Polychoerus caudatus nov. gen. et nov. spec.

by

Edward Laurens Mark,

Hersey Professor of Anatomy, Harvard University, Cambridge, Mass., U. S. A.

with Plate XXXI.

In the summer of 1889, while occupying a table at the Marine Biological Laboratory at Woods Holl, Mass., I was invited to accompany one of the almost daily excursions made by the steam launch in the service of the U. S. Fish Commission Laboratory to the neighboring island Nanshon. Favorite collecting grounds for many Invertebrates are the mud flats bordering the „Gutter“, which serves to connect the waters of Buzzard's-Bay with those of Hadley Harbor. The entrance to this passage from the Buzzard's-Bay side, though not very broad, is rather shallow, so that at low tide the bottom is covered with only a few inches of water, save near its western side where there is a somewhat deeper channel. This bottom is largely composed of tolerably clean sand, over which the water flows with considerable rapidity at each change of tide. While examining the bottom in the hope of finding some adults of the *Edwardsia* which is Parasitic in *Mnemiopsis*, my attention was attracted by small reddish or orange colored Turbellarians which were accumulated in large numbers on the under sides of the valves of *Pecten* that are scattered along the bottom where the current is not strong enough to sweep them away. A large number of the worms were easily collected, since they remained attached to the surface of the shells when the latter were removed from the water. Being comparatively hardy they were easily kept alive in the laboratory for many days.

Microscopic examination soon showed not only that they were Turbellarians, as had been inferred from their size and method of locomotion, but also that they were acoelous worms and unquestionably belonged to the family *Aphanostomida* of Graff and probably to the genus *Convoluta*. A careful comparison of their anatomy with that of previously described species has rendered it impossible to identify them with any of the known forms of *Convoluta*, although they appear to be in some respects closely related to *C. Langerhansii*, so far at least as one can judge from the brief account of this species drawn

up by von Graff (82, p. 234) from the notes of Langerhans, and from the figure reproduced by von Graff (Taf. II, Fig. 24) from Langerhans drawing.

Since the necessary limitations of contributions to the present Festschrift preclude an extended treatment of the histology of the worm here, I shall limit myself to a brief description of its more important anatomical features, and shall give in another place a more exhaustive account of its finer structural conditions. The material collected has also furnished an opportunity to pursue many stages in the development, which have been largely worked out by my friend and Assistant Dr. W. M. Woodworth.

A superficial examination of the worm impresses one strongly with its resemblance to *Convoluta Langerhansii* (Compare von Graff[1]) p. 234. Not only its agreement in size and general form, — being as it is broadly rounded in front and deeply notched behind, — but also minor features, such as the presence of a delicate, median tail-like filament[2]), are at once suggestion of the identity of the two. Even a more careful examination reveals many points of close resemblance, for example the compact ovoid penis, — in which *C. Langerhansii* differs from all other species of *Convoluta*, — and the thread-like nature of the seminal filaments.

On the other hand there are not a few points in which greater or less difference is manifest. The most noticeable of all these is the presence of a pair of pigmented eye-spots in *C. Langerhansii* and the entire absence of such organs in the new Turbellarian. Moreover these eye-spots and the single otocyst between them are much nearer the anterior end of the worm in *C. Langerhansii* than the otocyst is in the present species. The „subcutaneous brown ramified pigment cells“ of the former could hardly correspond to the purplish clusters of „Pigment-Stäbchen“ in the latter, nor could the two „layers of yellow cells“ in the former, if they „resembled the Zooxanthellen of *Conv. paradoxa*“ be compared with the irregularly shaped masses of yellow „Pigment-Stäbchen“ found in the latter.

It is, however, where one compares the female sexual apparatus of the two worms that the differences are found to be very important. They are, indeed, so great as to prove, not only that the two cannot represent the same species, but also that it is impossible to associate the new worm with representative of any described genus. It is neither the form nor position of the ovaries, — for by pressure they might readily be made to diverge as represented in von Graff's Figure 24 (Taf. II) — nor yet the position of the female sexual orifice[3]) which warrants the distinction; it is, rather, a difference in the accessory organs of the female generative apparatus — the bursa seminalis, which von Graff (91) has recently made the chief basis of his revised classification of *Turbellaria acoelia*. While *C. Langerhansii* appears from von Graff's description to possess a single chitinous apparatus connected with the female sexual orifice, there are a large number of chitinous „mouth-pieces“ developed in connection with the bursa of the new Turbellarian.

The discovery by Delage[4]) of a complicated nervous system in *Convoluta* has necessitated im-

---

1) Graff, L. von. Monographie der Turbellarien. I. *Rhabdocoelida*. Leipzig, Engelmann 1882. Fol. 441 pp., 20 Taf.

2) The entire absence of any allusion in the text to this delicate filament reads one to doubt if von Graff really understood what Langerhans intended to represent by it. After comparison with the figures and descriptions given in the present paper, however, there can be no doubt that Langerhans has represented a veritable and normal tail-like appendage.

3) It is apparently the result of an oversight that the sign ♀ marks the mouth opening in Figure 24 (von Graff, 82, Taf. II.), for the text —“ Das kugelige chitinöse Mundstück (*ch*) der Bursa seminalis zeigt nicht quere Streifung, sondern nach der weiblichen Geschlechtsöffnung convergirende Längsstreifen“ — shows clearly that von Graff interpreted the middle one of the three ventral pores, not the anterior one, to be the female sexual orifice.

4) Delage, Yves. Etudes histologiques sur les planaires rhabdocoeles acoeles (*Convoluta Schultzii* [O. Schm.]). Arch. de zool. exp. et gén. sér. 2, tom. 4. pp. 109—160. Pls. V, VI. 1886.

portant changes in the definition of acoelous Turbellaria, and his discovery of a so-called frontal organ has, though indirectly, brought about a considerable alteration in the classification of this group. In his recent paper on the organisation of the acoelous Turbellaria von GRAFF[1]) (pag. 53) has abandoned the idea that the position of the mouth and the presence or absence of a pharynx afford adequate criteria for classification of the primary subdivisions, for which, as he says, there is left only the sexual apparatus. This characterization of the Family „*Aphanostomida* as „*Acoelia* with two sexual orifices, the female situated in front of the male; with bursa seminalis and a soft penis" (von GRAFF '82, pag. 219) is still maintained, except for the omission of the clause concerning the nature of the penis, and in the emended form is applicable to the animal in hand. The distinction between the three genera embraced in this family is now (91) based, like the corresponding subdivisions of the Family *Proporida*, upon the bursa seminalis. In the genus *Aphanostoma* the bursa is destitute of hard parts, in *Convoluta* it is provided with one chitinous „mouth-piece" (Mundstück), in the new genus *Amphichoerus* with two symmetrically placed chitinous mouth-pieces. The Turbellarian with which we have to do clearly belongs to neither of these three genera. Adopting the method of designation employed by von GRAFF ('91, pag. 70) propose I for the new genus the name *Polychoerus*, and define it as embracing *Turbellaria acoelia* of the family *Aphanostomida* which possess a bursa seminalis with more than two chitinous mouth-pieces.

The present species may be characterized as follows:

Polychoerus caudatus n. g. n. sp. Broad and flat like *Convoluta paradoxa*; length (exclusive of caudal filaments) 3,5 bis 4 mm, breadth 1,5 mm; anterior end (at rest) broadly and evenly rounded; sides nearly parallel, slightly concave; posterior end rounded, more blunt than anterior end and deeply notched, producing two caudal lobes; 1 to 3 highly contractile caudal filaments arising from dorsal surface near the anterior margin of notch; animal capable of great variation of form. Color brick-red to orange; anterior half, margins and tail lobes translucent; pigment (Pigmentstäbchen) of two kinds, yellow and purple, the former located in both dorsal and ventral walls, the latter in dorsal wall only, both kinds wanting in caudal filaments; oval ring of opaque (white) spots occupies the anterior two thirds of the posterior half of dorsum. Mouth ventral, midway between anterior and posterior ends of body. Brain and otocyst four times as far from posterior as from anterior end of body. Female sexual orifice as far in front of hind end as otocyst is back of front end of body; male sexual orifice about 0,15 mm behind female; penis compact ovoid about 0,15 mm in diameter; testicular sacs lateral and dorsal to ovary, extend nearly as far forward as otocyst; ovaries ventral, mature ova in two lateral ventral rows converging from the level of the mouth toward the female orifice; bursa seminalis a large ill defined sac with numerous partial compartments and many (up to 40 or 50) chitinous „mouth pieces".

Polychoerus caudatus, is a thin, flat, spatula-like worm covered everywhere with a thick coat of fine cilia. When at rest the anterior end is broadly and evenly rounded, and sometimes so much expanded (Taf. XXXI, Fig. 22) as to give the whole animal a pear-shaped outline. The sides are usually parallel or slightly concave, often distinctly constricted in the middle opposite the mouth opening. The posterior end is somewhat broader and more bluntly rounded than the anterior and is deeply excavated by a large semicircular median notch. The lateral caudal lobes bounding the notch are exceedingly variable in form, tending to approach each other when the worm is at rest, and often pre-

1) GRAFF, L. von, Die Organisation der *Turbellaria acoela*, etc. Leipzig, ENGELMANN 1891. 4to. 90 pp. 10 Taf.

senting a sharp angle where the inner border is continuous with the outer (Taf. XXXI, Fig. 21). When swimming the body is more elongate and exhibits a more sinuous outline, the lateral margins often being infolded as in *Convoluta*; when creeping it is spread out flat and has a sinuous outline owing to the constant but irregular wave-like motions of its margins. The anterior end especially changes form with great rapidity, being evidently used as a highly sensitive tactile organ in the exploration of its surroundings.

The caudal filaments likewise probably have a sensory function and are capable of extensive and rapid change of proportions. While the animal is swimming, and often when it is at rest, the caudal filament trails behind the body for a considerable distance, often reaching a length of a millimetre or more. Sometimes it projects almost vertically, perpendicular to the flat surface of the animal, and whether in the horizontal or vertical position executes at times slow tortuous movements, the waves running from base to tip. When the animal is disturbed or the vessel containing it is jarred, the caudal filament is quickly contracted to a fraction of its original length, and may indeed become so short as not to project beyond the edge of the body. It then has a more or less conical shape, but when extended it is cylindrical and of nearly uniform diameter throughout its whole length. The filament its practically an evagination of the dermo-muscular sac of the body, its wall being continuous with the sac and its cylindrical lumen with the spaces in the parenchyma. The lumen is about equal in diameter to the thickness of the wall, and appears to contain a colorless fluid destitute of corpuscles. A filament 450 μ long had a total diameter of 27 μ. When there is only a single filament, it is always median in position; if more than one, the median is usually the larger; if there are three, the two lateral ones are symmetrical in position. Two and three filaments are by no means infrequently met with, and sometimes the individuals possessing more than one filament are as numerous as those which have a single one. I have never seen an individual with more than three caudal filaments, but many are found without any or with only very short rudiments.

A profile view of an adult, as well as longitudinal sections, shows that the body acquires its greatest thickness between the mouth and the sexual pores, that is, somewhere near the middle of the posterior two-thirds of its length. The thickening is principally due, a part from the variability caused by the amount of food, to an increase in the thickness of the ovaries in this region. Cross sections of the body vary considerably in their proportions in different regions. Through the anterior third or half the thickness is commonly from one eighth to one tenth of the breadth; in the middle third the proportions are much more variable, owing to the presence or absence of food, and for the same reason (as well as from the state of contraction of dorsoventral muscles) thinner marginal portions of the body are more or less sharply marked off from the central thickened region. These marginal tracts embrace each about one fifth of the total width of the body, and are of about the same thickness as the anterior third, becoming very gradually thinner toward the outer margin. The central region of the body, attains a thickness of a fifth or even a fourth its width in the same part.

The color is due principally to two kinds of pigment matter, one of which, the yellow, can be seen in both the dorsal and ventral aspects of the animal, the other (purple) only in the dorsal aspect. When seen from above over a white background with the unaided eye, *P. caudatus* has a brick-red appearance inclining toward orange. The pigmentation increases in general with the size of the animal, and although usually it is tolerably uniform for all parts of the surface, it is sometimes more concentrated toward the anterior end. The regions of the sexual organs, especially those of the ovaries, are also usually more deeply colored than the surrounding parts, and often incline toward a brown-

ish hue. When viewed over a black background the margins and anterior half are seen to be translucent, only the thickened central part of the posterior half being nearly or quite opaque. Examined under a low power the color is found to result from the presence of numerous irregular yellow or reddish-yellow patches interspersed with somewhat smaller and less irregular flecks of purple. These pigmented patches are distributed quite evenly, and the two kinds are intermingled without any definite order. The yellow spots are usually drawn out into numerous cusps lying in different planes, — so that they appear crenate, especially when seen from the surface of the animal, — or are greatly elongated and branching. Although exceedingly variable in size as well as shape, the larger ones are fairly represented by these two measurements; 10 × 65 μ and 20 × 45 μ. The middle of the patch is usually elevated into a cone-like projection which reaches the surface of the body. The deep portions of the purple pigment bodies are less drawn out and of a more regular outline than the yellow ones; the pointed outer ends project like those of the yellow patches, and like the latter approach more or less closely to the outer surface of the body. Their deep ends average about 10 μ in diameter and the greatest length, perpendicular to the surface of the body — is often as much 15 or 20 μ.

A higher magnification shows that both kinds of patches are produced by clusters of the minute rod-like bodies which VON GRAFF has named „Pigment-Stäbchen".

The yellow pigment-rods (Taf. XXXI. Fig. 14, 15,) when viewed by transmitted light under a high power appear of a bright greenish yellow color. They vary from 2 to 5 μ in length and from $^3/_4$ to 1 μ in diameter, are usually rounded at both ends, although occasionally pointed, and are often more or less bent. Not infrequently they are curved into a semicircle or even form a complete ring (Tafel XXXI, Fig. 14). When pressed out into the seawater they readily give up their color and undergo disintegration. The contents of these pigment patches (glands) are not always resolvable into pigment-rods, often appearing in the uninjured animal entirely homogeneous.

The purple pigment-rods (Taf. XXXI, Fig. 13) are even smaller than the yellow ones, seldom attaining a length of 2,5 or 2,7 μ, and rarely exceeding 0,9 μ in diameter. They are more frequently than the yellow rods pointed at one or both ends and are on the average more slender than the latter. By transmitted light they appear purplish or of a deep wine color and they do not readily give up their color when exposed to the action of seawater. As previously stated these clusters of purple rods are limited to the dorsal surface of the worm; the caudal filaments lack both kinds of pigment.

Besides these pigment-rods there are other and larger rod-like structures, the true Rhabdites which are most abundant at the margins of the body. These (Taf. XXXI, Fig. 12) resemble closely the corresponding structures of *Convoluta paradoxa* (Compare VON GRAFF, 82, Taf. II, Fig. 15, and p. 230).

They are long tapering bodies rounded at one end and finely pointed at the other, or occasionally tapering to a point at both ends, united into packets like bundles of cigars. They are 16 to 18 μ in length, sometimes much longer, and scarcely more than 1 μ in diameter. They are apparently quite flexible for they are often bent into graceful forms.

Finally there remain to be mentioned clusters of bodies which are arranged in a special pattern on the dorsum (Taf. XXXI, Fig. 2) and which in reflected light have a brilliant white appearance. These are more conspicuous in younger and less deeply colored individuals, but may be readily seen in older ones under a low magnification by using a central-stop diaphragm with the Abbé illuminator. The pattern has a more or less ring-like form surrounding an oval area, the anterior end of which lies nearly over the mouth. The ring has irregular edges, owing to the scattered arrangement of the white patches at its margins, and is drawn out at four points into horn-like projections, which give a

more or less marked quadrangular shape to the outer border. The anterior part of the horn-like projections is usually more developed than the posterior part and often reaches nearly to the margins of the animal. The ring in larger individuals becomes more elongated lengthwise of the animal and the white spots composing it are more scattered. The spots are made up of clusters of small, highly refractive, colorless bodies which appear as black specks when viewed by transmitted light. These corpuscles vary considerably in size and somewhat in shape. The largest ones are rod-like, bluntly rounded at both ends, and may attain a length of 5 μ with a diameter of 1 or 1,5 μ. They are straight or only slightly bent. Others are smaller and vary in shape from rod-like to spherical and in diameter from 0,5 to 1 μ. All of these corpuscles constantly exhibit Brownian motion in the living animal and the clusters appear to be included within a delicate even outline, as though contained in vacuoles of the parenchyma. Weak acetic acid, which causes the Brownian movement to cease, does not dissolve or appreciably affect the corpuscles.

The surface of *P. caudatus* is everywhere clothed with a dense covering of cilia, which are somewhat longer on the ventral surface (5,2 μ), especially in the region of the sexual orifices and on the caudal lobes, than on the dorsal surface (5 μ). The cilia at the margin of the oral opening become shorter quite abruptly; they line the tubular vagina throughout, and the male sexual pore. By focussing at the surface of the living animal with a high power, parallel wave-like bands produced by the rhythmical motion of the cilia are observable, but I have never seen any evidence that the cilia were arranged in bands, as they are shown to be in Amphichoerus by von Graff (91, Taf. I, Fig. 4). On the contrary, when, as often happens with worms that have been for some time under examination, the cilia stop for a moment their vibrations, they are seen to be evenly distributed over the surface.

By focussing upon the margins of an animal at rest, one often sees projecting here and there far beyond the outer ends of the dense mass of cilia, delicate straight bristle-like structures which I at first imagined to be non-contractile. More careful and prolonged study of a single region showed, however that these were long vibratile cilia. After remaining for many minutes perfectly straight and motionless such a cilium suddenly disappears, and after a few seconds as suddenly reappears in its former place. Closer attention with higher powers allows one to observe the basal end of one of these structures, while the free end moves with such velocity as to be practically invisible. The intermittent nature of the vibrations explains what had been a source of perplexity to me the presence of these structures in certain individuals and their apparent absence in others. If one chances to examine an animal in which the periods of rest are short or altogether wanting, these cilia will certainly not be recognized. They are exceedingly delicate, about three times as long (15—18 μ) as the ordinary cilia and of uniform size throughout. At the anterior end of the body they are somewhat more numerous than in the sides and tail lobes, but nowhere are they arranged at regular intervals. Their distribution is fairly represented by Taf. XXXI, Fig. 20. I have not seen them on other parts of the body than the margins, but have not made sufficiently careful examinations of other parts to be able to deny their presence elsewhere. I am unable to identify these cilia with either the „unbeweglich gewordenen Cilien“, the „Geisselhaare“ or the „Borsten“ described by von Graff (82, p. 48), but they are more nearly akin to the first than to the second or third. Possibly they represent a transition from vibratile to non-vibratile cilia, and they have, I doubt not, a sensory function.

The epidermis consists of a thin homogeneous layer in which cell boundaries are not distinguishable, and nuclei are only rarely to be met with. A description of the particulars of its condition as well as those of the parenchyma must be left for a subsequent paper to be accompanied by the

necessary illustrations. Concerning the parenchyma I will say here only that the digestive region shows a marked histological difference from the remaining portions.

The dermo-muscular sac is composed of circular, diagonal and longitudinal fibres, which can be seen in the living animal. The longitudinal fibres are separated by wide intervals, the oblique fibres are the smallest, and the circular fibres are well developed in the ventral wall, especially behind the mouth. Dorso-ventral muscles are numerous and large.

The mouth is capable of great distention and variability of form, but when the animal is at rest, has a transversely oval outline. It is surrounded by radiating clusters of yellow „Pigmentstäbchen“ (Figure 10), which are much more abundant here than at any other portion of the body.

The pharynx is of the kind designated by von Graff as simplex, being less differentiated than in *Convoluta paradoxa* (Compare von Graff, 91, Taf. VI, Fig. 1).

The nervous system (Taf. XXXI, Fig. 1) consists of a pair of ganglionic masses connected by a transverse commissure which lies above the otocyst. The ganglionic masses with their commissure measure about one third of a millimetre in a direction perpendicular to the median plane. From each of the lateral masses (Taf. XXXI, Fig. 1) there arise three stout nerve trunks; one (anterior) directed at first forward and outward, a second (lateral) directed outward and slightly forward, and a third (posterior) passing backward and outward. The first runs forward and bending toward the median plane, gives off a branch which unites with a corresponding branch from its mate to form an anterior stout commissure. Much diminished in size, the first nerve trunk continues forward, giving off branches toward the median and lateral sides (one of the latter forms the beginning of the „middle“ nerve) until it reaches the anterior margin of the body, where it appears to become continuous with a small marginal nerve. The second trunk after a short course sooner or later divides into two about equally well developed branches, one of which takes an oblique outward and forward direction, the other a more nearly lateral course. Both merge at some distance from the margin of the body into the stout „middle longitudinal“ nerve, which can be readily followed from its origin in a lateral branch of the anterior trunk, as it passes backward nearly parallel with, and at a considerable distance from, the edge of the body, until it reaches the base of the caudal lobe, where it bends forward to end in the vicinity of the sexual pores.

The third trunk, after bending outward a little, takes a nearly straight course backward parallel with the median plane, and in such a position as to leave between it and its fellow of the opposite side a space which is somewhat less than the interval between it and the „middle longitudinal“ nerve. This trunk I believe to be homologous with the „inner longitudinal nerve“ of Delage and von Graff, as the other large longitudinal nerve is homologous, I think, with their „middle longitudinal nerve“. Both of these nerves, as well as numerous transverse nerves which join them to each other, are quite conspicuous after treatment by Delage's gold-chloride method, and the greater portion of them can often be distinguished in the living animal, since they lie comparatively near to the dorsal surface. The lateral branches given off by the middle longitudinal nerve are more numerous than those connecting inner and middle nerve and usually branch once at least before merging into the small nerve near the margin, which is probably the equivalent of the external longitudinal nerve of the authors cited, but which it is difficult to follow even in gold-chloride preparations. The chief nerves thus conform in the main with the conditions of the dorsal nerves in *Convoluta* as described by Delage, although the meshes formed by them are much less regular in shape than are those which Delage (Pl. V, Fig. 1)

has figured. Corresponding with the greater distance between the otocyst and the anterior end of the body in *Polychoerus*, as compared with the *Convoluta* of Roscoff, there are two transverse commissures in front of the otocyst, which with the anterior nerve-trunks that give rise to them circumscribe two nearly equal squarish areas. Of the two commissures the anterior is much the more slender. The posterior one seems to correspond to the commissure described by Delage (86, p. 117) as uniting the pair of „superior [anterior] ganglionic enlargements". Perhaps the most conspicuous difference, however, is due to the relative insignificance of the regions in *Polychoerus* which appear to correspond to the „superior ganglionic enlargements" — the extremities of the larger of the anterior commissures. In *Polychoerus* the middle longitudinal nerve is not directly connected with this region as in Delage's *Convoluta*, but appears to begin much further forward. The second or lateral trunk corresponds, in my opinion, to the „racine accessoire" arising from the external angle of the „ganglion principal." This trunk moreover exhibits variations owing to its association with the anterior trunk for a greater or less distance, and to the place where it forks. Thus the anterior and lateral trunks sometimes appear to arise together, and at other times the lateral trunk forks so near to the brain that there seem to be four trunks instead of three given of from the central organ. The first anastomosing branch between the „inner" and „middle" nerve is often given off from the former before it has proceeded far from the brain. The space between inner and middle nerve is often so great that one or more of the large meshes embraced between them is traversed by a longitudinal anastomosing branch midway between the two great longitudinal nerves.

A description of the histological conditions and a discussion of the nervous system are reserved for a future contribution — I will only add here that I agree fully with the interpretation which von Graff (91, p. 36) have given of the ganglionic cells and their nuclei.

Viewed from above or below the otocyst is nearly circular in outline and about 25 μ in diameter. After compression of the animal it probably changes its position, for it then appears slightly conical with the more pointed end directed backward. Its thin homogeneous wall is probably produced by two cells which continue to line more or less completely its cavity. This at least, is certain: the capsule always contains two small nuclei, never more nor less. In the living animal the contents, a part from the otolith, are perfectly clear and sometimes of a faint pinkish hue. The inner surface of the capsule (Taf. XXXI, Fig. 11) often appears finely granular in two symmetrically placed regions of its posterior wall, one on the right, the other on the left. These I believe to be the nuclei and surrounding protoplasm of the two cells. In optical section they appear as slight lenticular elevations of the inner surface. Upon the addition of weak acetic acid two oval nuclei are at once made evident, even before the otolith has been affected. In well stained sections the two nuclei are distinctly colored, but the protoplasm remains colorless. The wall of the cyst is highly refractile and of uniform thickness (about 0,5 μ) in all parts. There are also usually a few highly refractive angular fragments of the otolith (?) contained in the cyst of corrosive-sublimate specimens after they have been sectioned.

The otolith when seen from above or below usually exhibits an even clear-cut circular outline and is on the average about 17 or 18 μ in diameter. When by a change in the position of the otocyst the otolith is seen from a different direction, it is found to have the form of a slightly excavated cup with very thick wall and rounded lip. The convex surface is directed upward, the concave downward. The margin is not quite even, being faintly sinuous, and the concave surface appears to be rough. The otolith upon being crushed breaks along radial lines. The addition of weak acetic acid to the sea water in which the animal is being examined first causes the concave portion of the

otolith to swell up into an irregular more or less opaque mass, in which I have not, however, been able to discover a nucleus. Then the convex homogeneous portion begins to show distinct lines concentric with the contour, and finally the whole structure becomes invisible.

Von Graff ('91 p. 39) says: „Die Otolithenblase ist wahrscheinlich aus Zellen des Parenchyms entstanden; sie enthält stets mehrere (bisweilen auch schon am frischen Objekte wahrzunehmende) abgeplattete Kerne, die ein wenig nach innen vorspringen (vergl. Taf. I, Fig. 7, 8 und Taf. X, Fig. 7)." The figures cited are those of *Amphichoerus cinereus* and *Proporus venenosus*, and in neither of them are there more than two such nuclei shown. Were it not for the positive statement that the vesicle always contains several nuclei, I should have imagined that the conditions in *Polychoerus* and the other *Aphanostomida* were alike. It is possible that the number of nuclei is not constant in *Polychoerus* but I have not yet met with a case in which there were more than two. Why von Graff believes that the wall of the otocyst has probably arisen out of cells of the parenchyma, I do not understand. Certainly the wall of similar cysts in other Invertebrates — leaving out of question the exact function of the organ — is of ectodermic origin, so far as is at present known, and I see no special reason for assuming a different origin in this case, until some direct evidence is produced. The position of the nuclei on the inside of the homogeneous wall of the cyst, seems to me to favor the view that they are epithelial cells originally produced by an involution of the ectoderm rather than differentiated elements of the parenchyma.

As in many other Turbellarians, the sexual products of the male organs attain maturity before those of the female organs.

The testes (Taf. XXXI, Figs. 3, 4) are of the follicular type and have a rather definite arrangement. The follicles are found nearly as far forward as the otocyst and nearly as far backward as the female sexual orifice. They are symmetrically arranged on either side of the median plane; the testicular regions have a dorso-lateral position and converge toward each other in the anterior part of the body. The separate follicles are usually more or less pear-shaped, the tapering end being directed inward (toward the median plane) and more or less backward. The inner margin of the testicular area when seen from above is therefore more continuous than the outer margin, which appears distinctly and irregularly lobed. In its posterior half each of these areas becomes gradually narrower and flanks the lateral margin of the mature ova, when such are present. The mature spermatic filaments occupy the inner borders of the areas and are continued backward from the posterior ends of the latter, slowly converging until they reach the level of the male sexual pore, where they bend somewhat abruptly inward to reach the basal (dorsal) end of the penis with its seminal vesicle.

The penis is a compact ovoid or pear-shaped organ resembling that of *Amphichoerus* or *Aphanostoma* (Compare von Graff '91, Taf. II, Fig. 2 and Taf. V Fig. 4) much more than that of *Convoluta*. The sheath of the penis is less developed than in *Aphanostoma* and the seminal vesicle in the basal portion of the organ is also smaller than in that genus. In optical cross section (Taf. XXXI, Figs. 3, 4, 6) the penis is nearly circular (about 170 μ in diameter) and the male sexual pore, although capable of great change of form, usually has the same shape.

At maturity the spermatozoa (Taf. XXXI, Figs. 8, 9) reach the great length of 300 or even 350 μ. The anterior eighth or sixth of the filament is very much smaller than the rest of it, and executes tolerably rapid motions, not unlike those of the flagellum of many flagellate Infusoria, as though testing the nature of its surroundings. The region of transition from the thicker posterior portion of the filament to this more attenuated anterior part is rather abrupt; the anterior part tapers evenly but very

perceptibly until it becomes so delicate as to be scarcely visible with a magnification of 600 or 700 diameters. The thickest portion of the filament is situated at a little distance back of the region of transition to the anterior attenuated portion, and from this point backward the size diminishes very slowly and evenly to the posterior end, which is by far less attenuated than the anterior end. The anterior more active portion of the filament is highly refractive and homogeneous; the remaining portion shows peculiar markings which sometimes give it a monilate appearance, but which in other instances seem to be due to superficial structure. The regular alternation often exhibited by these markings suggests the possibility of their being the result of a spiral coil investing an axial cord, such as exists in many of the higher Vertebrates. It seems more probable, however, that they are, as in *Amphichoerus*, simply the result of superficial markings. I have not succeeded in demonstrating the presence of any lateral wing-like appendage to the spermatozoön, like that found in *C. Roscoffensis* and other forms.

The ovaries can be traced in sections by means of the differentiated cells developing into ova, nearly as far forward as the testicular sacs extend. The ova which are more advanced in age lie close to the ventral wall of the body, except in the region between mouth opening and vagina, where, in a differentiated portion of the ovary, the cells destined to reach maturity at the same time undergo rapid increase in size and rise up into a more dorsal position. Never having been successful in detecting an animal in the process of oviposition I cannot state just how the mature eggs escape from the body. The female sexual orifice, the distance of which from the male orifice is not greater than the diameter of the penis, leads into a cylindrical ciliate vagina which is as long as half the thickness of the body in this region. This tubular organ is of uniform calibre, ascends vertically and appears to end blindly, or rather to abut upon the granular secretions of the bursa much as in the case of the oral opening and the naked parenchyma. The space above and especially in front of its deep end usually contains a mass of spermatozoa, often wound together into a more or less spherical large ball, occupying a vacuole in the granular secretion. This mass of spermatozoa occupies the deep or dorsal portion of a sac-like structure, the ventral portion of which is differentiated into a number of partial compartments communicating with the dorsal chamber. The whole constitutes a large and complicated bursa seminalis. Seen from the ventral surface this region has a more or less kidney-shaped outline, the female sexual pore occupying the position of the hilus (Taf. XXXI, Fig. 6). This region may be somewhat compressed laterally by the growth of maturing ova, so that it assumes a more nearly triangular outline (Taf. XXXI, Fig. 4), or it may envelope the female sexual orifice behind more completely than in either of the cases figured. What may be regarded as the ventral floor of the bursa is composed of a number of ovoid clusters of cells, the axis of each of which is occupied by a nearly straight chitinous „mouth-piece“ of an appearance similar those of other *Alpha-nostomida*. The number of these is sometimes as great as 40 or 50 in a single individual; sometimes a smaller number — only 8 or 10 — are present. I think it probable that they are developed successively and that consequently the greater number marks the older individual; but of that I am not yet quite certain.

Each chitinous structure (Taf. XXXI, Figs. 18, 19) consists of a slightly tapering conical central portion, which is traversed by a narrow axial canal and from which diverge numerous thin, close-set lamellae which are directed obliquely outward and toward the narrower end of the central piece. In general the axes of these chitinous „mouth-pieces“ are directed ventrally, converging somewhat toward the female orifice, and the narrower end is invariably the one which is nearer the ventral surface of

the body. The „mouth-pieces“ are usually straight, but may be slightly curved. From the arrangement of the nuclei at the periphery of the ventral portion of each such organ, I conclude that the chitinous structures result from the secretion-activity of cells whose nuclei occupy their peripheral ends, while the axial blade-like prolongations of the cells extend as far as the conical chitinous axis and separate the successive chitinous lamellae which go off from the latter (Compare von Graff 91, Taf. VI, Fig. 4). The basal end of the „mouth piece“ is surrounded by enlargements which are probably identical with the „Drüsenkranz“ figured by von Graff (Taf. II, Fig. 1, 2) for *Amphichoerus*. The „mouht-piece“ may reach a length of 40 or 50 μ and a diameter at the base of 3 or 4 μ, but is often considerably smaller. The whole cellular mass enveloping such a „mouth-piece“ may be 70 μ long and 40 μ in diameter. Cross sections of the chitinous mouth-pieces and their surrounding mantl of cells show that both are circular, and that the lumen of the former is likewise cylindrical and very narrow. Lying in a vacuole near the basal or larger end of the chitinous cone — sometimes in contact with it — there is almost invariably a small ball of tangled spermatozoa, such as constitute the larger and more dorsal ball previously alluded to. In many instances string-like masses of spermatozoa stretch from the larger to the smaller balls through the finely granular, flocculent, substance which makes up the greater portion of the basal ends of these ovoid cell masses. The exact histological nature of the deep or dorsal half of these cell masses — the ventral portions of which secrete the chitinous mouth-pieces — is not easily determined. The substance of adjacent masses seems to be more or less confluent into a finely granular pale substance in which are scattered a few faintly colored nuclei. The appearance is as though the cells of the deep half of each cluster had become distended into enormous gland-cells and then becoming confluent with each other had finally become vacuolated and lost to a great extent their cell boundaries. There can be little doubt but that the spermatozoa at copulation first find lodgment in the dorsal portion of the sac and subsequently make their way in smaller masses to the basal ends of the several mouth-pieces: but what their further course may be is not so easily inferred. The ventral ends of the ovoid masses of cells with their narrow „mouth-pieces“ are still deeply imbedded in the substance of the parenchyma and at a considerable distance from the ventral surface of the body, the wall of which shows no noteworthy modification in their vicinity. There are small lacunar passages in the parenchyma between the ventral ends of the ovoid masses and the ventral wall of the body, and I imagine that these serve in some way to transmit the spermatozoa to the ova, but I have not yet found spermatozoa in these passages nor even satisfactory evidence that they pass through the narrow lumen of the chitinous mouth-pieces[1]). I hope to be able in a future communication to give a more precise account of the course of the fertilizing elements, and shall there illustrate more fully the structural conditions described here.

The close relationsship between *Polychoerus* and *Amphichoerus* will be at once apparent to one who compares the preceding account with von Graff's ('91, p. 70) description of the latter genus.

[1]) A statement by Repiachoff*) (p. 272) concerning the mouth-piece of the bursa in a species of acoelous Turbellaria studied by him at Naples shows that no direct opening to the outside is also the condition in other forms. He says: „Die Acoela, deren Entwicklung ich untersucht habe, unterscheiden sich von allen in Graff's Monographie beschriebenen Gattungen im Baue ihrer Geschlechtsorgane. Bei oberflächlicher Untersuchung ist man geneigt, das Thierchen für *Nadina sensitiva* Ulj. zu halten, bei näherer Prüfung findet man aber bei ihm ein chitinöses „Bursamundstück“, welches sich jedoch nicht nach aussen, sondern in das Körperparenchym öffnet. Andererseits steht die Bursa durch einen Canal mit der gemeinsamen neben dem hinteren Körperende gelegenen Geschlechtsöffnung in Verbindung. Sehr oft habe ich neben der inneren Bursamündung einen Haufen in einer Vacuole sich bewegenden Zoospermien gesehen, von denen einige aus der eben erwähnten Oeffnung nach verschiedenen Richtungen ausstrahlen.“ If I rightly understand this statement, the spermatozoa after traversing the chitinous mouthpiece make their way out in various directions into the parenchyma. This is exactly what I expect to find in the case of *P. caudatus* when the favorable specimen comes under examination, and I further suspect that this condition of the chitinous mouth-pieces opening into the parenchyma is coupled with an internal fertilization of the ova.

*) Nachtrag zur vorstehenden Mittheilung (S. Pereyaslawzew, Sur le développement des Turbellariés). Zool. Anzeiger, Jahrg. VIII. p. 272. 1885.

Here also the bursa seminalis has a form which differs considerably from that of other *Alphanostomida*. It is „in der Mitte in der Regel etwas eingeschnürt und aussen jederseits in eine stumpfe, nach vorn gebogene Warze ausgezogen, die je ein entsprechend hornförmig gebogenes chitinöses Mundstück (*ch*) umschliesst". The most evident differences from this condition of the bursa presented by *Polychoerus* are its much greater size and the remarkable increase in the number of the chitinous mouth-pieces. An interesting fact in this connection is recorded by von Graff ('91, p. 73), who has represented (Taf. II, Fig. 4) a rare case in which there were present within the bursa, in addition to the two normal mouth-pieces, two others (ch^1) enclosed within a vacuole and in process of degeneration. While it is perhaps not probable, it nevertheless seems to me possible that all four of these mouth-pieces may have been functional at the same time and that consequently neither of the assumptions made by von Graff to explain their presence[1]) are necessary. But in that event the generic distinctions between the two forms would be practically obliterated, and the name *Amphichoerus* would be for both less appropriate than *Polychoerus*.

In the living animal (*Amphichoerus*) von Graff sometimes (Taf. II, Fig. 1) finds the whole bursa filled with spermatozoa, somesimes (Fig. 2) only a roundish ball of spermatozoa attached to each mouth-piece and the space between them occupied by granular secretion (*s*), and finally at other times (Fig. 3) the bursa quite empty, except for irregular vesicles with granular detritus that are joined to the mouth-pieces. These von Graff regards as successive conditions, the latter resulting from the progressive consumption of the spermatozoa acquired at copulation. Similar conditions are to be observed in *Polychoerus*, where the „granular secretion" is, however, much more voluminous than in *Amphichoerus* and where the nuclei of the secreting cells do not retain a peripheral position in the wall of the bursa, but appear as though scattered through the secretion. This condition is due, I think, to the great enlargement of the secreting cells, the nuclei being forced into a position at the periphery of the cell, but still retaining their relation to the cell-wall, which now projects far into the cavity of the bursa.

I now return to *C. Langerhansii* to say a word about the bursa seminalis as figured by von Graff ('82, Taf. II, Fig. 24). I suspect from the form and markings of this organ that von Graff has mistaken the whole bursa for its „spheroidal chitinous mouth-piece" (compare foot-note p. 299) and that the converging „Längsstreifen", which in the figure become narrower as they approach the sexual orifice, are the real chitinous mouth-pieces. There are seven of these represented in the figure, and their size, form and direction render the suggestion I have made as to their nature highly probable. If this should prove to be true, *C. Langerhansii* would undoubtedly belong to the new genus, but, for reasons set forth at the beginning of this paper, would constitute a species distinct from *P. caudatus*.

[1]) „Im vorliegenden Falle bleibt aber nur die Annahme einer pathologischen Bildung oder eines normalerweise stattfindenden Wechsels der Mundstücke übrig, die in das Innere der Bursa fallen würden, nachdem sie abgestossen worden sind."

Tafel XXXI.

Mark, Polychoerus caudatus n. g., n. sp.

Fig. 1. Dorsal aspect to show the nervous system. × 58. Compare side view (Fig. 16.)

Fig. 2. Dorsal view of an immature individual (1,75 mm long). × 30. The whitish quadrilateral area is produced by colorless corpuscles.

Fig. 3. Ventral aspect of a mature worm, swimming. × 30. Shows otocyst, testes, mouth, pigmented ova, sexual orifices, caudal filament and caudal lobes.

Fig. 4. Sublimate, borax-carm., clove-oil preparation seen from below. × 30. Shows bursa with „mouth-pieces." (Compare Fig. 6.)

Fig. 5. Dorsal view of a swimming individual with three tails. × 20.

Fig. 6. Osmic-acetic, Beal's carm., glyc. preparation. × 95. Bursa and chitinous „mouth-pieces." The shaded area surrounding each cone-shaped „mouth-piece" represents the mass of cells which secrete the chitinous structure; their nuclei are at the periphery of the mass.

Fig. 7. Dorsal aspect of adult swimming. × 30.

Fig. 8. Two spermatozoa and anterior portion of a third. × 450. The anterior eighth much attenuated, active. Regular markings make posterior seven-eighths appear monilate.

Fig. 9. Anterior end of spermatozoon more highly magnified. Markings alternately arranged.

Fig. 10. Mouth opening with radiating clusters of „Pigment-Stäbchen."

Fig. 11. Otocyst under pressure, from a crushed worm. × 450. The two granular areas are two cells.

Fig. 12. Rhabdites, isolated and in packets. × ca. 1100.

Fig. 13. Purple rod-like bodies („Pigment-Stäbchen"), isolated, much smaller than „rhabdites." × ca. 1100.

Fig. 14 u. 15. Yellow „Pigment-Stäbchen", isolated. Sometimes (Fig. 14) very much curved. × 1000.

Fig. 16. Side view of individual seen in Fig. 1, to show thickening due to ♀ organs.

Fig. 17. Outline of a swimming worm with lateral margins in front infolded.

Fig. 18. Chitinous „mouth-piece" of bursa seminalis, from a crushed individual. × ca. 1000.

Fig. 19. Chitinous „mouth-piece" with spermatozoa attached to basal (dorsal) end. × ca. 1000.

Fig. 20. Portion of the margin of Fig. 3 more highly magnified to show cilia, scattered bristle-like cilia *(cil¹)* and clusters of „Pigment-Stäbchen", one purple and protruding.

Fig. 21. Posterior end of same individual (Fig. 3), to show form of caudal lobes at rest.

Fig. 22. Outline of a quiescent individual with greatly expanded anterior half.

Reference letters,

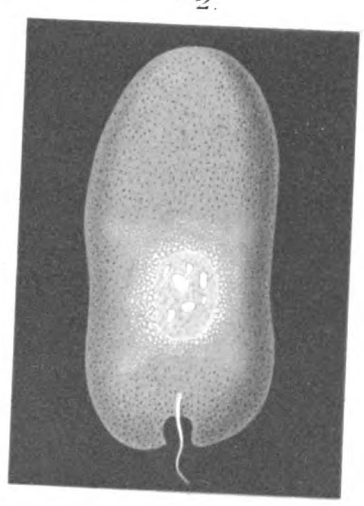
alphabetically arranged.

a Anterior. — *ca* Median tail. — *ca¹* Lateral tail. — *cil* Cilia. — *cil¹* Long bristle-like cilia of the margin of the body. — *cht* Chitinous structures („mouth-pieces") belonging to the bursa seminalis. — *d* Dorsal. — *or* Mouth. — *otl* Otolith. — *otc* Otocyst. — *ov* Ova. — *p* Posterior. — *pe* Penis. — *rhb* Yellow „Pigment-Stäbchen." — *rhb¹* Purple „Pigment-Stäbchen." — *t* Testicular sacs. — *v* Ventral. — *vd* Vas deferens. — ♀ Female sexual orifice. — ♂ Male sexual orifice.

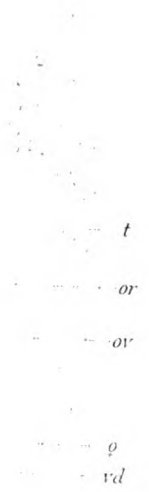
Note. All figures are of *Polychoerus caudatus*, and all except 2, 3, 5, 7, 17, 21 and 22 were drawn with the aid of the camera lucida. Figures 5, 9, 10, 12, 14, 18 and 19 were drawn by Dr. W. M. Woodworth. Figure 2 was copied to black ground by Mr. A. G. Mayer from a sketch by the author.

1.

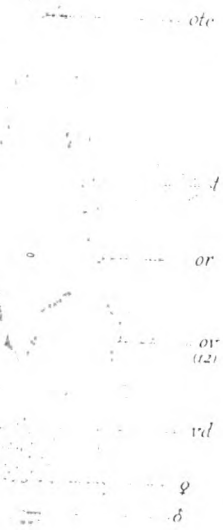
2.



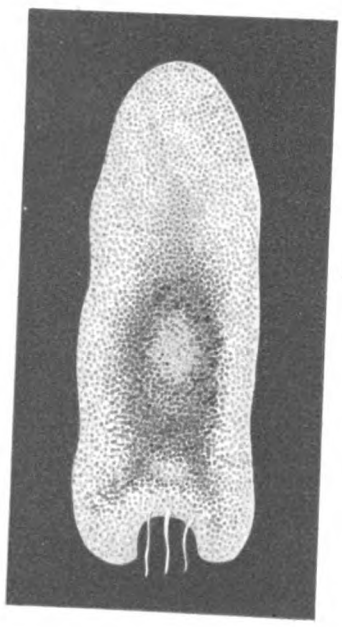
3.



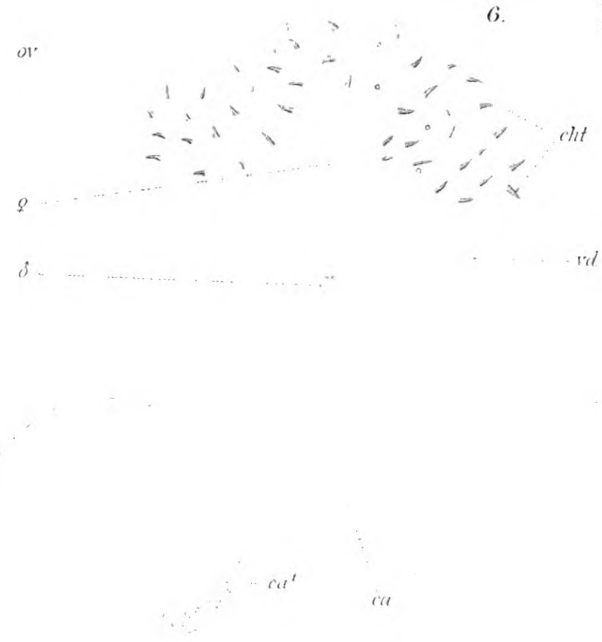
4.



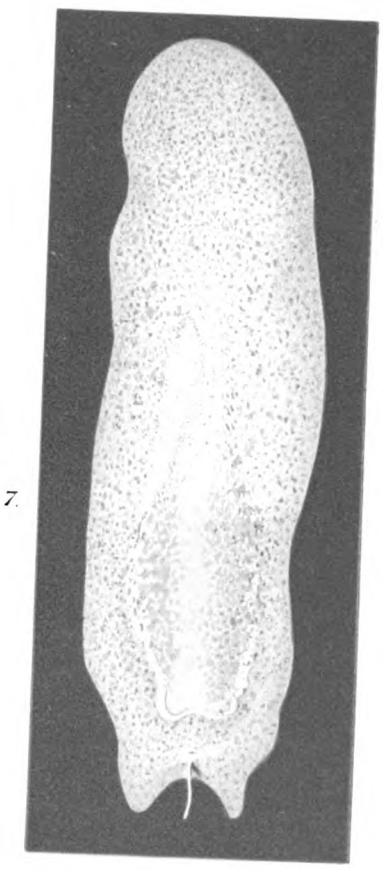
5.



6.



7.

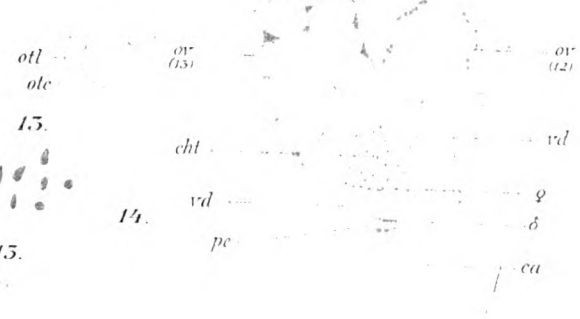


8.

9.

10.

11.



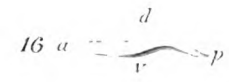
12.

13.

14.

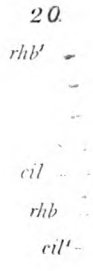
15.

16 a



17.

18.



19.

20.

21.

22.

Verlag v. Wilh. Engelmann, Leipzig.