*, Ehrbg. (Pl. xvii, fig. 25.)

*External characters.*—Specimens have an average length of 3—4 mm. The animal is whitish in colour, and fairly transparent. The prostomium is prolonged into a proboscis-like projection, which, during the forward progression of the animal, is frequently bent backwards, at least when examined in the usual way under a cover-slip; it is in length about equal to the diameter of the body (*v.* plates xvii, xviii, figs. 25, 29). The number of segments in the single animal appears to vary between about 20 and 30 (see also below, *Asexual reproduction*). Backward progression is as free and almost as often resorted to as forward progression, and indeed some specimens have appeared to move backwards for choice; in this connection it may be noted that the posterior end of the body is specially well furnished with large sensory "hairs."

*Asexual reproduction.*—The greater number of specimens examined exhibited some phase of the process of fission. In one case, after the twelfth segment intercalation of new segments had taken place, evidenced by small newly-developed setal bundles; of these there were ten pairs, four belonging to the anterior and six to the posterior animal. In a second case, intercalation had again taken place behind the twelfth segment, and five newly-formed setal bundles belonged to the anterior animal, six, as before, to the posterior; 15 segments had thus been established in the anterior animal, and others were probably in process of formation at the posterior end; while in the posterior animal 21 were established, and others were apparently being produced posteriorly. In a third case the setæ were apparently well grown as

far as the seventeenth segment, behind which three smaller bundles were visible; as before, the first six setal bundles of the posterior animal were new formations; the number of definable segments was thus 20 in the anterior animal, while in the posterior there were 21 In an animal which divided under observation there were in the anterior portion 22 segments *plus* several newly forming at its hinder end, and in the posterior portion 24 *plus* similarly several newly forming posteriorly.

The zone of budding may therefore form as far forward as the twelfth segment; and in the posterior animal it appears to be the rule that the first seven (prostomium, peristomium, and six seta-bearing segments) are new formations.

Chains of three animals are occasionally met with.

*Setæ.*—The ventral setæ (fig. 27) are of an elongated shape, straight for the greater part of their length, with curved ends; they are unequally forked at their free extremity, and possess a slight nodulus; their length is from a half to two-thirds the diameter of the body; they do not project far outside the body-wall; they occur in bundles of 3 to 9, 5 being the commonest number.

The dorsal setæ begin like the ventral setæ on the second segment, and are capilliform. Those of the second segment are as a rule somewhat shorter than those of other segments. Those of the *third* segment, two or occasionally three on each side, are much longer, about three times the diameter of the body; frequently where there are two in the bundle, however, while one is of the full length just stated, the other is only about two-thirds as long, that is, about equal to twice the diameter of the animal's body. When turned forwards the long setæ reach about as far as the tip of the prostomium. These long setæ, however, appear to be liable to damage on account of their length; they may be found on one side only; or on the posterior of two not yet separated animals only, or even only on one side of this. They may break off while under examination; or a specimen which had them when first examined may, on re-examination after an interval, be found to have lost them. The distinction between this species and the next is thus sometimes rendered difficult. On *the remaining segments* the dorsal setæ attain a length equal to or somewhat greater than the diameter of the body; in the posterior part of the body, where the diameter is somewhat less, they may be nearly twice as long as the diameter of the body.

The dorsal setæ of this species were formerly supposed to be smooth; of late years, however, it has been recognised that they present on one side a fine notching, or series of saw-teeth (Michaelsen [5], [6]; Piguet [7]). These saw-teeth vary in size and visibility in specimens from different localities, and are absent from the specially elongated setæ of the third segment.

I have detected this notching in all specimens where I have specially looked for it; it is visible, though it cannot be called obvious, with a $\frac{1}{12}$ inch oil-immersion lens; it is absent towards the base of the setæ, and does not occur on the setæ of the third segment; the setæ themselves are slightly bowed, and the notching is present on the convex side only; the teeth are set apart at a distance of about 3 $\mu$ from each other.

Besides this notching, the dorsal setæ may show also a fine fraying out of the sides, such as has been already described for the *Nais variabilis* of this country. This is often absent, sometimes hardly visible, sometimes obvious; in one case in the dorsal setæ of segments ii and iii, it far surpassed that figured (for *Nais variabilis*) in plate xvi, fig. 9, and the setæ resembled nothing so much as minute feathers with close-set though unconnected barbs.

The explanation of this phenomenon I take to be the same as in the *Nais* previously described.

In number the dorsal setæ are 2, 3, 4 or 5 per bundle; but they are not all of equal length; they may be roughly classified into long, intermediate, and short; the long may be said to be those which are of the full length described above; the intermediate are a half to two-thirds the length of the long; while the short may hardly project beyond the surface of the body.

The *setal sacs* are large, conspicuous, and of bulbous shape (fig. 25). Those of the specially elongated setæ of the third segment were very frequently noticed to be quivering, or oscillating slightly and rapidly in an antero-posterior direction; this occurred when the animal was quite at rest, and when all the other setal sacs (and setæ) were motionless; on seeing it in an animal whose long setæ had been damaged, I thought it might be due to irritation, but I soon found that it occurred also in animals whose long setæ were quite intact. It appears probable, therefore, that the elongated setæ of the third segment have a special sensory function; and that this, and not any advantage in locomotion, is the purpose subserved by their lengthening; the slight vibration of the setæ brought about by the continual small contractions of the muscles attached to the setal sacs would be of use in exploring the surface at the extremities of the setæ.

The *septa* are well-developed. The body-cavity contains *corpuscles*, which contain a varying number of spherical brown bodies resembling minute drops of oil (*v.* fig. 28); in each corpuscle there may be only a few—three or four—such bodies, which are then of relatively large size; or the corpuscles may appear to be made up of a large number of very small brown particles. As a rule these particles are larger than those of similar colour in the walls of the intestine; they may also sometimes be found free in the body-cavity. White refractile particles like those in the corpuscles of *Nais variabilis* may co-exist with the above-described brown droplets.

*Alimentary canal.*—The *mouth* is transversely placed; the *buccal cavity* occupies the first segment. The *pharynx* is protrusible; cilia may be seen working in its interior, sometimes particularly in an oval patch in its centre (*v.* fig. 25); its apparent extent varies slightly; it may be limited to the second segment, or may extend partly or wholly through the third (*v. inf.*, *septal glands*); it may have a distinctly nodular appearance (figs. 25, 29). The *œsophagus* reaches to the end of the seventh segment; it is of uniform calibre, and has the septal glands attached to it. The *septal glands* (figs. 25, 29, 30, 38) are small masses of somewhat irregular shape, situated at the sides of the œsophagus; they usually appear to rest against the septum posterior to them, but sometimes no definite relation to the septa is to be

made out. They vary in number from two to four on each side; one specimen, however, appeared to have one only on one side; the two sides have not always the same number; there may be four on one side and two on the other. They are attached to the œsophagus by strands of tissue which are probably ducts, often also to the body-wall and to each other. They are present in the fourth and fifth segments, sometimes also in the third, or sixth, or in both third and sixth. The duct of the gland in the sixth segment usually runs transversely to the œsophagus, while the ducts of the glands of the fourth and fifth segments take a more forward course; that of the gland of the fourth segment may reach the hinder end of the pharynx, or may enter the œsophagus in the third segment; when glands are present in the third segment, their ducts enter the hinder end of the pharynx (figs. 25, 29).

In general, the glands are somewhat lobed, of hyaline appearance, and may have some resemblance to an ovary. Their size, like their distribution, is variable.

Beddard [1] describes the septal glands as masses of pear-shaped cells, each cell being prolonged to form its own duct, and the ducts appearing to enter the pharynx. He thinks they are simply epidermic glands which have been invaginated along with the stomodæum.

I have not been able to see the actual prolongation of each cell into a separate duct; and the ducts seem in the majority of cases to enter the œsophagus and not the pharynx. Instead of saying that they are epidermic glands which have become invaginated, I should prefer to describe them as pharyngeal digestive cells which have lost their direct connection with the alimentary canal. My meaning will be clear on comparing the diagrams of the pharynx of *Nais variabilis*, plates xv, xvi, figs. 2, 14, with figs. 29 and 38, plate xviii. The pharynx of *Nais* occupies the third, fourth and fifth segments, and has a nodular appearance due to its being surrounded by a number of ovoid or pear-shaped hyaline cells; it will be at once apparent that the pharynx of *Nais* is the equivalent of the pharynx *plus* most of the œsophagus of *Pristina*; that this part of the œsophagus of *Pristina* is simply the pharynx of *Nais* stripped of its cells, which are here aggregated to form septal glands; and that the variable length of the pharynx of *Pristina* (*v. sup.*) simply depends on the amount of this "stripping" that has taken place. The variations in size, distribution and ducts of the septal glands are thus easier to account for; and it would seem that the "pharynx" of these animals is not so much a muscular organ as a glandular one.

The *stomach* (glandular ventricle of Beddard) is a small globular saccule in the eighth segment (fig. 25). The glandular appearance of its walls is due to large ovoid or tailed nucleated cells, and the longitudinal markings which may be faintly seen are the intervals between these cells. The walls of the stomach contain also a number of brown particles resembling minute droplets of oil. The *intestine* also contains in its wall these coloured particles, which may, however, be absent from the posterior fourth of the body; an "antiperistaltic" action is usually to be observed, as in *Nais*; and the large cilia of this part of the tract work, as also in *Nais*, in a direction from behind forwards.

*Circulatory system.*—The general relations of the blood-vessels are the same as in *Nais*. The ventral vessel appears to fork at a more posterior level, at about septum 6-7; and the transverse commissures in the œsophageal region are more numerous. These occur regularly in all segments from the second to the seventh inclusive; those in the second segment are non-pulsatile, and are situated in the anterior part of the segment, in front of the level of the setæ of the segment; in all the remaining segments the commissures are pulsatile, and are placed posteriorly, lying on the septum; they increase somewhat in calibre as one passes backwards; and the largest and most obviously contractile are thus those of the seventh segment, which lie against septum 7-8, just in front of the stomach. My description, therefore, does not quite agree with that of Beddard [1, p. 291], who states that there are four vascular arches, in segments v-viii; in another place [*ib.*, p. 290] he admits five. Michaelsen [3] also, in defining the species, places the vascular arches, six in number, in segments iii-viii. As to the position of the most anterior commissure in the second segment in the Lahore specimens there can be no doubt; nor, I think, as to the remainder being on the anterior, not the posterior, face of their respective septa.

The *nephridia* commence regularly in the ninth segment, two segments behind the corresponding position in *Nais*; which may be correlated with the fact that the genital organs in this genus also occur two segments further back than is usual in the Naididæ. Beddard [1] places the first nephridium in the tenth segment. They possess a ciliated funnel, which projects through the septum into the next anterior segment.

The *nervous system* has the usual relations. The cerebral ganglion is deeply indented in front and behind (plate xviii, fig. 31). It reaches behind to the level of the dorsal setæ of segment ii, in front to a level somewhat anterior to that of the mouth. On one occasion when a specimen was viewed from the ventral surface (fig. 32) the ventral nerve cord was seen to present a series of small "button-holes," somewhat similar to those seen in *Chætogaster*, in its anterior portion as far back as the fifth segment.

*Sensory organs* are apparently represented only by small hair-like projections on the proboscis, and especially also at the hinder end of the body (*cf. ant., External characters*).

The *reproductive organs* will be described afterwards for the two species of the genus. The same ectoparasite so often seen on *Nais variabilis* was also found here on several occasions.

*P. longiseta* appears to be a somewhat variable species, and Piguet [7] remarks on the differences between his specimens, obtained in Switzerland, and those previously studied by Vejdovsky in Bohemia. The forms observed by me agree with those of Vejdovsky in the gradual passage of the tentacle-like "proboscis" into the pre-oral lobe at its base, whereas in Piguet's specimens the "proboscis" is sharply marked off at its base; and also in the comparatively moderate length of the dorsal setæ of the third segment. They agree, however, with Piguet's rather than with Vejdovsky's in the smaller number of dorsal setæ per bundle, in the facts that the

nephridia begin in the ninth segment and not the tenth, and that there are six pairs of œsophageal commissures, not five, the last being in the seventh segment, not the eighth.

*Pristina æquiseta*, Bourne.

This worm is also common in certain situations in or near Lahore; a large number were obtainable at one time from a small tank surrounding an artificial fountain in the Municipal Gardens. In general it closely resembles the former species, and the description may therefore be considerably abbreviated.

It is smaller than *P. longiseta*, averaging about 2 mm. in length; it resembles the former species in the elongated prostomium, and frequent backward progression.

The *ventral setæ* are usually three in number in each bundle; in their characters they correspond to those of *P. longiseta*. The *dorsal setæ* of the third segment are not elongated. There are throughout the extent of the animal almost always two in each bundle, of which one is capilliform, and in length equal to the diameter of the body; the other a short "needle" hardly projecting at all from the surface of the body, straight and without nodulus; this second, short seta does not appear to be an immature hair-seta, since its length does not vary, and in all the bundles it is found, as said, just protruding from the surface. I have no record of a "toothed" condition of these setæ similar to that of *P. longiseta*, but quite possibly I have overlooked it.

The *alimentary canal* may be described in the same words as that of *P. longiseta*. Septal glands were seen in segments iv, v, and vi.

The *circulatory system* is also on the same lines, and the œsophageal commissures occur in exactly the same positions; only those in segments vi and vii were, however, seen to be contractile. The *corpuscles* of the body-cavity are of the type described for the former species; and the nephridia begin, similarly, in the ninth segment.

*Asexual reproduction* was observed, and the number of segments appears to be about 20.

I have no record of *genital organs* in an undoubted specimen of this species; the appearances noted in an animal which most probably belongs to it are recorded below.

This species is distinguished from the last by the absence of the greatly elongated setæ of the third segment; but it is evident that where the long setæ have been damaged, or broken off, or have fallen out altogether, the distinction will be difficult. I have, I believe, been careful to take only specimens where these setæ were quite sound and uninjured for the purpose of the above description; and I believe, further, that the distinction between the two forms can be made by the usually smaller size of this second form, as well as by the peculiarities noted as common to all the bundles of its dorsal setæ, the general occurrence, that is, of only one long capilliform seta with one short needle-shaped seta in each bundle; my specimens of *P. longiseta* have possessed varying numbers of setæ of varying lengths in each bundle, and all capilliform.

I hesitate, however, to describe this second form confidently as *P. æquiseta*, for the following reasons: This species is described, as indeed is the whole genus (Michaelsen [3]), as possessing only capilliform setæ in the dorsal bundles; there is stated to be only one pair of transverse commissural vessels (Michælsen [3]; and Beddard [1]); and the length of the animal is given (Michælsen [3]) as 7—8 mm. In a later publication [5], however, the latter author brings down the length to 2—4 mm.; which does not seriously conflict with the description I have given.

As regards the dorsal setæ it is possible, I think, to suppose that the "needles" described above are in reality hair-setæ arrested at an early stage in their growth; which, so long as their companions are entire, remain in their immature stage, and only receive an impulse to further growth when the accompanying hair-setæ fall out. Seeing that, as stated above, I purposely chose only specimens with perfect setæ, at least on the third segment, for purposes of description, it would follow on the above hypothesis that I should, as happened, find the second or short setæ of each bundle arrested at the stage in which I have described them.

I cannot, however, reconcile the two descriptions of the commissural blood-vessels.

### *Reproductive Organs of* Pristina.

I have grouped together my observations on the genital system of both species of *Pristina*, because they are few in number, and because probably the anatomy of both is the same; moreover, I am not quite confident of the species of one or two of my specimens.

The earliest condition met with is shown in fig. 38. Here there was no clitellum; the seminal vesicles occupy the seventh and eighth segments, and, though apparently consisting of four separate masses, may be all portions of the same sac. These organs had a hyaline or finely granular appearance, and no distinct cells could be made out. Anteriorly in the sixth segment were a few aggregations of small round cells, possibly developing sperm-morulæ.

In fig. 39 the clitellum has developed over the eighth and ninth segments; when this has happened, it is impossible by ordinary examination to make out with exactitude the internal anatomy in that region; the seminal vesicles, however, occupy a large part of those two segments. In segments ix and x is seen an oval mass, pure white in colour to the naked eye, dull and opaque under the microscope by transmitted light, and evidently similar to the mass described (*v. ant.*) in *Nais variabilis*.

In fig. 40, plate xix, the clitellum reaches forwards half way over the seventh segment; a small nodular mass just behind septum 6-7 perhaps represents the testis; the vesiculæ seminales extend backwards to the posterior boundary of the ninth segment, and now contain filiform spermatozoa; a number of sperm masses appeared to be free in the body-cavity in the seventh segment, and at the hinder border of the ninth segment also were two masses of cells which might, from their appearance, have been either young ova or sperm-morulæ. The large opaque body occupied segment x,

This "opaque body" may be extruded uninjured from animals which are beginning to break up under examination in consequence of the drying up of the water or pressure of the cover-glass; it may also be extracted from the animal by manipulation with needles. Its substance consists, as in the case of *Nais variabilis*, of oval or slightly irregular highly refractile structureless particles.

In two specimens modified *genital setæ* were seen. In one case they were on the sixth segment, two in number on each side, and of the shape shown in fig. 33. In the other, the setæ of the sixth segment were not modified, but those of the fourth, though of the usual type, were extraordinarily massive, being slightly longer and twice as thick as the normal form; the forking of the distal end was much more unequal, and the curve sharper, than usual (fig. 34): it is, however, possibly incorrect to call these genital setæ. Both specimens were well advanced as regards the development of the genital organs, and resembled the stage shown in fig. 39.

*Variations met with in the genus* Pristina.

I wish here to describe two specimens, one of *P. longiseta* and one of *P. æquiseta* which differ from the normal individuals in the greater or less length of the prostomium.

Text-fig. 4 shows the specimen of *P. longiseta*. The *Stylaria*-like elongation

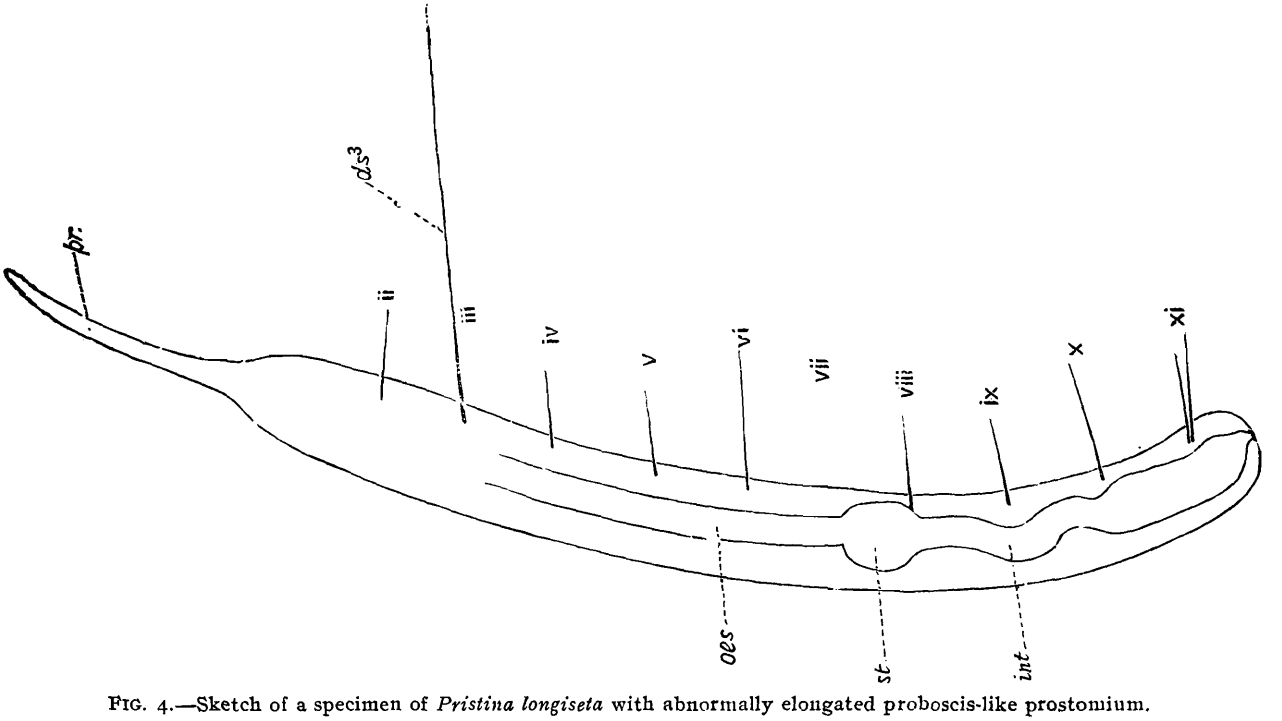


FIG. 4.—Sketch of a specimen of *Pristina longiseta* with abnormally elongated proboscis-like prostomium.

of the prostomium is obvious; but the species of the specimen can hardly be doubtful, in view of the presence of dorsal hair-setæ on all segments behind the first (they have, however, fallen out in the seventh), the great elongation of those of

the third segment, the œsophagus occupying segments iv-viii, and the globular stomach in segment viii. The animal has been mutilated at its posterior end.

Text-fig. 5 shows what is, I think, a specimen of *P. æquiseta*, the prostomium

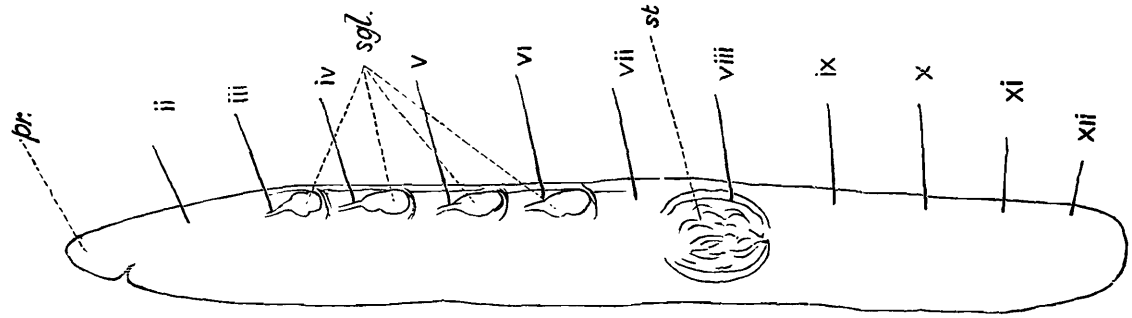


FIG. 5.—Sketch of a specimen of *Pristina æquiseta* with abnormally short prostomium.

exhibiting no elongation at all. It will be seen that the dorsal setæ begin in the second segment and are of equal length in all segments; septal glands are present in segments iii-vi, and a globular stomach in segment viii; and to my original sketch notes are appended to the effect that the dorsal bundles contained constantly one long and one short seta, that the ventral bundles contained three setæ, and that the first nephridium occurred in the ninth segment. In all these points, the specimen agrees with the form just described as *P. æquiseta*. It is curious that this animal, like the last, should also have been mutilated at its posterior end. A second specimen of *P. æquiseta* was also met with, showing a prostomium but little larger than that of text-fig. 5, and much shorter than that of the normal animal.

These variations are interesting as bearing on the morphological value of the length of the prostomium. Beddard [2] is of opinion that it is slight, and would group together under one name genera which differ in little else than the length of the prostomium. It would, in fact, appear from the above specimens that an amount of variation supposed to characterize different genera may occur within the limits of a single species.

*Slavina punjabensis*, sp. nov. (Pl. xix, fig. 41.)

This worm was found in considerable numbers in two ponds in the Lawrence Gardens, Lahore, during the months of April and May, 1907; and again in April, 1908. In length it varies considerably; the average length appears to be about 6 mm., but specimens up to 12 or 15 mm. have been met with. Like the species of *Pristina* previously described, it moves backwards apparently with as great freedom as forwards.

As seen with the naked eye, its colour is whitish and somewhat opaque; under the microscope, the animal is seen to be covered with foreign particles, diatoms and grains of inorganic matter, which may be so thickly spread as to obscure almost completely the internal anatomy; these foreign particles may be more thinly distributed posteriorly, where the animal is then consequently more transparent. In such cases (fig. 42), there may be seen a homogeneous colourless or slightly yellow

coating on the surface of the body, in which the foreign particles are entangled; this is presumably a mucoid secretion produced by the epidermal cells.

The *prostomium* is rounded, and not at all pointed or conical; in some animals, perhaps recently separated, it is even flattened in front; it is provided with *sensory hairs*. There is a pair of *eyes*, at the level of the mouth, laterally situated, the black pigment of which they are composed having, as in *Nais variabilis*, a violet tinge. One eye may be smaller than the other; there are sometimes numerous "Nebenaugen" in the vicinity (plate xviii, fig. 35). The skin of the general surface very often contains numerous small masses of *pigment*, of a more or less circular, or it may be quite irregular form; their relative size may be seen in plate xx, fig. 50, and will be observed to vary from mere points upwards. In animals which possess this pigmentation the pigment is of a brown colour, and is almost absent from the first five segments; it is absent again from several segments at the posterior end of the animal, and, as seen in the figure, from the newly-formed segments at the zone of budding. The extreme posterior end of the animal, immediately around the anus, is ciliated, the cilia being an extension of those which here, as elsewhere, line the intestine.

The skin bears a number of small sensory papillæ; these are projections of the shape of a truncated cone, or are sometimes cylindrical; they bear a number of minute stiff hairs on their summit; they are clear, colourless, and not covered by foreign particles.

Their distribution is somewhat variable; they may, for example, be arranged fairly regularly in rows across the dorsal surface of the animal, one row in each segment from the anterior to the posterior end; or they may be absent from the posterior end of the body; or they may be segmentally arranged as far back as the sixth segment, and be less numerous and less regular behind this; or the converse may be the case, *i.e.*, the segmental arrangement may be better marked behind the sixth segment than in front. The prostomium may or may not bear them; the ventral surface appears to be altogether without them; and they frequently seem to be especially well-developed in two lines along the lateral surfaces of the body.

The level of the transverse rows of papillæ is that of the insertion of the dorsal setæ in each segment. The papillæ are not themselves retractile, but the papilla as a whole may be (probably temporarily) depressed into a slight pit on the external surface of the body, from the bottom of which it then appears to arise.

The number of *segments* varies considerably. The smallest number counted was 23; several animals were noted as having over 40, in one case 46. There is a small region of the body posteriorly where definite segments are unrecognizable, not as yet having been differentiated The first five segments may be very short.

A number of specimens were seen which I was at first inclined to regard as pathological. They possessed no distinctly differentiated head (plate xx, fig. 51), no eyes, and no recognizable pharynx. That the portion of the animal shown in the figure is the anterior end is evidenced by the long setæ; and what has presumably happened

is that this specimen has been separated by fission before the complete development of the structures at the head end; thus there are only three pairs of ventral seta; bundles in front of the beginning of the dorsal setæ and these contain only one seta each. Figure 52 shows an animal with eyes as yet on one side only. It seems possible that this early separation may be the rule in the species; but my observations do not allow of a definite statement.

The *ventral setæ* are present in all segments from the second onwards. They resemble those of the foregoing genera in type, being curved like an elongated ∫ the length varies from about ·14 mm. (anteriorly) to ·12 or ·10 mm. (posteriorly); they are forked distally, with the prongs of equal length, and the proximally situated prong of the fork much stouter than the other. The nodulus is situated slightly proximally to the middle of the length of the seta, and is a little more prominent on one side than the other (fig. 36). There are usually three in a bundle, sometimes two or four.

The *dorsal setæ* begin in the sixth segment. They are long and short, the long being typical hair-setæ, and the short probably having the same relation to these as that surmised to exist between the long and short setæ of *Pristina* (*v. antea*); that is to say, they may be looked on as immature hair-setæ, destined to take on further growth when the long setæ of the bundle drop out. In the sixth segment the long setæ may be as much as three times the body-diameter in length, about ·8 mm.; shorter lengths, for example one of two diameters, may be met with; these specially elongated setæ may be broken, or may exist only on one side. In the remaining segments their ordinary length is about the diameter of the body, or somewhat less than this (max. 4 mm.; more usually ·3—·25 mm.); they diminish somewhat in size towards the hinder end of the body.

These setæ are frequently smooth; but not uncommonly they present, like the corresponding setæ of *Nais* and *Pristina* (*v. antea*), many fine thorn-like projections (plate xviii, fig. 37), to which foreign particles may adhere. The explanation of these "thorns" I take to be the one I have given for *Nais variabilis*; and this is to some extent supported by the fact that the setæ in the anterior part of the body may be found to possess these "thorns," that is, to have become frayed out, while the younger setæ, at the hinder end of the body, remain quite smooth.

The short setæ are needle-like, ·07 mm. in length, have no curve, end in a single point, and may scarcely project at all from the surface of the body; in any case they are very short. Intermediate sizes between the long and short setæ are not found, or found only rarely.

The general rule as to the composition of the dorsal setal bundles is that one long and one short seta exist together in each. Two long setæ are sometimes seen, two short setæ with one long one also occur; rarely a bundle occurs where no short seta is visible at all. All setæ may be absent from a bundle, perhaps in consequence of injury.

The body-cavity contains a large number of *corpuscles*. These are unlike those of the previous genera; they are very large, and the bulk of the substance of which

they are composed is perfectly clear, like clear glass; but the majority contain also a quantity of granular matter, opaque, and of a dark brown colour, which may be aggregated within the corpuscle into all kinds of irregular shapes (fig. 43). Some corpuscles contain no granular matter and are quite clear.

*Alimentary tract.*—The *pharynx* occupies the second, third, fourth and fifth segments; it is lobulated in appearance (fig. 41), this being due to the large cells with which it is surrounded. The *œsophagus*, in the sixth and seventh segments, has in its walls a number of minute brownish globules, similar to those described in the alimentary tract of the previous genera; these globules are present throughout the subsequent length of the tract. The *stomach* is shown in fig. 41 as a globular dilatation in the eighth segment; it varies, however, in distinctness, it may be but a slight dilatation, or there may be no recognizable stomach at all. Since the actual character of the walls of the tract is the same from the œsophagus onwards, it follows that in the last case no differentiation of separate parts of the canal exists behind the pharynx.

The *intestine* presents the same phenomena of a reversed ciliary action and antiperistalsis as have been noted for *Nais* and *Pristina*.

It will not be necessary to describe the remaining systems in detail. The *pharyngeal commissures* of the vascular system form a plexus, not a series of simple arches. The first *nephridium* is in the seventh segment; on one occasion it was seen in the sixth, and fig. 52 shows a specimen where it is drawn in what appears to be the fifth segment. In the case where it was seen in the sixth, the dorsal setæ were observed to begin in the fifth segment; and the figure just referred to is (*v. antea*) that of an animal whose anterior end is not fully developed. It would seem, therefore, that one, or in the second case two, segments are still to be added before these particular animals are fully formed; and we may here compare what was said previously as to the possibility of early separation of the posterior animal, before the full number of anterior segments has been produced, being the rule in *Slavina*. The two halves of which the *cerebral ganglion* of the Naididæ is always more or less obviously composed, are much more distinct in this species than is usual. Figures 44 and 45 show it to consist of two oval or somewhat triangular masses, distinct from each other, but closely apposed in the middle line. *Reproductive organs* were not observed.

Only two species of *Slavina* are described by Michaelsen [3], and of these only *S. appendiculata*, Udek., possesses cutaneous papillæ. This species has, besides small papillæ, regular circular rows of larger sensory projections, which correspond, I think, to the papillæ I have described for the present form. There can be little doubt as to the close connection of this form with *S. appendiculata*, from which latter, however, it differs in possessing only one row of the large papillæ per segment, in having pseudexiform instead of simple commissural vascular arches, as well as, perhaps, a smaller number of setæ in the sixth dorsal bundle. I propose for it the name *Slavina punjabensis*.

*Stylaria lacustris*, L. (Pl. xix, fig. 46.)

A single specimen of *Stylaria* was observed, of which the following is a short description:—

The worm was very active, resembling certain insect larvæ in its quick wriggling movements. Under the microscope, it was transparent The long proboscis-like *prostomium* is shown in the figure (fig. 46); *eyes* were present; the posterior end of the body was provided with *sensory "hairs."* The specimen was preparing to divide asexually, the anterior half having 21, the posterior 22, segments; the region around the site of division was darker and less transparent, and the skin was thicker here.

The dorsal setæ began in the sixth segment, were capilliform, smooth, in length equal to the diameter of the body, or somewhat shorter than this; they were two, or sometimes three, per bundle, but of these only one in each bundle was of the full length given above. The *ventral setæ* occurred in all segments from the second onwards; while more or less of the usual type, the proximal prong of the fork was very small, and the nodulus distinctly one-sided (*v.* fig. 47); there were five or six in each bundle.

A few brown *corpuscles* were present in the body-cavity. The *pharynx* occupied the region from the second to the fifth segment inclusive; the *stomach* was a slight dilatation in the eighth; the *intestine* showed the usual antiperistalsis, and ciliary motion in its posterior portion. The *blood* was colourless; there were no blood-corpuscles. The first nephridium occurred in the ninth segment (as in *Pristina*, not as in *Nais* and *Slavina*). The posterior horns of the *cerebral ganglion* were much elongated, and the anterior portion of the mass was of a more granular appearance than the rest (fig. 48).

Though no reproductive organs were seen, the above description, so far as it goes, corresponds to that of *S. lacustris*, L., and is perhaps of interest as being probably the first record of the genus from the Punjab. Up till 1900, at least, it had been recorded only from Europe and North America.

*General Remarks on the foregoing species.*

Though most of the species described above are already known, I have given somewhat detailed accounts of them, because it may be of interest to compare descriptions even of the same species from widely distant countries; and because in some respects, *e.g.*, the reproductive organs, our knowledge of the anatomy of the Naididæ is still defective.

Besides referring to the interest of the fact of the occurrence of the forms in the Punjab, I may be allowed here to mention the following points, brought out in the above descriptions, which, though not in all cases new, seem to me to merit notice:—

(1) The very variable and irregular thorn-like projections on the dorsal setæ of several forms, and their probable cause.

(2) The suggested sensory function of the dorsal setæ of the third segment of *Pristina longiseta*.

(3) The variations of the length of the prostomium in the genus *Pristina*, and the morphological value of this structure.

(4) The comparison of the pharynx of *Pristina* with that of *Nais*, and the conception of the morphology of the septal glands of the former.

(5) The "antiperistaltic" action and the reversed ciliary current in the intestine of all these forms, and the probable respiratory significance of these. Though the phenomenon of intestinal respiration is well known in the Polychæta, I have not, even in the larger works of reference, found mention of a similar occurrence among the Oligochæta. (*Cf.*, also, its occurrence in a species of *Æolosoma* described by me [9].)

(6) The concomitance of sexual and asexual reproduction in *Nais variabilis*; it was formerly stated that these two processes alternate and are mutually exclusive in the Naididæ; I have, however, also observed their co-existence in a species of *Chætogaster* [9]. Michaelsen [4] has done so in *Nais elinguis*, and Piguet [7] has observed the same in several forms.

(7) The ectoparasite of *Nais variabilis*.

## ÆOLOSOMATIDÆ.

*Æolosoma hemprichi*, Ehrbg. (Pl. xx, figs. 53—55.)

The following record of the occurrence of this form, not hitherto, apparently, described from anywhere in Asia, may be of interest. The description which follows is fairly full, in order to facilitate more accurate comparisons with the accounts of the species as it occurs in Europe and America.

The worm is fairly common in stagnant waters in and near Lahore. It will live and multiply under somewhat unfavourable artificial conditions; thus it was found in numbers in a glass vessel in the laboratory verandah after the summer vacation, and I found it again in the same vessel a few days ago (January); the vessel has remained in the same place for six months, the water being occasionally replenished from the tap. *Chætogaster punjabensis* was similarly found on both occasions and seems to be equally hardy, and resistant to both heat and cold. *A. hemprichi* will live a whole morning under microscopic examination, though the water around it may, through inadvertence or otherwise, be suffered repeatedly to evaporate almost completely.

Its length is on the average about 1 mm. (·85—1·35 mm. extended, as little as ·45 mm. contracted). Its diameter varies greatly, according to the degree of contraction or extension, and is usually about ·06 mm. Owing to its transparency, it is scarcely discoverable by the naked eye in its usual surroundings, and has to be searched for with a lens. Progression in an anterior direction is a smoothly-gliding

movement, as in other species of the genus; backward progression is effected by a series of jerks, as in the Naididæ.

The *prostomium* is large, rounded, flattened, broader than the body, very mobile, and continually altering its shape; its ventral surface is ciliated; no special ciliated pits were observed. The œsophageal region, which succeeds the buccal funnel, is followed by the region of the stomach, where the diameter of the body is greater than at other parts; the region of the stomach may be said roughly to comprise the middle third of the animal; behind it, the diameter gradually diminishes to the posterior end.

The *oil-drops*, which occur in the integument over the whole body, are of a bright brownish-red or very deep orange colour. They vary in size, and there is always a special aggregation of very large droplets at the extreme posterior end of the animal; the single drops may here reach ·01 mm. in diameter, or about one-fifth of the width of the animal at this part (figs. 53—55). Over the remainder of the body they vary from ·006 mm. downwards. They are absent from the under surface of the prostomium. They lose their colour soon after the death of the animal.

The number of *segments* of the single animal varies from eight to eleven. Specimens preparing to divide asexually contained seven or eight segments in the anterior, six or seven in the posterior half. Elongated chains of three, four, or more animals have not, so far, been met with.

The *setæ* are arranged in four bundles per segment, two dorsal and two ventral, beginning just behind the posterior end of the buccal funnel. They are almost straight, sometimes very slightly bowed or ∫-shaped. They are all capilliform, and vary in length, being usually about equal to the diameter of the body. The number in each bundle varies from two to five.

There are no definite septa, but strands stretch across the body-cavity from body-wall to alimentary tube; these are more numerous at the site of an approaching division. Some large body-cavity *corpuscles* were seen on one occasion, possibly broken off from the sides of the alimentary canal (*cf.* the large cells, *c.*, in fig. 55).

The *buccal funnel* has a thick, prominent rim, the lateral limbs of which bend outwards at their dorsal and anterior ends (fig. 53, *r.*). Ciliary motion is markedly visible in the interior of the funnel. The *œsophagus* occupies the second and third segments, the *stomach* the fourth, fifth and sixth. The *stomach* has thicker and more granular walls than the rest of the tract, and its calibre is greater; its walls are ciliated; the cilia move in an antero-posterior direction sometimes, sometimes in the posterior half in the reverse direction, and sometimes the motion is not definitely in either direction.

The case is different in the *intestine*, where the ciliary action is always postero-anterior; it may be very violent and distinct, so as to be visible with the low power of the microscope. The intestine also exhibits the same "antiperistaltic" movements that are such a marked feature in the Naididæ; these may extend as far forwards as the anterior end of the stomach; or may, for a time, be confined to the stomach; or, as in one case observed, there may be an antero-posterior peristaltic movement

in the anterior third of the stomach, and an "antiperistaltic" (postero-anterior) movement through the whole of the alimentary tract behind this, which, meeting the direct (antero-posterior) movement in the stomach-walls, overcomes the latter and then continues forward.

The *ventral blood-vessel* is intimately connected with the alimentary canal for the greater part of its extent; it is a wide tube, nearly as wide as the lumen of the alimentary tract itself (*cf.* fig. 55), non-contractile, bifurcating posteriorly to the buccal funnel, and thence continued forwards as two commissural vessels in the funnel-wall, meeting dorsally at the base of the cerebral ganglion. There is in the intestinal region no separate *dorsal vessel*, but a system of lacunæ or *sinuses* in the intestinal wall; this system does not seem usually to be independently contractile, apart from the "antiperistaltic" contractions of the intestinal wall; but on one occasion, in a very sluggish, somewhat contracted animal, where the "antiperistaltic" contractions were entirely in abeyance for some time, the sinuses in the intestinal wall kept up a rhythmical postero-anterior contraction of their own. The system of sinuses extends through the stomach also; but here a distinct though small dorsal vessel makes its appearance as an interrupted cavity much smaller in its vertical calibre, as seen from the side, than the well-marked ventral vessel. In the œsophageal region there is, dorsally situated, a series of large, vacuole-like chambers, or a single chamber traversed by strands or septa, which extends forwards to just behind the first setal bundles; this, probably formed posteriorly by the union of the dorsal vessel and sinus system of the stomach, is continued forwards as a definite blood-vessel as far as the base of the cerebral ganglion; it is contractile as far as this latter point, usually in a postero-anterior direction, the contractions at times appearing to be a continuation forwards of the "antiperistalsis" of the alimentary tube, while at other times they are quite unconnected with the rhythm of the latter. On two occasions the contractions of this part of the vascular system were certainly not definitely postero-anterior, and appeared to be rather in the reverse (antero-posterior) direction.

The *blood* is colourless, and contains no corpuscles.

The *nephridia* usually begin in the space between the first and second setal bundles; on one occasion one only could be defined in this place, and on two occasions they were absent here on both sides, beginning between the second and third setal bundles. They are always present here and in the succeeding space, but posteriorly there are slight variations in their distribution, the fourth, or fifth, or sixth setal interspace being sometimes destitute of nephridia. The hindmost segments seem never to have nephridia; I have not noted their occurrence behind the seventh setal bundles. They open anteriorly by a large ciliated funnel; and appear to have an attachment to the wall of the alimentary canal.

The *cerebral ganglion* is rounded in front, markedly indented behind. As is the rule in the genus, it is closely connected to the surface epithelium, appearing in a lateral view (fig. 54, *c.g.*) merely as a local thickening of the latter. No nerve cords or commissures were discoverable.

*Genital organs* were not seen in any of the specimens examined.

This form thus resembles closely *A. hemprichi*, according to the diagnosis of the latter as given in Michaelsen's Oligochæta [3]. The specimens hitherto observed elsewhere would appear, however, to have been considerably larger (2—5 mm.), and to have varied more widely (4—13) in the number of their segments.

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### EXPLANATION OF REFERENCE LETTERS USED IN THE PLATES.

The small Roman numerals (i, ii, iii, etc.) indicate the numbers of the segments.

*An.*, anus; *b.c.*, buccal cavity; *b.f.*, buccal funnel; *c.*, large cells adhering to cœlomic surface of intestinal wall; *c.g.*, cerebral ganglion; *cil.*, cilia; *cl.*, clitellum; *con.*, constriction where fission is about to take place; *conn.*, connecting strands between intestine and body-wall; *corp.*, corpuscles of the body-cavity; *d.*, duct of

septal gland; *d.b.v.*, dorsal blood-vessel; *d.s.*, dorsal setæ; *d.s*$^{1}$., first dorsal setal bundle; *d.s*$^{2}$., *d.s*$^{6}$., etc., the dorsal setæ of the second, the sixth segment, etc.; *e.*, eye; *f.b.*, foreign bodies; *gg.*, the ganglia of the ventral chain; *int.*, intestine; *int. cil.*, ciliated wall of intestine; *m.*, mouth; *mor.*, sperm-morulæ; *m.s.*, muscle of the setal sac; *muc.*, mucoid coating; *n*$^{1}$.—*n*$^{4}$., the four pairs of nephridia; *nau.*, "Nebenaugen"; *n.c.*, nerve-commissure; *o.*, oil-drops; *o.b.*, "opaque body"; *oes.*, œsophagus; *ov.*, ova; *par.*, parasite; *pg.*, pigment-bodies; *ph.*, pharynx; *ph.cil.*, the specially ciliated region of the pharynx; *pr.*, prostomium; *pr*$^{2}$., prostomium of second animal; *r.*, rim of buccal funnel; *r. sem.*, receptaculum seminis; *s.*, spaces of peri-intestinal sinuses; *s.gl.*, septal glands; *s.h.*, sensory hairs; *sp.*, septum; *sp.g.*, subpharyngeal ganglion; *s.s.*, setal sac; *st.*, stomach; *sz.*, spermatozoa; *tes.*, testis; *v.n.c.*, ventral nerve cord; *v.s.*, ventral setæ; *v.s*$^{1}$., first ventral setal bundle; *v.s*$^{2}$., *v.s*$^{3}$., etc., the ventral setæ of the second, third segments, etc.; *v.sem.*, vesicula seminalis; *v.v.*, ventral blood-vessel.