

On a Species of *Macrostomum* (Turbellaria: Rhabdocoela) Found in Tanks of Exotic Fishes

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I. Introduction

In 1882, von Graff described a new *Macrostomum* under the specific name *tuba*. The most salient character of this species is the tubular penis stylet with a bulbous tip (Fig. 13). It is to be noted that the animal came from a pond in the botanical garden in Munich and hence its endemicity may be questioned. In 1905, Luther published an account of the histology of the genus *Macrostomum*, based on three species, one of which was said to be *M. tuba*. The material of *M. tuba* consisted of three preserved specimens sent to Luther by Böhmig but the source of the specimens is not stated. Luther added many details to Graff's account of *M. tuba* but his figure and description of the penis stylet differ from those of Graff, showing the penis stylet with a simple oblique tip without bulbous enlargement (Fig. 15). If this is the correct shape of the stylet tip of Luther's specimens, then it would appear that those specimens could not have been *M. tuba*. However, Luther worked entirely from sections and probably the stylet tip had been cut away or lost in the sectioning process; Luther's figure (Fig. 15) certainly suggests some such mishap. It will be assumed in what follows that Luther actually had *M. tuba*.

In his 1913 monograph of the Rhabdocoelida, Graff gave a description of *M. tuba* which is simply a combination of his 1882 remarks with material added from Luther's work. Evidently Graff had had no fresh material of the species. He cited and figured as characters of the penis stylet of *M. tuba* both the bulbous tip of his own original description (Fig. 14) and the simple diagonal opening of Luther's description (Fig. 15). No species of *Macrostomum* can have two such differing penis stylets and hence the penis stylet of the original description must be taken as correct.

Between 1913 and 1930 there have been a number of records and descriptions in the literature of *Macrostomum* specimens identified as *tuba*. These are listed by Ferguson (1940) and will be referred to in detail later. Here I may say that probably none of them were actually *M. tuba* with the possible exception of the form used by Ruhl (1927) in regeneration experiments. Identification appears to have been based chiefly on the bulbous stylet tip of these forms without regard to other characters.

In 1930, Okugawa described as common in Japan a *Macrostomum* which he named *M. tuba gigas*, differing from *M. tuba* in size, body contour, and characters of the penis stylet. A more detailed description promised in the future apparently never appeared. Kepner and Stiff in 1932 published on a

rhabdocoel found in a pond near the University of Virginia which they considered to be an American representative of *M. tuba*. Their animal agrees with Graff's original description in body contour and general anatomy of the male apparatus; but differs in lacking lobulated ovaries and in having a penis stylet like that of Okugawa's form. They noted that the bulbous stylet tip is caused by a thickening of the wall, not by an expansion of the lumen as was the case with the original *M. tuba*; but this thickening had already been figured by Beklemishev (1927), Gieysztor (1930), and Okugawa (1930). In 1936, I identified as *M. tuba* a *Macrostomum* which I had found in abundance in tanks of exotic fishes in the greenhouse of the Department of Animal Behavior of the American Museum of Natural History, and which still exists in those tanks. This form appeared to me to agree satisfactorily with Graff's original description except for the penis stylet which in its much greater length and thickened tip resembled the figures of Beklemishev, Gieysztor, Okugawa, and Kepner and Stiff.

In 1939-1940, Ferguson published a monograph of the genus *Macrostomum* in which he described a number of new species and varieties, created a number of new names, and attempted to evaluate the species in the literature. Although this work is indispensable to future students of the genus and contains a valuable bibliography, the author unfortunately failed in many instances to conform to the international rules and stated the synonymy, apart from that copied from von Graff, in a very confusing manner, in footnotes and incidental remarks in the text. It appears, although this is not clearly stated, that Ferguson regards Kepner and Stiff's form as belonging to his new name, *M. bulbo-styium*, and he also puts the forms called *M. tuba* by Beklemishev and Gieysztor under this species but *M. tuba gigas* Okugawa is left as a subspecies of *M. tuba*. Ferguson called attention to an important point which I had overlooked,¹ namely, that the bulbous stylet tip in Graff's 1882 description is caused by an expansion of the lumen (Fig. 14), whereas in all other figures of forms assigned to *M. tuba* except Ruhl's, it is caused by a thickening of the wall, without enlargement of the lumen (Fig. 9). If this character be taken to remove all these forms from *M. tuba*, then clearly Okugawa's animal cannot be a subspecies of *M. tuba*. Ferguson gives no grounds for the synonymy just stated and for reasons that will be stated later, I am unable to agree with his disposition of these forms.

In regard to *M. tuba*, Ferguson made the mistake of attributing to *M. tuba* a figure of the pharynx which he copied from Graff (1882) but which really pertains to *M. hystrix*. Graff gave only three figures of *M. tuba*: the male copulatory apparatus, the spermatozoon, and the adhesive papillae.

Ferguson dismisses my 1936 description with scant consideration as a "dubious species," and censures me for not having produced a more detailed

1 Because of having overlooked this point, I failed in my 1936 article to understand correctly some remarks of Kepner and Stiff about the penis end; for this misunderstanding I apologize. I was also in error in that article in stating that Luther obtained his specimens from von Graff; he got them from Böhmig.

description and particularly for not having figured the excretory system, the stylet tip, and the spermatozoon. I did not see the excretory system and as this is not described for the original *M. tuba* or other specimens assigned to this species, it is not clear what aid it would have been to identification. As to the stylet tip, I stated that this in my animal was identical with the figures of Beklemishev and Okugawa and this should have been sufficient information. I was certainly at fault in not examining the sperm but as will appear later this would not have led to any certain conclusion either.

I have now restudied my animal and reached the same conclusion as previously, i.e., that my form differs from *M. tuba* (insofar as the original description goes) only in characters of the penis stylet, and that it is identical with the animal described as *M. tuba* by Beklemishev (1927) and as *M. tuba gigas* by Okugawa (1930). I also believe the *M. tuba* of Gieysztor's 1930 description (which I overlooked before) to be conspecific with my animal. If the characters of the penis stylet (greater length, thickened wall of the tip) are to be taken as of specific value, then it follows that neither I nor the other authors mentioned had *M. tuba* or a variety thereof, that Okugawa's subspecies must be raised to specific rank, and the name of the animal must be *M. gigas*.

The following is a redescription of my animal, which I now identify as *M. gigas*, based on renewed examination of many living individuals, normal and compressed, and of the sections of several animals prepared for my 1936 account.

II. Description of *Macrostomum gigas* Okugawa 1932

The animal reaches a length of 3.5 mm., although most sexually mature worms are a little shorter than this; hence it is really large as compared with other *Macrostomum*s, which are said by Ferguson to range from 0.8 to 2.5 mm. The body is of elongated oval form (Fig. 1), rounded at both ends, sides slightly outcurved, hence body widest through the middle third. The anterior end is often distinctly narrowed (more so than in Fig. 1) because of the indentations where the cilia cease (Fig. 2). The rear end is generally rounded in the extended moving animal but may be slightly expanded in especially large specimens as in Okugawa's figure; it is never, however, decidedly spatulate as in some *Macrostomum* species.

Most species of *Macrostomum* are said to be transparent or translucent but *M. gigas* is distinctly whitish to the naked eye; the digestive tract takes the color of recently ingested food. The ripe eggs in the oviduct and antrum are very opaque white under low magnification, gray with higher magnification. The purple color of the pharyngeal glands noted in my previous account (1936) was absent in the present specimens.

The anterior margin is devoid of cilia and provided with many (mostly 40 to 60 in mature specimens) stiff conical projections which appear to be tactile sensilla; they are evidently what Ferguson calls spines (Fig. 2). This spine-bearing margin is marked off from the adjacent ciliated epidermis by little

indentations, often quite marked even under low magnification. There are no such spines elsewhere on the body. Along the sides and rear end of the body there are a few scattered sensory hairs (Fig. 1), longer and more flexible than the spines. For the most part these occur singly, not in groups or tufts as described by Ferguson for a number of species. Occasionally a long sensory hair was seen to be accompanied by one or two shorter ones. The long sensory hairs are more numerous along the adhesive rear end than along the body sides (Fig. 3).

The posterior margin is provided with adhesive papillae (Fig. 3), which are retractile, hence visible only when the animal pauses and attaches. Such attachment involves only the papillate region which then spreads out in a fan-like manner (Fig. 3) and displays the papillae. The latter appear as short clear blebs somewhat irregular in length and shape (Fig. 3). The papillate region appears to be devoid of cilia, at least the cilia if present are shorter and less evident than elsewhere so that during attachment there is a clear demarcation between the papillate region and the regular ciliated epidermis (Fig. 3).

The epidermis is pierced between cells by bundles of rhabdites which as usual are much more numerous dorsally than ventrally. In my animal these bundles are about evenly distributed throughout the dorsal region, not more abundant along the body margins. The rhabdites are of clavate form (Fig. 5), about $18-20\mu$ in length, up to ten per bundle, mostly six to eight. They appeared to be of about the same length throughout the body; especially long ones (thammites) connected by tracts to the brain occur in a small area of the anterior tip. Among discharged rhabdites there are to be seen some more attenuated at the narrower end than the majority, as in the right-hand rhabdite of Figure 5. These run to 25μ or longer. I found no rhabdites around the mouth as recorded for other species but there do seem to be some especial eosinophilous elements in a circle around the mouth.

The eyes of my animal, situated immediately in front of the pharynx and immediately behind the main nervous mass, appear in compressed specimens as a pair of reniform black masses each curved around a rounded clear body. The latter is usually called a lens in taxonomic descriptions of *Macrostomum*, and appears to be evident in low-power examination of the eye in all species, hence of no taxonomic value. This is not really a lens (extra-retinal refractive body) but a part of the retinal cell. As is well known, the eye of *Macrostomum* consists of a single retinal cell inverted into a pigment cup. The retinal cell has the usual parts known to be characteristic of the turbellarian eye since the classical work of Hesse (1896), i.e., a rod or striated border, a clear region ("lens" of various authors), and a proximal part containing the nucleus and continuing by a nerve fiber into the adjacent brain. The best eye section on my slides is shown in figure 4. My findings are similar to those of Kepner and Stiff although I see no grounds for the terminology developed by Kepner for the regions of the retinal cell.

No attempt was made to work out the nervous system in detail but incidental observations indicate close similarity with Luther's figure (1905, text fig. 3)

of the nervous system of *M. tuba*. A sketchy representation of my findings has been added to figure 1. The main nervous center or brain appears as a thick band passing in front of the eyes; this continues backward on each side as a ventral nerve cord which encircles the viscera of the worm. The posterior part of this continuous cord, passing behind the male apparatus, was mistaken by Okugawa for an excretory vessel. From the brain a network of nerve strands can be seen permeating the precerebral part of the anterior end and especially supplying the anterior margin; many fine branches also pass from the rear part of the nerve cord into the adhesive posterior end. There is also a nerve ring around the pharynx connected on each side with the ventral cord by a connective; the exact manner of junction of the pharyngeal ring with the brain was not clearly ascertained. It seems probable that the main features of the nervous system—the encircling cord and the pharyngeal ring—are common throughout the genus.

The digestive system offers nothing of specific value. The mouth slit occupies about two-thirds the length of the pharynx. The pharynx is an oval muscular organ connected to the intestine by a brief narrowed esophagus. Mouth and pharynx are capable of great distension. In sections the pharynx is seen to be lined by a tall ciliated epithelium and as already noted there is a ring of elongated slightly eosinophilous structures in its wall near the mouth. The intestine is an elongated sac, tapering to a point posteriorly just in front of the male apparatus. It has slightly wavy walls composed of a tall bulbous epithelium, packed in most of my sections with food balls resembling those seen in the intestinal epithelium of planarians; their presence suggests that digestion in *Macrostomum* must be largely intracellular.

Despite repeated efforts I was totally unable to see any trace of the excretory system. Aqueous eosin as recommended by Ferguson proved of no value for rendering the excretory vessels visible in my species. Azur II was not available. As already mentioned what Okogawa regarded as a transverse excretory vessel in the rear part of the animal is in reality the nerve cord. I was myself deceived by this for a time and probably the same mistake has been made with other species of the genus.

The reproductive system conforms to the general plan for the genus. The testes are elongated, slightly lobed, cylindrical bodies alongside the anterior part of the intestine (Fig. 1). They are rather transparent and rendered visible chiefly by the sperm accumulations in their lumen. From the rear end of each testis a sperm duct proceeds backwards alongside the intestine behind the rear end of which the two ducts enter an expansible thin-walled sac of changeable shape. This is called false seminal vesicle in the literature but since it functions as a genuine storage sac for the sperm, the name is not a happy one and spermiducal vesicle is suggested instead. From the rear wall of this (Fig. 8), a narrowed tube leads into the seminal vesicle, of cylindrical form, thicker-walled and of more definite shape but smaller than the spermiducal vesicle. The seminal vesicle is directed anteriorly and leads into the granule vesicle, also directed anteriorly. The granule vesicle is a firm body of fusiform shape,

whose proximal part is surrounded by eosinophilous granule glands, containing coarse eosinophilous granules, which are discharged into the granule vesicle by several conduits (Fig. 8). The distal end of the granule vesicle narrows to a curved tube which incloses the proximal end of the penis stylet. The latter is a long curved tube of hard material (usually called chitin but not proved to be this substance) which is directed backwards and tapers slightly to its tip. This tip lies at the male genital pore and is of bulbous shape because of a ring-like thickening of the wall (Fig. 9). The penis stylet is some three or four times the length of the granule vesicle (not counting the arched neck of the latter). As the stylet is curved, often markedly so, it is difficult to get an exact measurement of its length. The length is certainly subject to wide variation but in most specimens seems to be 400 to 500 μ .

The fresh spermatozoon (Fig. 6) is an elongated filament tapering at one end into a flagellum ("feeler" of Ferguson), kept in constant undulation, and having for its other end a long filamentous tail always writhing and twisting about. There is no obvious enlarged "body," but the part bearing the flagellum evidently corresponds to the body since this remains quiescent, apparently adhering to the substratum, while flagellum and tail are in constant motion. Sections show that this body part contains the nucleus. At the junction of body and tail there are two bristles or setae but I was able to see these only with the greatest difficulty. Because of the constant writhing of the fresh sperm, it is impossible to get an accurate measure of their length but they appear to be 40 to 50 μ long. After a short exposure to water, the body of the sperm swells to a globular shape (Fig. 7) and the tail shortens greatly. The sperm then resembles Graff's 1882 figure of the sperm of *M. tuba* and also other figures of *Macrostomum* sperm in the literature. As one cannot know whether or not these figures are based on fresh sperm or sperm swollen with water, their taxonomic worth is dubious. Gieksztor also found that the sperm of the animal she called *M. tuba* is filamentous when fresh and comes to resemble Graff's figure only after exposure to water.

The ovaries (Fig. 1) are situated behind the testes, one on each side, slightly shorter than the latter. They are so transparent as to be seen with difficulty in the living animal but become more visible after staining with aqueous eosin. They are highly lobulated, consisting of many small lobes attached to a central region from which a broad oviduct, often distended with several ripe ovocytes, proceeds posteriorly. In the available sections I was not able to see any transitional stages between the very young ovocytes in the lobes of the ovary and the ripe ovocytes. An oviducal wall around the ripe ovocytes is detectable with difficulty in sections. I was unable to trace the oviducts into the female antrum or to determine whether they unite to a common oviduct before entering the antrum. However, one of my sections shows a ripe ovocyte in process of passing into the antrum through an opening in the anterior wall of the latter and one may presume that the ovocyte is coming from a common oviduct especially as this latter structure appears to be general throughout the genus.

The female antrum is a large rounded chamber ventral to the rear end of the intestine. Its wall consists of a cuboidal epithelium which when the antrum contains an egg become so stretched that cell boundaries are no longer detectable in some places (Fig. 10). The antrum opens ventrally by the female genital pore and is surrounded by a great halo of eosinophilous glands which open through the tall epithelium bounding the genital pore (Fig. 10). These glands probably secrete some adhesive material causing the egg shells to stick to objects. Such cement glands in connection with the female apparatus are of common occurrence throughout the Turbellaria.

As they proceed towards the antrum the ovocytes begin to show a peripheral layer of spherules and these form a definite surface layer of the ovocyte in the antrum (Fig. 10). These spherules presumably fuse and alter to form the egg shell. A mitotic figure is evident in the ovocyte in the antrum (Fig. 10) and appears to be the figure for one of the maturation divisions. In the best figure found on my sections, three chromosomes are evident (Fig. 10) so that apparently reduction had already occurred and the diploid chromosome number is six, as appears to be the rule throughout the genus. The material was not favorable for determining the shape of the chromosomes but they seemed to be V-like.

Numerous sperm are evident in the antrum in the sections so that presumably fertilization takes place in this chamber or in the oviducts.

My animal breeds freely in small dishes. Pairs in copulation were often observed but separated as soon as touched so that the relations of parts in copulation could not be ascertained. The copulatory attitude is the same as depicted by Ferguson (1939, p. 8). Presumably the penis stylet is inserted in the female genital pore of the partner. Ferguson claims that the fertilization is one-sided although mutual fertilization is the rule among the Turbellaria. A specimen examined immediately after copulation showed both spermiducal and seminal vesicles emptied of sperm and scattered active sperm in the granule vesicle and penis stylet.

The eggs are found in large numbers adhering to debris on the sides and bottom of the culture dish. They are spherical brown objects each containing a single embryo. Development is rapid and at room temperature the eggs hatch in probably not much more than a week. The complete little worm is seen curved inside the egg shell making movements of escape. The actual hatching was not witnessed but the empty shells show a neat round hole (Fig. 11). The young worms are transparent, of clavate shape, with disproportionately large eyes and brain ganglia (Fig. 12). They grow rapidly to sexual maturity and begin to show sperm and ripe ovocytes when not much more than 2 mm. long.

The animal is easily cultured in finger bowls in the laboratory and may be fed crushed *Daphnia*, chopped mealworms, or naid annelids such as *Dero* which in turn are easily grown in lettuce culture (Hyman, 1941). Although *Dero* is many times larger than the *Macrostomum*, the latter attacks the

annelid without hesitation and with widely distended mouth quickly swallows a large piece of the *Dero*. During the attack, the *Macrostomum* attaches to the substratum by its adhesive papillae but does not let go its prey even when torn loose from its hold by the writhings of the annelid. After being gorged with food, *Macrostomum* retires under a piece of debris and remains quiescent in a contracted almost circular shape. The animals are negative to light, positive to contact. *Macrostomum gigas* will also flourish in hydra cultures, feeding on the excess *Daphnia* or other food supplied to the hydras.

The present species has been found only in tanks of exotic fishes in the American Museum of Natural History and is evidently not endemic to the United States.

III. Synonymy and Comparisons

There is a confusion in the literature between *M. tuba*, *M. gigas*, and *M. bulbostylum*. Because of the lack of details in many of the available descriptions this confusion cannot be definitely cleared at present and the following is presented merely as a preliminary attempt at evaluation of these forms.

MACROSTOMUM TUBA (Graff), 1882

Syn. *Macrostoma tuba* Graff, 1882.
Macrostoma tuba Graff, Luther, 1905
Macrostomum tuba (Graff), Graff, 1913
Macrostomum tuba (?) Ruhl, 1927

Characters from the original description: 2.5 mm. long, broadest in the anterior third, both ends rounded, hyaline, anterior margin with sensory spines, posterior margin with retractile adhesive papillae, rhabdites clavate, 15μ long, eyes with evident "lens," shaped as in *M. hystrix* (i.e., somewhat hemispherical), male copulatory apparatus (reproduced in my figure 13) with spermiducal vesicle, fusiform seminal vesicle, retort-shaped granule vesicle provided proximally with granule glands, tubular penis stylet, not much longer than granule vesicle, tapering to bulbous tip caused by expansion of the lumen (Fig. 14), sperm (probably swollen with water) with oval body, three setae, slender tail. Locality, pond in botanical garden, Munich. Added from Luther's description: sensory hairs in groups, rhabdites more numerous along body margins where also longer ($16-20\mu$) than dorsally ($8-13\mu$), long slender rhabdites (?) around mouth, sperm filamentous, ovaries highly lobulated, broad oviducts unite to small common oviduct.

It is my opinion that *M. tuba* has not been seen again since the original description. Of the many records of this species in the literature, that of Ruhl, 1927, is the only one that might be *M. tuba* with any probability. Ruhl figures the entire animal and the penis stylet. The former resembles the original description in being widest through the anterior third but differs in that the rear end is decidedly spatulate. The penis stylet is also similar to Graff's original figure but it cannot be decided from Ruhl's drawing whether the bulbous end is caused by a widening of the lumen or a thickening of the wall.

Of the other records of *M. tuba*, the following are mere locality records so that the identification may be doubted: Plotnikov, 1906, region of Bologoje, province of Novgorod, Russia; Steinböck, 1926, flowing water in Steiermark, near Graz, Austria; Valkanov, 1926, Bulgaria; and Vialli, 1927, Cremona, Italy. Fulinski (1915) reported finding *M. tuba* in Poland, giving as the only description the statement that the penis stylet resembles the drawing of Luther, having a slightly expanded tip. This is a most bewildering remark, since the trouble with Luther's drawing (reproduced here as figure 15) is that it does *not* show an expanded tip. (Perhaps Fulinski referred to the other penis stylet figured by Luther and doubtfully attributed by him to *M. tuba*). Sibiriakova (1929) doubtfully identified as *M. tuba* specimens from the Angara River, Russia, but her figure of the penis stylet and granule vesicle shows that the animal could not have been either *tuba* or *gigas*. In their report of *M. tuba* from Poland, Fulinski and Szynal (1932) mention only that tufts of tactile hairs are limited to the anterior body third. This excludes *M. gigas* and is of doubtful applicability to *M. tuba* as Luther implies an even distribution of sensory tufts in the latter.

MACROSTOMUM GIGAS Okugawa 1930

Syn. *Macrostomum tuba* (Graff), Beklemishev, 1927
Macrostomum tuba (Graff), Gieysztor, 1930
Macrostomum tuba gigas Okugawa, 1930
Macrostomum tubum (Graff), Hyman, 1936
 (Not *Macrostoma tuba* Graff, 1882)

Characters from the original figures and description: 3.5 mm. long, anterior end somewhat narrowed, body widest through middle third, anterior margin with sensory spines, posterior end slightly expanded, with adhesive papillae, eyes reniform with distinct "lens," ovaries lobulated, penis stylet a long curved tube, terminating in a bulbous inflation caused by thickened wall, granule vesicle fusiform, penis stylet about three times the length of the granule vesicle. Added from present description: anterior margin bearing sensory spines devoid of cilia, posterior end expanded only in largest specimens, mostly rounded, adhesive papillae retractile, visible only during attachment, sensory hairs along sides and posterior margin mostly single, rhabdites clavate, mostly 18-20 μ long, bundles evenly distributed throughout dorsal surface and body margins, everywhere of about equal length, ovaries of many small lobes attached to central strand which continues as broad oviduct, male apparatus with expansible spermiducal and smaller tubular seminal vesicle (these two vesicles not shown as distinct in Okugawa's drawing), sperm filamentous, about 50 μ long, with two setae, alters greatly after short exposure to water. Locality, lakes, ponds, and rice fields in Japan, imported into the United States with exotic fishes; also if above synonymy is correct, common in eastern Europe, and probably a widespread Eurasian species.

It is evident that *M. tuba* and *M. gigas* have very similar characters, differing only in size, body contour, shape of the eyes, length of the penis stylet, shape of the granule vesicle, construction of the bulbous tip of the stylet,

possibly in shape of sperm. It might well be questioned whether these differences are of specific rank, but on the basis of the available information, it seems best to so consider them at present. To prove that they are variations of one species it would be necessary to show that intermediate forms exists.

I regard the *M. tuba* of Beklemishev's 1927 description to be really *M. gigas* because of its large size (4 mm. long or even more), and because the penis stylet in length, shape, and bulbous tip is identical with that of my specimens. I also consider the *M. tuba* of Gieysztor's 1930 description to be *M. gigas* because of the whole male apparatus as figured by her is indistinguishable from that of my specimens and because she found the sperm to be filamentous and to alter on exposure to water. Other points mentioned by these two authors fit either *tuba* or *gigas*.

MACROSTOMUM BULBOSTYLUM Ferguson 1939

Syn.? *Macrostomum tuba* (Graff), Kepner and Stiff, 1932
(Not *Macrostoma tuba* Graff, 1882)

Characters from the original description and figures: 2.5 mm. long, anterior end rounded without sensory spines, posterior end spatulate without adhesive papillae, rhabdites shown as oxeote in one figure, clavate in another, rhabdites more numerous along body ends than elsewhere, sensory hairs in tufts, occurring along whole margin, penis stylet straight, with bulbous tip due to thickened wall, ovaries compact, indented, spermatozoon like Graff's 1882 figure but has two setae instead of three. Locality, ponds, streams, lakes, springs, Virginia, Tennessee.

On paper, *M. bulbostylum* appears to be quite different from *M. tuba* and *M. gigas*. However, many of the stated differences could not be verified on examination of the paratypes deposited by Ferguson in the U. S. National Museum and kindly lent for examination by that institution. This material consists of six whole mounts and eleven sets of serial sections. I find on study of the whole mounts that the rhabdites are clavate, the ovaries are lobulated, the penis stylet is curved in all six specimens, and the whole male apparatus (not figured or well described by Ferguson) is identical with that of my specimens. As to the rhabdites Ferguson's account and figures are confusing and contradictory. In his figure 22, the rhabdites are shown as oxeote (although this is not mentioned in the text) and in his figure 23, they are shown as clavate with a little tip to the broad end. I saw no oxeote rhabdites on the paratypes and nothing but the simple clavate rhabdites such as those of my animal. The ovaries on the whole mounts and sections appeared to me to be lobulated and not to differ from those of my animal. I could see no difference in length, shape, or bulbous tip of the penis stylet from those of my specimens and others in the literature which I consider to be *M. gigas*. In short there remain as characters of *M. bulbostylum* which apparently differentiate it from *M. gigas* only the following: rhabdites are more numerous on the two ends than elsewhere, the sensory hairs occur in tufts, the anterior margin lacks sensory spines, and the posterior margin lacks adhesive papillae. The first was

verified on the paratypes; the last three could not be checked as living material is necessary for their study. The sperm figured by Ferguson resembles that of my animal after exposure to water and has no diagnostic value until the conditions under which it was drawn are known. Many of the points mentioned by Ferguson are either too trivial for specific diagnosis or else are common to many if not all species of the genus (i.e., the parts of the retinal cell).

Ferguson regards the animal described by Kepner and Stiff as belonging to *M. bulbostylum*. There are some discrepancies between the text and the figures in Kepner and Stiff's article. In a letter Dr. Kepner has informed me that the figures are to be taken as correct. It would then appear that their animal differs from Ferguson's description in lacking a spatulate rear and from Ferguson's paratypes in having non-lobulated ovaries. However, it probably is the same form as Ferguson's *M. bulbostylum*, allowing for inaccuracies and discrepancies in the descriptions. Ferguson also considers the forms of Beklemishev and Gieysztor to be *M. bulbostylum*. This is impossible since Beklemishev's animal had adhesive papillae² and Gieysztor's had filamentous sperm, also lobulated ovaries (denied by Ferguson for *M. bulbostylum*).

If the characters of the male copulatory apparatus, especially of the penis stylet, are to be regarded as the most important diagnostic characters for the species of *Macrostomum*, then there is no difference in this apparatus between *M. bulbostylum* and *M. gigas* (according to my examination of the paratypes of the former) and the former should probably be considered an American subspecies of *M. gigas*.

IV. Summary

The species of *Macrostomum* which often appears in the literature under the name of *M. tuba* (Graff) 1882 is considered to be identical with *M. tuba gigas* Okugawa 1930; this is raised to specific rank. Specimens now believed to be *M. gigas*, formerly attributed to *M. tuba*, occur in tanks of exotic fishes in the American Museum of Natural History and are used as a basis for a detailed description of *M. gigas*. *M. bulbostylum* Ferguson 1939, confused by Ferguson with *M. gigas*, is considered to be a subspecies of the latter, pending less conflicting information as to its characters.

LABELS OF ALL FIGURES

1, sensory spines; 2, nervous system; 3, mouth; 4, pharynx; 5, pharyngeal ring of nervous system; 6, testis; 7, intestine; 8, ovary; 9, oviduct; 10, ripe eggs in oviduct; 11, sperm duct; 12, ripe egg in female antrum; 13, spermiducal vesicle; 14, seminal vesicle; 15, granule vesicle; 16, penis stylet; 17, pigment cup of eye; 18, rod border of retinal cell; 19, retinal cell; 20, nucleus of retinal cell; 21, brain; 22, granule gland cells attached to granule vesicle; 23, peripheral layer of spherules of egg composed of shell material; 24, cement glands; 25, female genital pore.

² I am greatly indebted to Miss Francesca La Monte of the department of ichthyology of the museum for translating for me the original Russian text of the articles of Beklemishev and Sibiriakova.

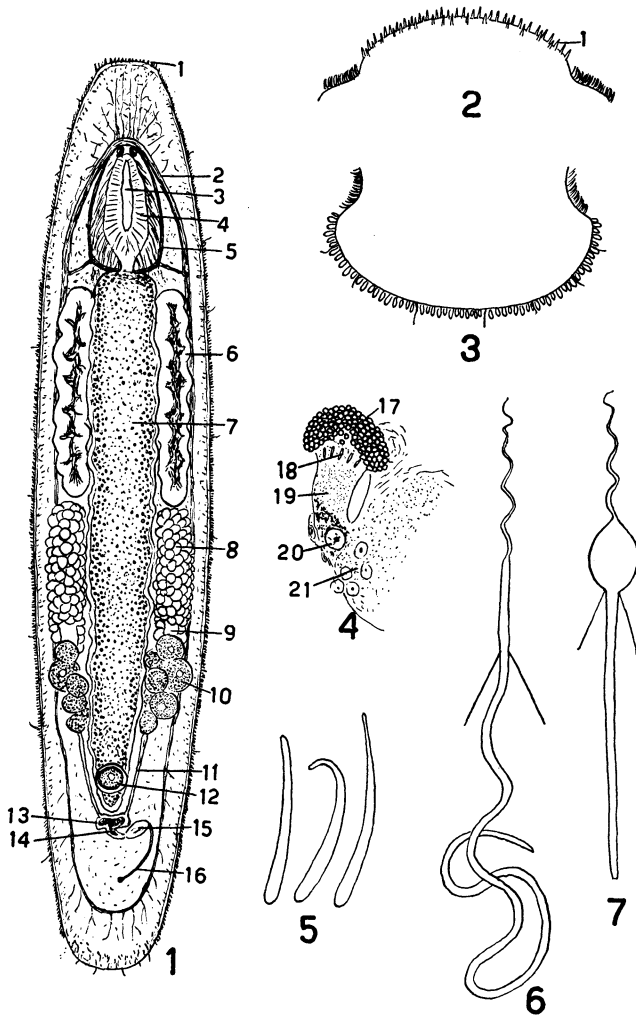


Fig. 1. *Macrostomum gigas* from life, shape carefully drawn from extended, freely moving animals, details added from study of compressed live specimens. Fig. 2. Anterior margin of *M. gigas*, showing sensory spines, and lateral indentations where cilia cease. Fig. 3. Posterior end of *M. gigas* during attachment showing protruded adhesive papillae, visible only at this time. Fig. 4. Section of the eye of *M. gigas*. Fig. 5. Rhabdites of *M. gigas*. Fig. 6. The fresh normal spermatozoon of *M. gigas*. Fig. 7. The spermatozoon after swelling from exposure to water.

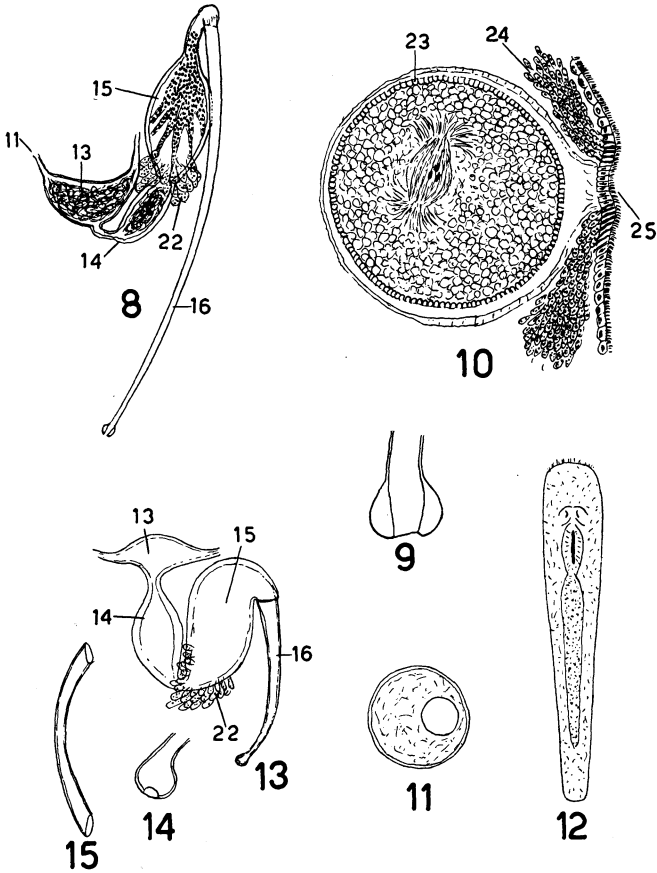


Fig. 8. The male copulatory apparatus of *M. gigas*. Fig. 9. The tip of the penis stylet enlarged to show bulbous thickening of the wall. Fig. 10. Sagittal section through the female antrum and genital pore of *M. gigas*, showing an egg in mitosis in the antrum, and the cement glands opening around the genital pore. Fig. 11. Hatched egg of *M. gigas*, showing hole through which young worm escapes. Fig. 12. Recently hatched young worm. Fig. 13. The copulatory apparatus of *M. tuba* traced from the original figure of von Graff 1882. Fig. 14. The penis tip from Fig. 13, enlarged. Fig. 15. The end of the penis stylet of *M. tuba* according to Luther, 1905; drawn from sections and probably lacking the true tip.

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