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Descriptions and Records of Fresh-Water Turbellaria from the United States

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The smaller Turbellaria of North America, of both fresh and marine waters, are very poorly known, and knowledge of them may be expected to accumulate only with exasperating slowness. The reasons for this are the paucity of competent taxonomists in this group, the necessity of obtaining an ample supply of well-fixed material, and the difficulties of identification even when such material is available. The present study is based wholly on material that has been generously sent to me and owes what value it has to the efforts of the collectors, especially Mr. Tom Daggy of Davidson College, North Carolina, and Dr. Miriam Pennypacker of the University of Pennsylvania. The Pennypacker material was collected by Dr. R. G. Schmieder.

Abbreviations for All Figures

1, Eye; 2, mouth; 3, pharynx; 4, intestine; 5, testis; 6, yolk gland; 7, yolk duct; 8, capsule; 9, male apparatus; 10, copulatory bursa; 11, seminal receptacle; 12, ovary; 13, suspensory cell of ovary; 14, proximal part of ovovitelline duct; 15, muscle fiber; 16, distal part of ovovitelline duct; 17, pyriform gland cells; 18, long-necked gland cells; 19, common gonopore; 20, intercellular vacuoles; 21, epidermis; 22, subepidermal muscle fibers; 23, gland cell; 24, special layer for algal cells; 25, algal cells; 26, general mesenchyme; 27, gland cells of sperm duct; 28, sperm duct; 29, seminal vesicle; 30, gland cells of seminal vesicle; 31, prostatic part of male apparatus; 32, cut pieces of penis stylet; 33, handles; 34, transverse bar; 35, end branch; 36, spines; 37, mass of sperm; 38, proximal oviduct; 39, prostatic glands; 40, wall of penis bulb; 41, penis papilla; 42, inner tube of penis papilla; 43, plasmatic lining; 44, eosinophilous masses; 45, uterus;

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46, common antrum; 47, distal oviduct; 48, glands of distal oviduct; 49, entrance of common yolk duct; 50, cluster of rhammite-forming cells; 51, rhammite tract; 52, brain; 53, pharyngeal cavity; 54, stalk of copulatory bursa; 55, sac of copulatory bursa; 56, antral glands; 57, ciliated pit; 58, statocyst; 59, male antrum; 60, common ovovitelline duct.

ORDER LECITHOPHORA

DEFINITION: Turbellaria of small size, with bulbous pharynx and simple intestine in the form of an elongated sac; protonephridia paired; female system with germovitellaria or separate ovary (or ovaries) and yolk glands; eggs provided with yolk cells; with common gonopore or separate female pore behind the male pore.

SUBORDER DALYELLIOIDA

DEFINITION: Lecithophora with dolioform type of pharynx and mouth at or close to the anterior tip; with common gonopore and generally armed penis.

FAMILY DALYELLIIDAE

DEFINITION: Dalyellioida with posterior gonopore, single (rarely double) ovary separate from the paired smooth or diverticulated yolk glands; testes paired, compact; penis in the form of a complicated cuticularized stylet of bars and spines.

GENUS *DALYELLIA* J. FLEMMING, 1822

Vortex EHRENBERG, 1831.

DEFINITION: Dalyelliidae with copulatory bursa and seminal receptacle; with or without uterus; terminal male apparatus an undivided tube that encloses the seminal vesicle and the complicated penis stylet.

Dalyellia viridis carolinensis, new subspecies

Figures 1–9

A large number of specimens of a green *Dalyellia* were sent to me by Mr. Tom Daggy who had collected them in an open vernal pool in a grassy meadow of the flood plain of the Rocky River in Cabarrus County, North Carolina, during February, 1952. Mr. Daggy reported having found the same green worms in abundance annually in this pool at the same time of the year, from January to March.

The length was given as 3.5 to 4 mm. in life. In shape the worms are very plump through the middle, with greatly narrowed ends. Figures 1 and 2 show the shape from above and from the side, made from

sketches provided by Mr. Daggy. The color in life is a bright grass green except for the pale, straw yellow anterior tip bearing the two eyes.

The general structure of the worm as seen in a cleared whole mount is represented in figure 3. The two eyes occur near the anterior margin.

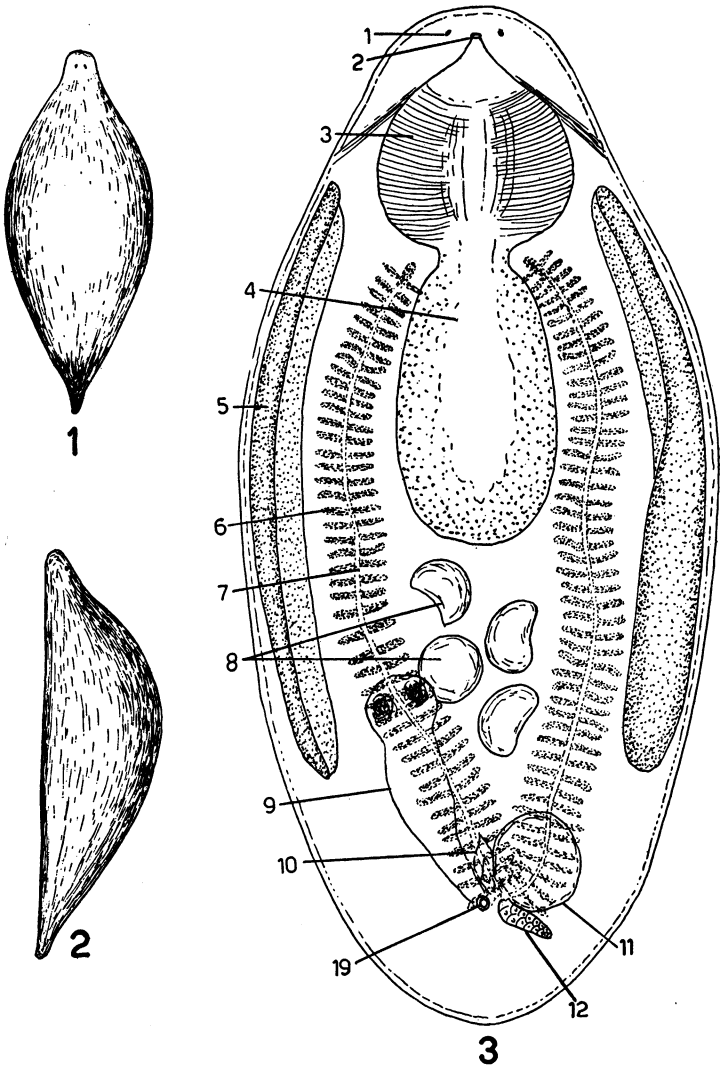

FIG. 1. *Dalyellia viridis carolinensis*, dorsal view.
FIG. 2. Same, side view.
FIG. 3. Same, dorsal view of cleared whole mount.

The mouth is found at about the level of the eyes and leads into a conical pharyngeal cavity the wall of which is continuous with the dolioform pharynx. The latter leads into the blind intestine, having the form of an oval sac. No attention was paid to the histological details of pharynx and intestine, as these have been fully discussed in classical works on Turbellaria. For taxonomic purposes interest must be centered on the reproductive system, of which the main parts are detectable in whole mounts, although they can be fully understood only by means of sections.

The testes are seen as a pair of flattened elongated bodies fitting into the curve of the body sides. Their outer surface is convex, their inner surface concave, as also verified in sections (fig. 7). In sections they are seen to consist of a loose mass of darkly staining cells (fig. 7). The two yolk glands are found in the median dorsal region above the digestive tract and are formed of a succession of narrow lateral diverticula attached to both sides of a central duct. Sections show that this duct lacks a definite wall (fig. 7); the lateral diverticula consist of strands of rounded cells containing darkly staining inclusions and differentiate from primordia at the free ends of the diverticula. The yolk glands extend from the rear end of the pharynx to the copulatory complex situated near the posterior body end. This complex is seen to spring from the common gonopore in the midventral line near the posterior end. From the gonopore the three main parts of the copulatory complex extend forward. To the left is located the male apparatus in the form of a broad tube narrowing towards the gonopore and receiving at its anterior end a sperm duct from the posterior end of each testis; the sperm ducts are mostly not detectable in whole mounts. The male tube contains successively from the anterior end backward the seminal vesicle, the prostatic region, and the penis stylet. The central structure attached to the gonopore is a small sac, the copulatory bursa (bursa copulatrix), of uncertain function. The third part of the copulatory complex, extending from the gonopore anteriorly to the right, is the remainder of the female apparatus, of which the most conspicuous part is the large spherical seminal receptacle. The small ovary is located close to its posterior surface. In the interior of the worm the dark brown, hard-shelled, dormant egg capsules are conspicuous objects, noticeable even to the naked eye. They are generally fewer than 10 in number, but up to 20 may be present. They are presumably spherical in life but often show one flattened or concave surface in preserved specimens.

The epidermis is a cellular cuboidal epithelium that is presumably

ciliated in life, although no cilia were seen in the sections. Its cells appear to be separated frequently by spaces, or possibly these are intracellular vacuoles (fig. 6). Beneath the epidermis is a narrow muscle layer, of mainly longitudinal fibers, and this is followed by a distinct layer, thicker dorsally than ventrally, that contains the green algal cells responsible for the color of the worm. These are extremely small round cells, more numerous dorsally than ventrally. Just to the inner side of the algal layer are seen occasional large cells, considered by von Graff (1882) to be gland cells opening at the surface. The algal layer is very sharply delimited from the interior mesenchyme which seems to consist of an indistinct fibrous mesh.

The details of the female apparatus are shown in figure 4. Its most prominent part is the huge seminal receptacle, actually 0.2 to 0.3 mm. in diameter. It is naturally perfectly spherical, but often distorted to an oval shape in fixed material. Its wall seems to lack cellular construction and is probably somewhat cuticularized. Its interior is nearly always filled with a large ball of sperm, presumably received by copulation from another individual. A few large cells are seen near its exit, in the center of its posterior surface; this exit is continuous with the ovovitelline duct, and the seminal receptacle is best regarded as an appendage to this duct. The single ovary is a fusiform body located near and behind the seminal receptacle and always on the side of the female apparatus away from the copulatory bursa. The free end of the ovary consists of many small ovocytes that gradually increase in size towards the attached end of the ovary where there are large egg cells occupying the entire width of the ovary. The ovary hangs from the ovovitelline duct by way of a conical cell filled with coarse granulations. In no case has any opening been seen from the ovary into the duct. Despite the most diligent efforts it has been impossible to trace the ducts of the two yolk glands into the female apparatus. These ducts are very tenuous and in sections through the yolk glands appear merely as holes (fig. 7). It is my impression that the yolk ducts do not unite to a common duct (or if they do it must be extremely short) and that they open into the ovovitelline duct at its beginning, that is, at the attachment of the ovary. If they do not enter here, they must enter very shortly distal to this point. For this reason I speak of the duct leading from the ovary to the seminal receptacle as ovovitelline duct, rather than as oviduct. It is called "ductus transversus" by some authors, but there seems no need of creating a special name for it. This proximal portion of the ovovitelline duct, between the ovary and the seminal receptacle, is histologically peculiar. Its outer and posterior

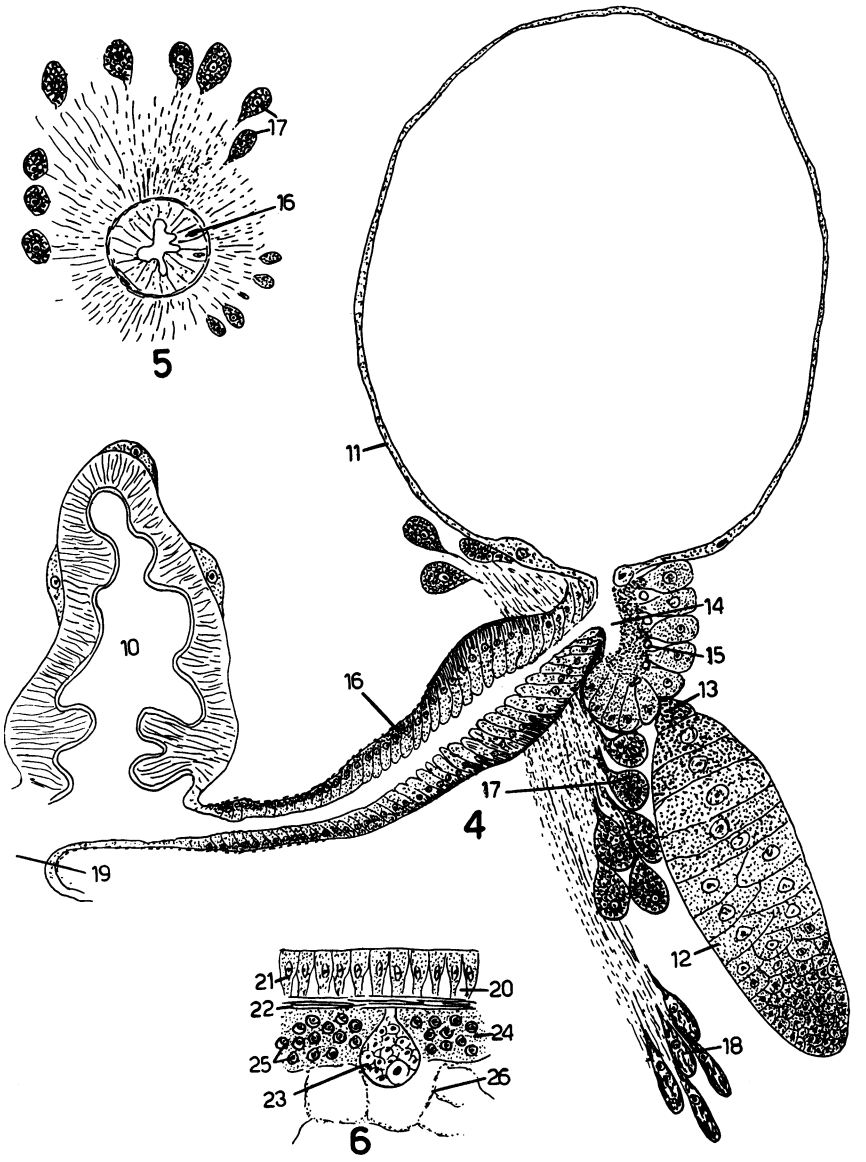

FIG. 4. *Dalyellia viridis carolinensis*, section of the female part of the copulatory apparatus.

FIG. 5. Same, cross section of the ovovitelline duct distal to the entrance of the seminal receptacle.

FIG. 6. Same, section through the body wall.

walls are composed of somewhat separated cells with narrowed bases, and between these bases is found the circular cross section of what appears to be a circular muscle fiber. This set of muscle fibers is therefore located at the base of the epithelium, certainly a peculiar situation. In the lumen of the duct to its outer side is found a finely granular secretion.

After receiving the seminal receptacle the ovovitelline duct (often called ductus communis in the literature) makes a sharp bend medially and posteriorly and continues to the common genital antrum (or atrium) as an elongated duct that broadens at first, then gradually narrows. The part adjacent to the seminal receptacle receives the ducts of many long-necked gland cells that encircle it. There appear to be two sorts of gland cells opening into the ovovitelline duct, a pyriform type with an interior network enclosing granules and an elongated type with longer necks and coarse inclusions. The gland cells are more numerous on the side of the duct adjacent to the ovary, and the long-necked type occurs on this side only. Figure 5 shows a cross section through the ovovitelline duct, with attached gland cells from a level just after the duct has received the seminal receptacle.

The bursa copulatrix is relatively small and inconspicuous in this subspecies. It is a conical appendage extending anteriorly from the common genital antrum between the ovovitelline duct and the male apparatus. It appears to lack cellular construction except for a few large cells that have been seen applied to its external surface. It is lined by what seems to be a cuticularized membrane thrown into folds, and its thick wall is made of transverse fibers, presumably muscular.

The male apparatus extends forward from the left end of the common genital antrum. From the posterior end of each testis a sperm duct proceeds to the anterior end of the male apparatus; as the latter is to the left, the right sperm duct is considerably longer than the left one. Shortly after leaving the testis the sperm duct receives a number of unicellular glands (fig. 8). It then curves around the side of the seminal vesicle and enters this distally. The seminal vesicle is the chamber filled with sperm that forms the anterior end of the male apparatus. In this subspecies it is the broadest part of the male apparatus and is somewhat subdivided by a partial median partition. From it a funnel-like duct passes posteriorly through the next part of the male apparatus which is the prostatic region. A circle of gland cells is attached to the beginning of the prostatic region, to its wall. It is not clear where these gland cells open, but they seem to open into the seminal vesicle. The prostatic region appears devoid of definite cellular structure. Its thin

wall seems not to be composed of cells, and its interior except for the central sperm conduit is filled with spherules. At its posterior end its walls contain muscle fibers operating the penis stylet. The third and most posterior part of the male apparatus contains the characteristic penis stylet, separated from the prostatic region by a transverse partition.

The penis stylet cannot be understood from sections and is best

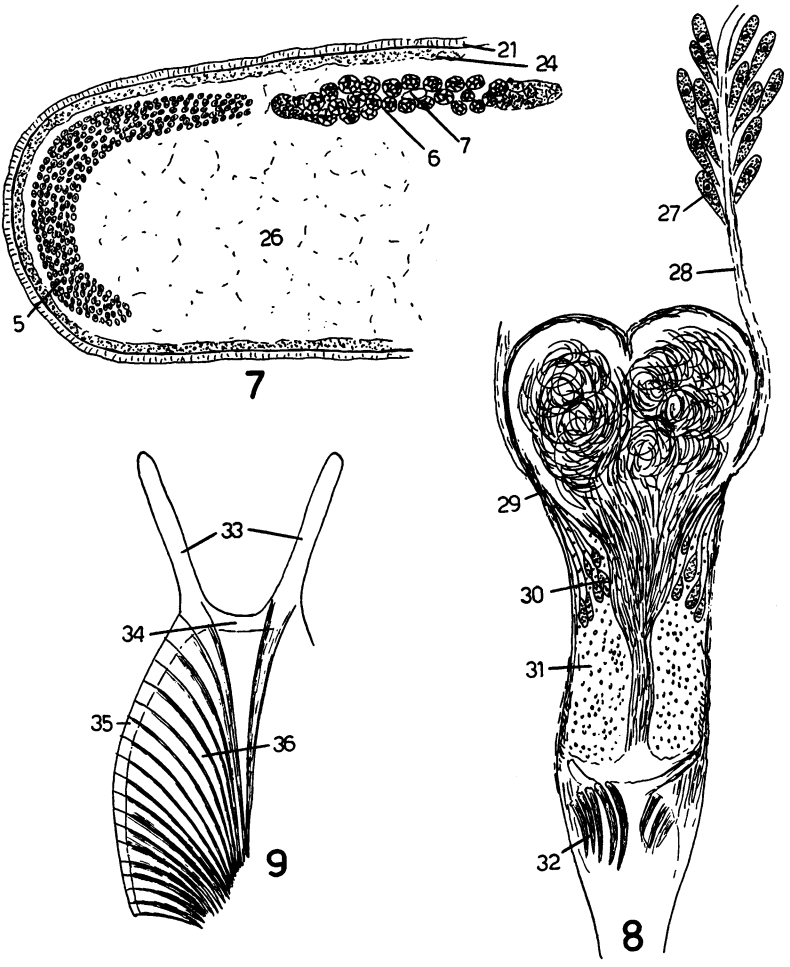

FIG. 7. *Dalyellia viridis carolinensis*, half of a cross section through the middle of the body.

FIG. 8. Same, longitudinal section of male copulatory apparatus.

FIG. 9. Same, penis stylet, spines filled in on one side only.

studied by isolating it from live specimens through crushing them on a slide. Three mounts of such isolated whole stylets have been kindly provided by Mr. Daggy. The penis stylet furnishes one of the most important diagnostic characters of the many species of the genus *Dalyellia*. It consists of an array of bars and spines composed of a hard, clear, cuticularized material. The penis stylet of *D. v. carolinensis* is shown in figure 9, in which the spines have been filled in on one side only. The stylet consists of two handles or stalks (*Stiel* of German workers), a transverse bar connecting the bases of the handles, and two end branches (*Endästen* of German workers), each of which bears a row of spines or teeth on its inner surface. In the present subspecies the handles are simple, not bifurcated, the transverse bar does not bear any median spine, and there are on each end branch 17 or 18 spines. The spines appear as curved blades decreasing in length from the proximal to the distal end of the branch, but probably they are not flat but three-angled as shown by von Graff (1882, pl. 12, fig. 13) in his illustration of the spines of the European *Dalyellia viridis*. The spines appear to be jointed onto the end branch and probably can be opened out. The penis stylet is operated by muscles attached to the adjacent walls. Distal to the penis stylet the male tube narrows and enters the left side of the common antrum.

The common genital antrum is a transversely elongated chamber that receives into its anterior wall the three terminal parts of the reproductive system already mentioned and opens in the midventral line by the common gonopore. It is lined by a typical epithelium underlain by muscle fibers. The gonopore is located a little to the left of the entrance of the copulatory bursa.

A uterus is wanting, and hence the capsules must rupture through the anterior wall of the genital antrum into the mesenchyme. Newly formed capsules, known by their soft wall, are always found in close proximity to the antrum. As they are pushed forward by subsequent capsules the wall hardens into a transparent, yellow material, presumably of scleroprotein nature, which shatters when hit by the microtome knife. As already noted the capsules are spherical, often with one flattened or concave side that probably results from collapse on fixation. They presumably contain one egg which is surrounded by a large number of yolk cells. As they age they slowly turn dark brown. They can escape only by the death and disintegration of the parent, and the capsules then lie dormant until the following spring when they hatch into colorless young that rapidly grow to sexual maturity, acquiring the green algal cells early in ontogeny. It is characteristic of the *Dal-*

yellia viridis group of *Dalyellia* species that the capsules accumulate in the parental mesenchyme, whereas in other *Dalyellia* species they mature singly in the uterus and are then laid through the gonopore.

The occurrence in North America of green flatworms belonging to the genus *Dalyellia* has long been known, but prior to the present instance none of these has been subjected to a taxonomic analysis. Von Graff (1911) found hundreds of specimens that he called *Dalyellia viridis* in a peat bog at Rochester, New York, but does not appear to have made an exact study of them. Shelford (1913) recorded the presence of a vernal green flatworm under the name *Vortex viridis* in several temporary prairie ponds in the region south and southeast of Chicago. In my student days at the University of Chicago I saw this worm on field trips with Dr. Shelford and do not share the doubt of Ruebush (1937) that it is a form of *Dalyellia viridis*. This is no doubt the same worm that was used by MacArthur (1921) in his experiments. In May, 1936, Dr. L. G. Saunders sent specimens of a green *Dalyellia* collected from a vernal pond near Saskatoon, Canada; no doubt, this too is a form of *Dalyellia viridis*, but the specimens were returned without detailed study. Kenk (1949) found a green *Dalyellia* common from April to June in two temporary ponds that he called Ponds I and II in the vicinity of Ann Arbor, Michigan. The specimens collected by Kenk cannot be located, but fortunately Dr. W. E. Hazen later collected an abundance of material in Kenk's Pond II, a prairie type of temporary pond, and has generously given me some of the specimens. I find that they are referable to *Dalyellia viridis* but are not identical with the Carolina specimens nor with the typical European representative of this species. Finally in the spring of 1954, Dr. Miriam Pennypacker advised me of the occurrence of a green *Dalyellia* in a temporary pool in a swampy place off Brandywine Creek in New Castle County, Delaware, but unfortunately no preserved specimens were secured. The colored sketches of this worm sent by Dr. Pennypacker indicate that it, too, is a form of *D. viridis*. It is evident that green rhabdocoels of the genus *Dalyellia* are widely spread in temporary vernal ponds in the United States and Canada, and I anticipate that they will be found to constitute geographic subspecies of *D. viridis*. This has here been demonstrated for the Carolina and Michigan specimens.

The occurrence of green rhabdocoels in vernal pools in Europe has been known for nearly 200 years. The most common of these is generally attributed to Shaw (1791) who described it under the name *Hirudo viridis* and gave some colored figures. Some workers, however, were of the opinion that Shaw's species was identical with *Fasciola helluo*

O. F. Müller, 1774, and hence they applied the name *Dalyellia helluo* to the species. It was pointed out by Sekera (1912), however, that Müller refers to spherical capsules, whereas the common species has distinctly oval capsules, as is also shown in Shaw's figures. It thus appears that Müller's species cannot be identified with certainty and that one may safely apply the name *Dalyellia viridis* to the commonest of the European green species of *Dalyellia*, distinguished by its oval capsules. The problem before me was to relate the North American green species of *Dalyellia* to the European ones. As regards the Carolina material it became clear at once that only *D. viridis* need be considered. Unfortunately, despite its wide distribution and frequent mention in the literature, there does not exist any satisfactory description of the European *D. viridis*. The best description and figures are those of von Graff (1882, pl. 12) but these are puzzling in several respects. In a cross section the testes are shown as medial and the yolk glands as lateral, something that certainly cannot be correct, as all figures of the entire animal depict the yolk glands as medial to the testes. Then, two quite different figures are given of the spines of the penis stylet. In one figure, the spines are short, widely separated, and oriented at right angles to the end branches, whereas in the other, they form a series of almost overlapping, arched blades directed backward. A great variability is further indicated by von Graff. There may be one or two ovaries, and the yolk glands may enter either between the ovary and the seminal receptacles or distal to the ovaries near the common antrum. One really wonders if von Graff may not have had a mixture of species. Prior to von Graff, figures and descriptions of the worm had been furnished by O. Schmidt (1848) who recorded one ovary, 12 to 18 spines on the end branches of the penis stylet, and a long common yolk duct entering the oviduct between the ovary and the seminal receptacles; and by M. Schultze (1851) who found two ovaries, 11 spines on the end branches, and a separate entry of the two yolk ducts between the ovary and the seminal receptacle. Schultze's figure, greatly improved, however, appears in Bresslau (1928–1930, fig. 83), and this is undoubtedly the best figure of the anatomy of the animal as a whole available in the literature. It shows two ovaries, about 14 or 15 spines on the end branches of the penis stylet, and separate entry of the two yolk ducts between the ovaries and the seminal receptacle. Brinkmann (1906) gave a brief description under the name *helluo* and some figures; he found but one ovary and a constancy of structure contradictory to von Graff's statements. Interesting ecological information was given by Sekera (1912) and Whitehead (1914). In

his 1913 monograph, von Graff repeated previous information without adding anything new, again giving the position of the testes as mid-dorsal. According to von Graff's description, the most authoritive available, there are generally two ovaries but sometimes one; the yolk ducts enter separately but the location varies, being sometimes distal, sometimes proximal to the attachment of the ovaries; there are 13 to 14 spines on the end branches of the penis stylet; the transverse bar usually bears a single spine; and the oval capsules contain four to 12 embryos (whereas Sekera invariably found one). Weise (1941) described variations in the penis stylet which may have bifurcated or simple handles or none and generally has a median spine on the transverse bar and 12 to 15 spines on the end branches. Interesting data were recorded by Middlehoek (1948) who has given the best available figure of the penis stylet. It is with or without a median spine on the transverse bar and with 12 or 13 spines on the end branches. This author records as many as 110 capsules in one worm, certainly a record figure.

Comparing now the Carolina worms with the European ones, one finds that as regards shape and size and general external appearance the two are indistinguishable, but they differ in almost every detail of the reproductive system. The testes of the European worms are oval in cross section, while those of the Carolina worms are much broader and convexo-concave in section, fitting into the curvature of the sides of the animal. The lateral diverticula of the yolk glands appear longer in the Carolina specimens. The anatomy of the rest of the female apparatus is invariable. There is never more than one ovary, and this is very definitely located with respect to the other structures, hanging from the ovovitelline duct on the side away from the copulatory bursa. The seminal receptacle is very much larger in the Carolina than in the European worms. Although the yolk ducts could not be traced into the oviduct, it is probable that they enter separately, and certainly it can be said that they invariably enter somewhere between the ovary and the seminal receptacle. The conspicuous glands attached to the ovovitelline duct as it leaves the seminal receptacle have received scant mention in the literature on the European worm, but figures of von Graff and Brinkmann indicate their existence. The copulatory bursa is much smaller and of a different shape in the Carolina worms. In the European worms the seminal vesicle is unanimously described and figured as a small rounded single vesicle, of less diameter than the prostatic region of the male apparatus, whereas in the Carolina worms the seminal vesicle is the broadest part of this apparatus and somewhat bisected. In the penis stylet the handles are always simple, not bifurcated

as is often the case in the European specimens, there is never any median spine on the transverse bar, and there are more spines on the end branches than in the European specimens. Finally the capsules are never oval but spherical, perhaps with one flattened or concave side.

It has been difficult for me to decide whether the foregoing differences are of specific rank, but in view of the lack of exact information about the European form and its variations, especially with respect to geographic location, and also in view of our ignorance of green forms of *Dalyellia* from other parts of North America, it appears best at present to designate the Carolina form as a subspecies of *Dalyellia viridis*. The subspecific characteristics of *D. v. carolinensis* are given in the preceding paragraph. A whole mount has been deposited in the American Museum of Natural History as holotype, and some of the best sections are also deposited.

This appears the proper place for me to put myself on record as strongly opposed to the division of the genus *Dalyellia* into *Dalyellia* in the restricted sense for the *viridis* group of species and *Microdalyellia* for the others, as proposed by Gieysztor (1934) and accepted by Ruebush (1937). The *viridis* group of *Dalyellia* species originally included *viridis*, *penicilla*, and *scoparia* and to these were added *cetica* and *styriaca* by Reisinger in 1924. In the members of this group symbiotic green cells are present in the mesenchyme adjacent to the epidermis, but this is not a proper generic character, as white individuals are frequent and only one-third of the population of *D. styriaca* is green. The species of the *viridis* group contrast with other *Dalyellia* species in their larger size, but size is not an adequate basis for generic differentiation and small variants of the *viridis* group of species have been noticed. Further increase in size is often concomitant with the presence of symbiotic algae. The absence of a uterus is given as a distinctive character of the *viridis* group, but indications of a uterus are seen in *D. styriaca* (Reisinger, 1924), and a well-developed uterus exists in *D. penicilla* (Gieysztor, 1934). The accumulation of capsules in the mesenchyme then remains as the sole distinctive character of the *viridis* group, for in all other *Dalyellia* species each capsule when completed in the uterus is laid through the gonopore. One may doubt that this character is of more than subgeneric value, as the accumulation of capsules in the mesenchyme to escape only by the death of the parent is probably an adaptation for a brief existence in temporary vernal pools. The fact that the penis stylet of *D. scoparia* is quite different from that of other members of the *viridis* group indicates the artificiality of this group.

GENUS *CASTRELLA* FUHRMANN, 1900

DEFINITION: Dalyelliidae with male apparatus proximally bifurcated into two parts, one of which contains the penis stylet; capsule stalked.

Castrella marginata (Leidy), 1847

Prostoma marginatum LEIDY, 1847b.
Vortex pinguis SILLIMAN, 1884.
Castrella pinguis FUHRMANN, 1900.
Castrella truncata KEPNER AND GILBERT, 1931.
Castrella pinguis HAYES, 1945.
Castrella marginata HYMAN, 1951.

About 15 years ago in the spring a friend brought me material from a pond near Hopewell Junction, New York, 60 miles north of New York City, in which four specimens of this species were found. The date was not recorded. A drawing of the animal from life under the name *Castrella marginata* appears in my book (Hyman, 1951) on page 133. This species is usually called *Castrella pinguis* but I am definitely of the opinion that it is identical with *Prostoma marginatum* Leidy, 1847. The latter is not, as supposed by Ruebush (1937), a species of *Dalyellia*, for Leidy saw the subdivision of the eyes, also the stalked capsule, that he mistook for a penis stylet. Von Graff (1913) correctly guessed that Leidy's worm belongs to *Castrella*. Von Graff, however, misidentified an undescribed species of *Castrella* as *C. pinguis*, and Hayes (1945) has correctly given a new specific name to this form, in the same article in which he described adequately *C. marginata* under the name *C. pinguis*. *Castrella marginata* appears to be common and widely spread in the eastern United States and is readily recognized by the biparted eyes, appearing as four, the brownish black coloration with a clear border, and the yellow capsule with its stalk recurved at the tip.

SUBORDER TYPHLOPLANOIDA

DEFINITION: Lecithophora with mouth more or less removed from the anterior end; pharynx usually of the rosulate type (some exceptions); with common gonopore or separate gonopores.

FAMILY TYPHLOPLANIDAE

DEFINITION: Typhloplanoida with one ovary, common gonopore, and paired highly lobulate or follicular or branching anastomosed yolk glands.

SUBFAMILY PHAENOCORINAE

DEFINITION: Typhloplanidae with mouth not far behind the anterior end and pharynx somewhat of the dolioform type; yolk glands branched and anastomosed, forming a conspicuous network throughout most of the body; gonopore anterior to the middle; protonephridia with separate pores laterally located; male copulatory organ in the form of a cirrus, often armed with minute thorns; with a genito-intestinal connection; antrum with pyriform lobes.

GENUS *PHAENOCORA* EHRENBERG, 1837

DEFINITION: With the characters of the subfamily.

Phaenocora kepneri Gilbert, 1935

Prior to the appearance of Gilbert's description I had recognized this as an undescribed species of *Phaenocora* from material collected in the vicinity of Princeton, New Jersey, by Dr. U. Dahlgren. The species was again seen recently when Dr. Miriam Pennypacker sent material, including sagittal serial sections, of specimens collected April 15, 1954, in a swampy place off Brandywine Creek, New Castle County, Delaware. Gilbert (1935) took *Phaenocora kepneri* in Pennsylvania and Virginia. The species is evidently common and widely spread in the central Atlantic states. Gilbert has given an exhaustive study of the genus *Phaenocora* in the eastern United States. The genus is readily recognized by the anterior mouth placed shortly behind the eyes, somewhat dolioform pharynx, copulatory apparatus immediately behind the pharynx, plump shape broadening posteriorly, then narrowing abruptly to a little tail, and vitelline network. Most species are more or less green from symbiotic algae but Pennypacker reported that the specimens she sent were colorless in life.

SUBFAMILY MESOSTOMINAE

DEFINITION: Typhloplanidae with rosulate pharynx and mouth more or less centrally located; protonephridia opening into the pharyngeal cavity; testes dorsal to the yolk glands, compact or follicular; copulatory apparatus immediately behind pharynx; copulatory organ in the form of a penis; no genito-intestinal connection.

GENUS *MESOSTOMA* EHRENBERG, 1837

DEFINITION: Mesostominae without a midventral pit between pharynx and anterior end.

Mesostoma vernale, new species

Figures 10–14

Five mature and a number of juvenile specimens were sent by Mr. Daggy who had collected them February 25, 1952, in two adjacent pools in a meadow on the flood plain of Rocky River, Cabarrus County, North Carolina. One of these pools is the same as that in which *Dalyellia viridis carolinensis* occurs but, strangely enough, the latter is not found in the other pool, although this appears ecologically identical.

The general appearance of *Mesostoma vernale* is shown in figure 10, drawn from a sketch from life provided by Mr. Daggy. The length in life is given as 3.25 to 3.50 mm. The body is plump, flattened below, convex above, widest just anterior to the middle and gradually tapering to a pointed tail. Anteriorly the body comes more abruptly to a point also. The two eyes are widely separated, with large white areas around them. The color is given as opaque brown to nearly black with large gray or yellowish gray splotches.

All the specimens have been sectioned lengthwise. The fixation is fairly good, but as the histology of *Mesostoma* was thoroughly described by Luther (1904) a detailed account appears superfluous here. The epidermis is taller and provided more densely with longer cilia ventrally than dorsally. In agreement with Luther, I find that it is composed of large polygonal cells, of which the large round nuclei are noticeable here and there. The epidermal cells in section appear closely striated; this appearance is seemingly caused by elongated intracellular vacuoles that divide the cytoplasm into strands oriented at right angles to the surface. The epidermis is everywhere of a dark brown color, being apparently infiltrated with the pigment that colors the animal; and this coloration extends into the tissues immediately beneath the epidermis. The epidermis is bounded from the mesenchyme by a basement membrane appearing as a thin line and to the inner side of this is seen the circular layer of the subepidermal musculature manifested in longitudinal sections as a single row of dots, followed internally by a thin stratum of longitudinal fibers. The animal seems somewhat lacking in muscularity, although the usual dorsoventral fibers are present. The interior is solidly filled with mesenchyme in which the organ systems and a variety of cells are embedded. Whether definite rhamnite tracts are present could not be ascertained. The well-developed brain sends several radiating nerves to the anterior end and a pair of ventral cords posteriorly as depicted by Luther. No attention was paid to the histology of the digestive tract.

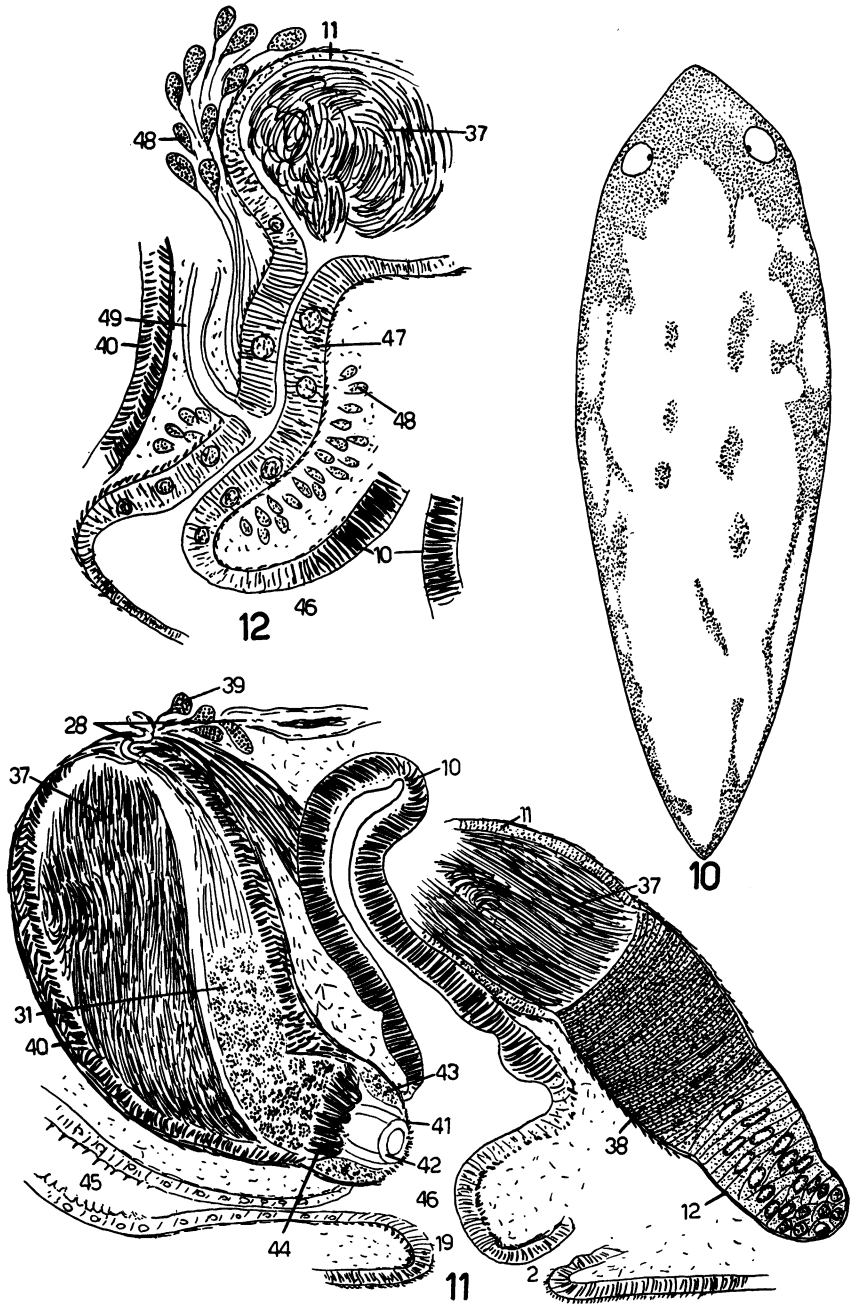

FIG. 10. *Mesostoma vernale*, entire worm from life.
FIG. 11. Same, sagittal section of copulatory apparatus, in part.
FIG. 12. Same, remainder of the copulatory apparatus.

Attention was centered on the reproductive system. The pair of testes is dorsally situated close beneath the epidermis as characteristic of the Mesostominae (fig. 13). Each testis is laterally lobulated into several relatively large lobes (fig. 13). The testes extend from near the posterior end to an anterior level shortly behind the brain. A sperm duct issues from the ventral surface of each testis somewhat behind its middle (fig. 13) and joins its fellow to form a common sperm duct that penetrates the summit of the penis bulb (fig. 11).

As typical of the genus *Mesostoma* there is a complicated aggregation of reproductive structures, which includes everything except the testes and the yolk glands. This complex is located close behind the pharynx. All the structures of the complex open into a common antrum of irregular shape that exits midventrally by the common gonopore. In the present species the common gonopore lies so close behind the mouth (fig. 11) that it may almost be regarded as opening in common with the mouth. The reproductive complex is difficult to understand in sections and difficult to represent in one drawing because of the overlapping of parts. Hence it was thought best to depict it in two drawings (figs. 11 and 12).

The female tract extends anteriorly from the posterior wall of the antrum and lies to the right of and above the pharynx. It is more elongated and hence reaches farther anteriorly than usual in the genus. Its blind proximal end consists of the ovary which begins with small ovocytes and continues with ovocytes of gradually increasing size that finally occupy the entire width of the ovary (fig. 11). The ovary then passes into the oviduct which in *Mesostoma* is differentiated into three portions, the proximal oviduct, the seminal receptacle, and the distal oviduct, often called ductus communis. The proximal oviduct or oviduct proper, extending between the ovary and the seminal receptacle, presents a peculiar appearance in *Mesostoma*, being composed of disk-like cells and seemingly lacking a lumen. It is succeeded by the seminal receptacle, a part of the oviduct with a thin wall and large lumen, typically packed with sperm. The seminal receptacle in the present species is of elongated oval form, about as long as and scarcely any wider than the proximal oviduct (fig. 13). From the distal end of the seminal receptacle, the suddenly narrowed oviduct proceeds directly ventrally to enter the posterior part of the genital antrum (fig. 12). As the distal oviduct or ductus communis would have to be represented in figure 11 as located directly in front of the penis bulb, it has been thought best to place it on a separate drawing (fig. 12). At about the middle of its course the distal oviduct receives into its posterior side

the common yolk duct; distal to this entrance the oviduct should strictly be termed ovovitelline duct. The distal oviduct is liberally supplied with gland cells. One cluster of gland cells is located alongside the distal end of the seminal receptacle and sends its long necks into the distal oviduct just above the entrance of the yolk duct (fig. 12). There are also a number of gland cells around the oviduct below the entrance of the yolk duct. The necks of these mostly sweep around the oviduct to enter its anterior side (fig. 14). The entire oviduct is clothed with a muscular layer of mainly longitudinal fibers that are especially evident on the surface of the seminal receptacle. The distal oviduct is composed of large cells without definite walls and with a striated cytoplasm as shown in figure 12.

The form of the yolk glands could not be determined exactly from the available material but is evidently of the follicular type. Small groups of yolk cells could be seen here and there ventral to the testes (fig. 13). Presumably these groups connect by ducts to a pair of yolk ducts that unite to a common channel.

The copulatory bursa or bursa copulatrix is situated directly in front of the penis (fig. 11) and is of characteristic shape in the present species. It is cylindroid, with a heavy wall of circular muscles and without definite cellular lining. Its blind proximal end curves slightly in the anterior direction and lacks altogether the usual sacciform expansion found in most species of *Mesostoma*. At its distal end it widens in a funnel-like manner and enters the roof of the central part of the common antrum.

The conspicuous penis bulb forms the most posterior part of the reproductive complex. It is an erect oval structure with a thick muscular wall of outer longitudinal, middle diagonal or perhaps spiral, and inner circular fibers. This is the usual construction of the wall of the penis bulb according to Luther (1904) who also states that the bulb is lined by a plasmatic layer without cellular construction, not detectable in the present material. The interior of the bulb is obliquely divided into a spermatic part or seminal vesicle and a prostatic part or prostatic vesicle. The common sperm duct enters the summit of the penis bulb, zigzagging through the muscle layers, and discharges sperm that fill the spermatic part of the bulb. The prostatic part is widest distally where it is filled with groups of eosinophilous granules. Towards the summit of the bulb it narrows and declines in staining properties, becoming a bundle of converging ducts that enter the penis bulb alongside the common sperm duct at the summit of the bulb. These ducts are undoubtedly the necks of the prostatic glands, but no very definite

cluster of prostatic gland cells could be located. The bundle of necks appeared to descend the side of the penis bulb along the side adjacent to the bursa, but conditions here are obscured by a strong muscle bundle connecting the summit of the penis bulb with the posterior side of the copulatory bursa as shown in figure 11.

At its distal end the penis bulb narrows to a rounded penis papilla that projects into the common antrum. The wall of the penis papilla is thin compared to that of the penis bulb, although containing muscle fibers continuous with those of the bulb. The wall is lined with a thick plasmatic layer. Centrally the penis papilla contains a tube with heavily cuticularized wall that presumably constitutes an ejaculatory duct. At its inner end this tube is surrounded by a circle of heavily eosinophilous structures. It was not clear to me whether these are muscle masses or terminal conduits of discharge for the eosinophilous prostatic secretion. The latter appears the more probable interpretation.

From the common antrum a uterus proceeds posteriorly to each side of the penis papilla. Near the antrum the uterus is tubular but posteriorly widens into a sac. The uteri are lined with a cuboidal epithelium underlain by a slight musculature. The egg capsules at first are contained inside the uteri where they ripen; later they escape into the general mesenchyme.

Mesostoma vernale is distinguished from other species of the genus primarily by the cylindroid copulatory bursa without proximal sacciform expansion and the mammiform penis papilla containing an inner tube. Other features, as the diagonal division of the penis bulb into seminal and prostatic portions and the entrance of the common sperm duct and the bundle of prostatic ducts together at or near the summit of the penis bulb, occur in other species but are diagnostic here in combination with the distinctive characters just mentioned.

A set of sections constitutes the holotype and has been deposited in the American Museum of Natural History.

Mesostoma curvipenis, new species

Figures 15–19

Dr. Miriam Pennypacker kindly furnished two sets of serial sagittal sections of this species and a third specimen that I sectioned but that proved in bad histological condition. The specimens were collected by Dr. R. G. Schmieder in a temporary pool in a swampy place off Brandywine Creek in New Castle County, Delaware, about April 15, 1954. Although the material is only in fair histological condition, it suffi-

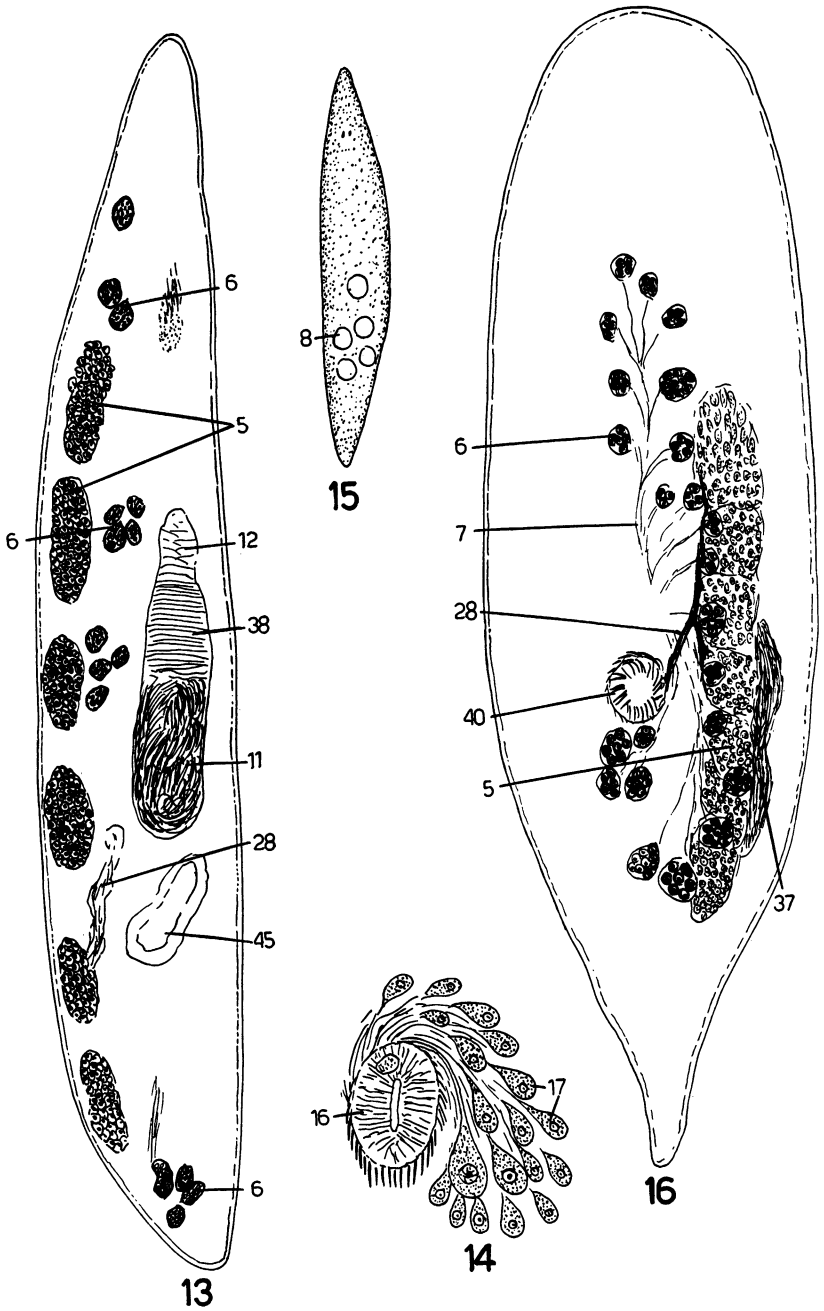

FIG. 13. *Mesostoma vernale*, longitudinal section through lateral part of body.
FIG. 14. Same, cross section of ovovitelline duct with glands.
FIG. 15. *Mesostoma curvipenis*, from life.
FIG. 16. Same, longitudinal section through the lateral part of the body.

ciently shows that a new species is at hand. Another *Mesostoma* species from the same pool could not be elucidated for lack of adequate material. What was probably *Mesostoma ehrenbergi* was also present.

According to a sketch from life sent by Dr. Pennypacker, reproduced as figure 15, the animal is of slender fusiform shape, pointed at both ends. The length was given as 3–4 mm., and the color as grayish brown. Brown egg capsules were generally present within the body.

The condition of the sections does not permit a detailed histological description, and the account is therefore confined mainly to the reproductive system. Mention must be made, however, of a large and conspicuous mass of rhammite-forming cells situated dorsal to the brain and in front of the pharynx (fig. 17) and sending a broad tract to the anterior end. Rhammite tracts are usually paired, but here the two tracts are seemingly fused to a single one.

The testes are a pair of elongated oval bodies, probably somewhat fused, situated shortly beneath the dorsal body wall. Their length is about half that of the body, but they are more extended posteriorly than anteriorly. A sperm duct originates from the ventral surface of each, somewhat anterior to the middle, and runs towards the penis bulb (fig. 16). A mass of sperm seen dorsal to the testis could not be related anatomically to the sperm duct. On the same sections taken vertically through the body sides, the yolk glands are seen as follicles of darkly staining cells connnected by tenuous ducts that proceed from the anterior and posterior follicles to the copulatory apparatus (fig. 16).

The copulatory apparatus forms the usual crowded complex immediately behind the pharynx and because of overlap of parts is shown in two figures (18 and 19). The female apparatus is similar throughout the genus, consisting of a short tract free at the ovarial end and attached to the common antrum at the distal end (fig. 18). The free end is formed of the single ovary, composed of ovocytes that are small at the free proximal end and gradually increase in size distally. The ovary is followed by the proximal oviduct peculiar to the genus, being formed of a succession of disciform cells. This is succeeded by the seminal receptacle, a chamber that is here somewhat broader than the proximal oviduct and of oval, elongated form. As usual it is packed with a dense mass of sperm. The wall is thick and muscular, composed of circular strands separated by spaces, covered externally by longitudinal muscle strands that also clothe the proximal oviduct. At its distal end the seminal receptacle narrows abruptly into the distal oviduct, also called the ductus communis, that curves sharply ventrally and somewhat anteriorly and enters the posterior wall of the common

antrum. About halfway along its course this duct receives into its anterior wall the common yolk duct and at this point is surrounded by gland cells.

The remainder of the copulatory apparatus, shown in figure 19, lies at the same level as the female tract, so that figure 18 should be superimposed on figure 19 to represent the whole apparatus as it exists in the worm. This remainder is constituted of the penis and the copulatory bursa. The penis consists of the conspicuous oval penis bulb bearing at its distal end the penis papilla, projecting into the common antrum. The penis bulb has a heavy muscular wall of the usual outer longitudinal, middle diagonal, and inner circular muscles, although these are not so distinct as in the preceding species. The interior consists almost wholly of seminal vesicle, filled with a mass of sperm. The prostatic portion was poorly indicated in the available sections but seemed to constitute a small area extending along the anterior wall of the bulb from about its middle to the penis papilla. The points of entrance of the common sperm duct and of the bundle of prostatic glands were not very clear. In the specimen figured in figure 19, the sperm duct enters near the middle of the anterior wall of the penis bulb, and the cluster of prostatic gland cells also enters here, but in the other specimen the entry point appeared nearer the summit of the bulb. The cluster of prostatic glands could be only partially represented in figure 19, as most of them are concealed here by the stalk of the copulatory bursa. At its distal end the penis bulb narrows to the penis papilla, a distinctive feature of this species. The papilla is of beak-like shape and curved against the wall of the bulb. It is but slightly muscular, being lined by a thick plasmatic layer of granular cytoplasm and contains as usual a cuticularized tube that forms the sperm conduit. The sections failed to show the exact opening but, as indicated in figure 19, the conduit probably opens at the side, not at the tip, of the beak. Immediately anterior to the penis bulb is found the stalk of the copulatory bursa which extends dorsally from the common antrum and enters the sacciform expansion that constitutes the copulatory bursa. This is of somewhat squarish shape, with a moderately thick wall containing circular muscle fibers. A peculiarity of the present species is the asymmetrical entrance of the stalk into the bursa. Instead of opening directly into the sac, the stalk curves around the sac and enters its posterior side. The stalk is only moderately muscular, containing the usual circular fibers.

There is a pair of uteri that extend as elongated sacs posteriorly from the posterior wall of the antrum, one to either side of the penis

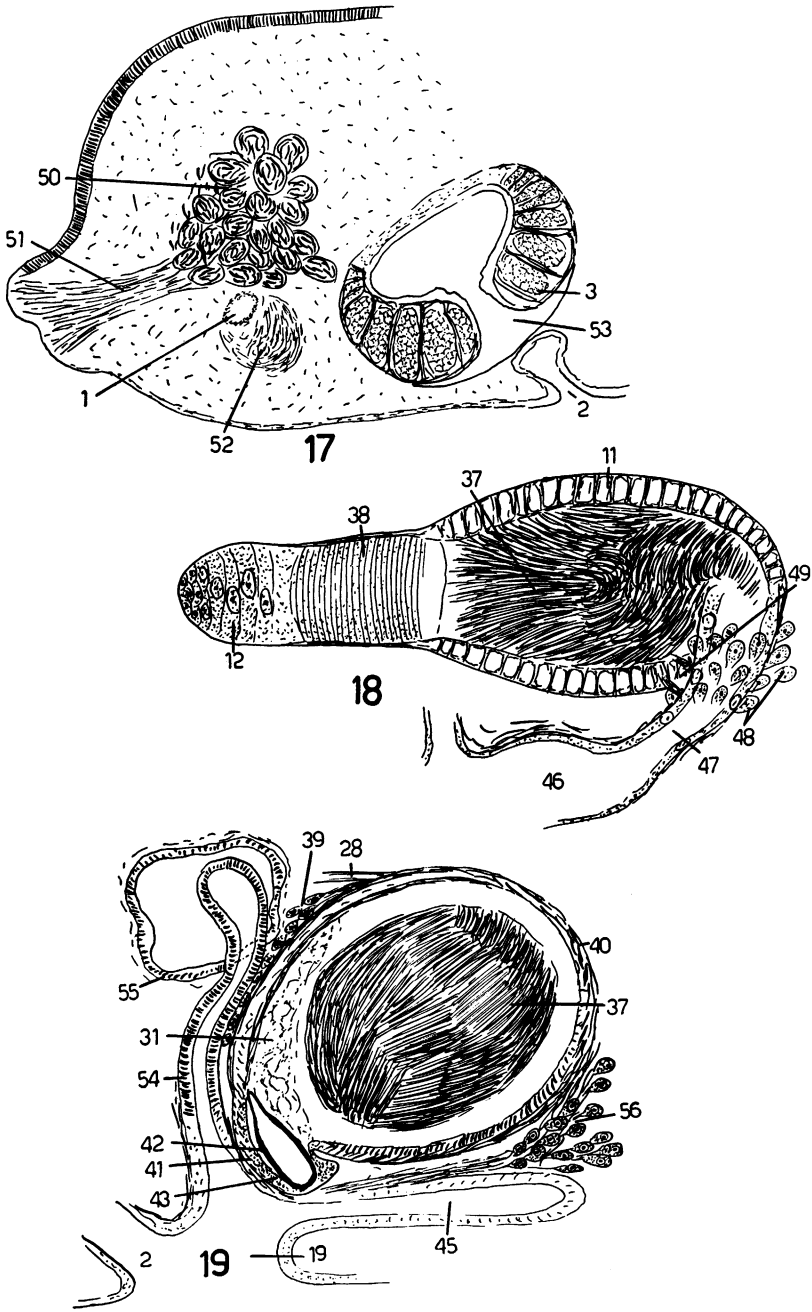

FIG. 17. *Mesostoma curvipenis*, sagittal section of anterior end to show cluster of rhammite-forming cells.

FIG. 18. Same, female tract.

FIG. 19. Same, penis bulb and copulatory bursa in sagittal section.

papilla. Between the entry points of the two uteri a large bundle of gland cells sends its necks into the antrum (fig. 19). Such antral glands do not seem to have been noticed in other species of *Mesostoma.*

Mesostoma curvipenis differs from other species of *Mesostoma* in the curved, beak-like shape of the penis papilla, the small extent and lateral position of the prostatic part of the penis bulb, and the asymmetrical relation of the bursal stalk to the bursal sac. A somewhat similar penis papilla is seen in *Mesostoma macropenis* Hyman, 1939, but the other details of the sexual complex of the latter differ altogether from those of the present species.

One set of sections (one slide) constitutes the holotype, deposited in the American Museum of Natural History.

A useful synopsis of the genus *Mesostoma* has been given by Ferguson and Hayes (1941) but is marred by an obsolete, cumbersome method of indicating synonymy copied from von Graff, and by a stylized mode of figure presentation. I rather object to the stylization of my figures by these authors. I should think that, in general, alteration of taxonomic illustrations is not permissible. The genus *Mesostoma* is sufficiently difficult without adding to the difficulties by schematization of the figures. According to the Ferguson and Hayes synopsis only one European species of *Mesostoma* has been found in North America, the cosmopolitan *M. ehrenbergi* or a geographic variant thereof. Several endemic species have been described, namely: *M. virginianum* Kepner, Ferguson, and Stirewalt, 1938, from high mountain swamps in Virginia; *M. arctica* Hyman, 1938 (probably should be *arcticum* as *Mesostoma* is a neutral word), from pools on the tundra at Churchill, Manitoba, and alpine bogs in the Medicine Bow Mountains, Wyoming; *M. macropenis* Hyman, 1939, from Douglas Lake, Michigan; *M. macroprostatum* Hyman, 1939, from a temporary pond in the Medicine Bow Mountains, Wyoming; and *M. columbianum* Hyman, 1939, from a pond in the District of Columbia. Dr. Julian Darlington, examining my slides of *M. macroprostatum*, kindly pointed out to me the presence of a midventral pit about halfway between the pharynx and the anterior end, a feature I had overlooked in my original description. The presence of this pit necessitates the removal of this species from *Mesostoma*, either to *Bothromesostoma* or to a new genus, but better material is desirable before a decision can be made. With the addition of the two present species there are thus six endemic species of the genus known for North America. As indicated above, still another, probably undescribed, species occurs in the same pool with *M. curvipenis*, and Dr. Darlington has discovered an undescribed species in temporary pools

in Georgia. The genus is thus well represented in North America, but, surprisingly, no endemic species has been reported for South America.

ORDER ALLOEOCOELA

DEFINITION: Small Turbellaria with plicate or altered dolioform (variable) pharynx; intestine sacciform, with simple or more or less diverticulated contour, interrupted by the pharynx in only one genus (*Bothrioplana*); often with ciliated pits or a ciliated groove or a statocyst; testes generally follicular; with germovitellaria or separate ovaries and yolk glands; nervous system with three or four pairs of longitudinal nerves connected by transverse commissures.

SUBORDER SERIATA

DEFINITION: Alloeocoela with plicate pharynx directed downward or backward; with one pair of compact overies separated from the pair of follicular yolk glands; with common gonopore or separate female pore behind the male pore; sometimes with an accessory sexual pore.

FAMILY OTOMESOSTOMIDAE

DEFINITION: Seriata with central pharynx directed downward and sacciform intestine of simple contour continuous above the pharynx; with conspicuous statocyst and two pairs of ciliated pits; with one pair of follicular testes, one pair of compact ovaries located shortly behind the pharynx, and separate male and female gonopores; bursa wanting.

GENUS *OTOMESOSTOMA* GRAFF, 1882

DEFINITION: With the characters of the family.

Otomesostoma auditivum (Forel and Du Plessis), 1873

Figure 20

Mesostomum auditivum FOREL AND DU PLESSIS, 1874.
Mesostomum morgiense DU PLESSIS, 1876.
Otomesostoma morgiense GRAFF, 1882.
Monotus relictus ZACHARIAS, 1884.
Otomesostoma auditivum HOFSTEN, 1907.

A number of specimens of this species, including transverse sections, were sent for identification by Mr. W. C. Freihofer, a graduate student of the zoology department of the University of California, who had collected them on the bottom at depths of 41 to 128 feet in Echo Lake, a high alpine lake at 7500 feet elevation in the Sierra Nevada Mountains near Lake Tahoe, California. Collections were made in August and September, 1949, and again in February, March, and April, 1951.

Identification was based on the study of sections. A single brown egg capsule was present in the rear part of the body in specimens collected from February to April, and hence capsule deposition is probably seasonal. Some degeneration of the reproductive system was apparent in specimens from fall collecting.

There is frequent mention of this species in European literature, for it is widely spread in Europe, living typically in alpine lakes and pools at depths varying from a meter or two to 125 meters. It was previously recorded from the United States by Carter (1928) who found it from April to July in streams and pools near the University of Virginia. Carter does not state the grounds on which she made her identification, and the identification must be regarded as doubtful for the habitat given is not typical for the species.

Despite frequent accounts of this species in European literature there does not appear available a naturalistic figure of the worm as a whole. I therefore present figure 20, drawn from a cleared, unstained whole mount. The worm has an oval contour and plump shape, being very rounded dorsally. The anterior end is bluntly rounded and the posterior end forms a little tail, often lost in contraction of preserved specimens. European specimens are stated by von Graff (1913) to be 5 mm. or more in length, but the Lake Echo worms could hardly exceed 2 mm. when alive, extended. The color was reported as light bluish gray, whereas European specimens are described as light to medium brown, being paler the greater the depth at which they live. In the whole mount may be seen the conspicuous statocyst usually accompanied by two pigment masses which in sections do not present the structure of eyes but may represent degenerated eyes. In the center of the body is seen the pharynx, appearing as an oval when viewed from above, actually a tube directed ventrally. The intestine is more or less evident as an oval sac extending nearly the body length. The most conspicuous structures in the whole mount are the yolk glands, consisting of numerous, darkly pigmented follicles that form a broad band on each side. The remainder of the reproductive system must be studied in sections. Such study has shown no difference from European specimens, of which Hofsten (1907) has given a very extensive account, including all histological details. Near the posterior end in figure 20 is seen an egg capsule, distorted and cracked by preservation. There is some doubt as to the shape of the egg capsule in European literature, but here the form seems definitely spherical.

A whole mount has been deposited in the American Museum of Natural History.

ORDER TRICLADIDA

DEFINITION: Turbellaria of considerable size with tubular plicate pharynx directed backward and highly diverticulated three-branched intestine, having one median anterior branch and two posterior

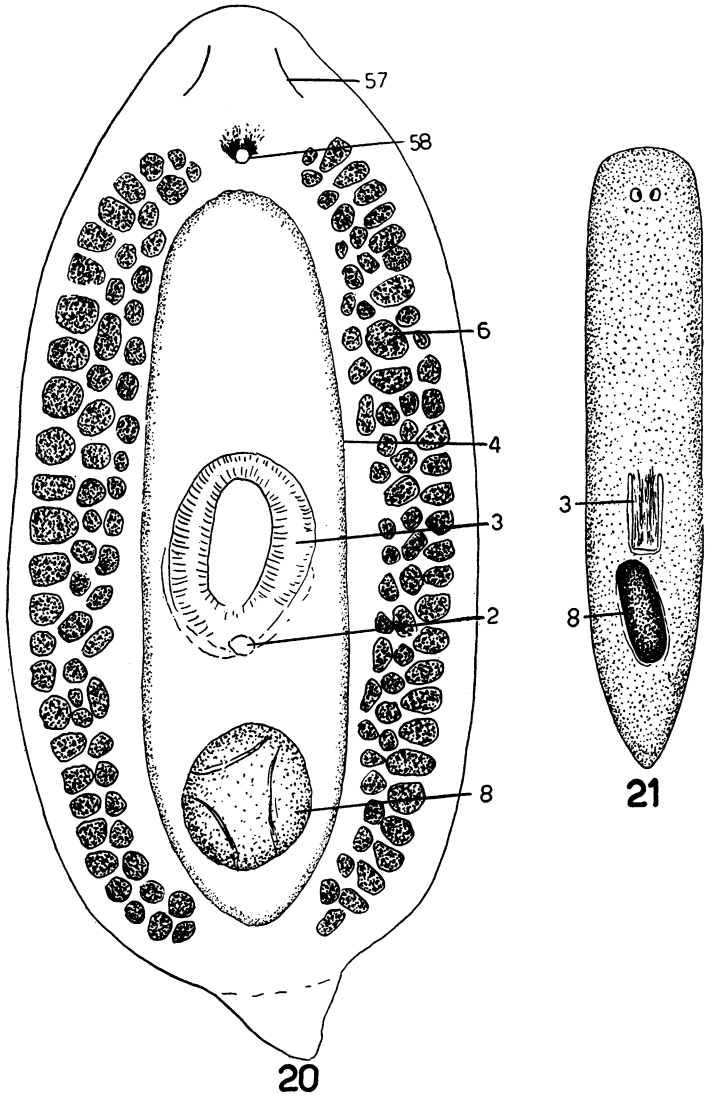

FIG. 20. *Otomesostoma auditivum*, dorsal view of cleared whole mount.
FIG. 21. *Hymanella retenuova* carrying an oval capsule.

branches; with one pair of ovaries, usually anteriorly located, numerous yolk glands opening into the oviducts, and few to many follicular testes; copulatory complex behind the pharynx; common gonopore, rarely one or two accessory bursal pores.

SUBORDER PALUDICOLA

DEFINITION: Fresh-water Tricladida; copulatory complex with a bursal sac (copulatory bursa), rarely absent, located between the male apparatus and the pharynx, and opening into the female part of the common antrum by a long canal.

FAMILY PLANARIIDAE

DEFINITION: Paludicola without an adhesive organ on the anterior margin; circular and longitudinal muscle strata of the inner muscular zone of the pharynx distinct.

GENUS *PHAGOCATA* LEIDY, 1847

Fonticola KOMARÉK, 1926.
Albiplanaria KOMARÉK, 1926.

DEFINITION: Planariidae with truncate head without well-developed auricles; penis with bulb and well-developed papilla; common ovovitelline duct enters the roof of the male antrum; capsules spherical, not stalked.

Phagocata velata (Stringer), 1909

Planaria velata STRINGER, 1909.
Fonticola velata CASTLE AND HYMAN, 1934.
Phagocata velata HYMAN, 1937.

This species, interesting from its habit of fragmenting into small pieces, each of which encloses itself in a mucous cyst wherein it reorganizes into a tiny worm, was hitherto supposed to occur only in the Mississippi Valley. However, I had several times collected worms in the vicinity of New York City that certainly appeared to be *P. velata*. Lack of sex organs made it impossible to identify these with certainty, and doubt remained because they could conceivably be young specimens of *P. gracilis* that had not yet become polypharyngeal. I am not able to find in the literature any information as to the size at which *P. gracilis* begins to develop accessory pharynges or whether in fact it is hatched with only one pharynx. Recently, however, I obtained young *P. gracilis* of the same size as the suspected specimens of *P. velata* and found that at that size they are already provided with sev-

eral pharynges. Further, Mr. Victor Jelin brought me planarians appearing to be *P. velata* which he had collected April 11, 1954, under stones in a stream running into Winona Lake near Newburgh, New York, 60 miles up the Hudson River from New York City. These specimens fragmented in typical fashion, and the fragments encysted, hatching some weeks later. Hence it may no longer be doubted that *P. velata* is found in the vicinity of New York City. To be sure, *P. velata* cannot be distinguished externally from *P. vernalis* Kenk, 1944, and no sexual specimens were available to check the identification. However, according to Kenk, *P. vernalis* inhabits temporary pools and ditches, whereas *P. velata* is more apt to occur in streams under stones. It is therefore probable that the New York specimens are *P. velata.*

Komarék (1953) refuses to accept the synonymy of his genus *Fonticola* with *Phagocata*, but he fails to produce any definition by which the two genera can be distinguished. As, in my opinion, it is impossible to produce any such definition, I must continue to regard *Fonticola* as a synonym of *Phagocata.*

GENUS *HYMANELLA* CASTLE, 1941

DEFINITION: Planariidae with head truncate or of very low triangular form with scarcely evident auricles; eyes two; penis reduced to a small papilla without bulb; common ovovitelline duct enters roof of male antrum or sometimes the anterior surface of the distal end of the bursal canal; capsule oval, not stalked.

Hymanella retenuova Castle, 1941

Figures 21, 22

Planaria simplicissima CHIDESTER, 1908 (misidentification).

This planarian was hitherto known only from vernal pools and a spring-fed swampy stream in Massachusetts, but specimens have been received from North Carolina and Delaware. The North Carolina specimens were sent by Mr. Daggy who collected them in the same two vernal pools that yielded *Mesostoma vernale.* The Delaware specimens came from Dr. Miriam Pennypacker and were taken in the same pool that harbored *Mesostoma curvipenis.* Thus *Hymanella retenuova* is probably widespread in vernal waters in the central Atlantic states.

Information derived from these specimens differs in minor points from the original description. Castle figures the head as of low triangular form, whereas a sketch from life, reproduced in figure 21, and data provided by Daggy indicate that the head is truncate as in *Phagocata.* Castle reported that the common ovovitelline duct enters either the

anterior face of the distal end of the bursal stalk or the roof of the common antrum and that a typical copulatory sac (bursa copulatrix) is wanting. I have sectioned sagittally three of the Carolina specimens and find the sexual anatomy more typical than Castle's statements. Possibly these differences are geographical, but more likely Castle's specimens were strongly contracted so that the bursal sac appears squashed into the shape of a vertical tube and the opening of the common ovovitelline duct has been displaced posteriorly. In view of the differences in my material from the original description I have thought it desirable to present a figure of a sagittal view of the copulatory apparatus of a Carolina specimen (fig. 22).

The sperm ducts, ascending from below, enter the penis which as correctly stated by Castle totally lacks the usual bulb and is reduced to a papilla projecting into the anterior end of the male antrum. The penis papilla seems to consist mostly of epithelial cells with muscle fibers outlining the lumen. The male antrum is an elongated chamber that gradually narrows to the gonopore. It is lined by crowded epithelial cells with rounded free ends containing the nucleus that bulge into the lumen. Outside the epithelial cells are layers of longitudinal and

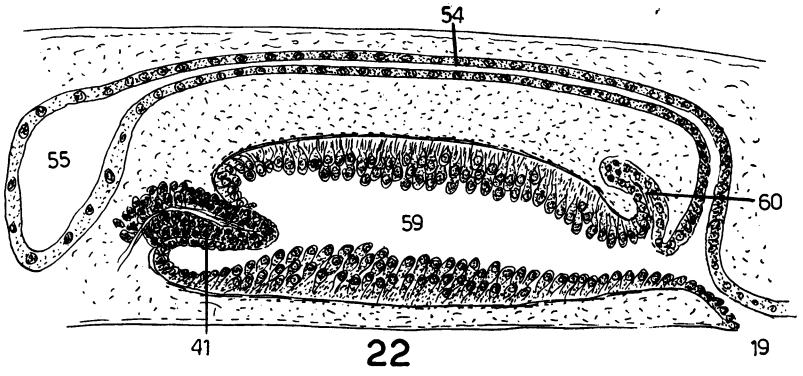

FIG. 22. Sagittal section of the copulatory apparatus of *Hymanella retenuova*, North Carolina specimen.

diagonal muscle fibers. Just before it joins the distal end of the bursal canal the male antrum receives into its dorsal wall the terminal part of the ovovitelline duct. This duct very definitely enters the roof of the male antrum, not any part of the female canal. A typical copulatory sac is present situated between the penis papilla and the posterior end of the pharynx. From it the usual slender bursal canal or duct proceeds

backward above the male antrum; it then turns abruptly ventrally and, widening slightly, joins the male antrum to form the small common antrum that slants posteriorly to the gonopore.

FAMILY DENDROCOELIDAE

DEFINITION: Paludicola in which the longitudinal and circular muscle fibers of the inner zone of the pharynx are intermingled, not relegated to distinct strata; with or without an adhesive organ in the center of the anterior margin.

GENUS *PROCOTYLA* LEIDY, 1857

DEFINITION: Dendrocoelidae with massive cylindroid penis bulb composed of muscular and glandular layers; ejaculatory duct ventrally located in the wall of the penis bulb; penis papilla small, weak; without adenodactyl.

Procotyla fluviatilis Leidy, 1857

This species, grossly misidentified as the European species *Dendrocoelum lacteum* in much of the literature on fresh-water planarians in the United States, is common in the eastern United States as far south as North Carolina. It appears wanting in the Gulf states. It commonly lives in lakes, ponds, rivers, and springs, and hence it was a little surprising to find it present in the temporary vernal pools in North Carolina and Delaware already repeatedly mentioned. In my study of this species (Hyman, 1928) I indicated that capsule deposition in the Chicago area was limited to the months of September through December. It seems more likely that sexual reproduction continues through winter into spring. Anderson (1951) observed sexual reproduction in February in specimens collected at Providence, Rhode Island, DeWitt's specimens collected in March and April near the University of Michigan laid a number of capsules in the laboratory (DeWitt, 1953), and Jelin informed me that a worm collected around New York City laid a capsule in May.

Morgan, in her "Field book of ponds and streams" (1930), made two statements about *Procotyla fluviatilis* (erroneously called therein *Dendrocoelum lacteum*) that have continued to puzzle students of fresh-water planarians. She said that the capsule is stalked and that the worm could be fed on hard-boiled egg yolk. The question of the capsule stalk has been settled by Anderson (1951) and DeWitt (1953). They showed that there is no typical stalk such as exists in the capsules of *Dugesia* but only a mucous strand. According to my observations

Procotyla fluviatilis will eat only live food. Dr. P. B. Sivickis, while a graduate student at the University of Chicago, made a prolonged effort to find some practical food for this species but in vain. It will not eat liver, blood clot, or egg yolk (raw). Although DeWitt succeeded in feeding a newly hatched *P. fluviatilis* on a piece of a naid worm Anderson failed to get young worms to feed on liver or small crustaceans. He reported that the adults could be maintained on live isopods and would if sufficiently hungry eat fresh fat body of meal worms.

Procotyla typhlops Kenk, 1935

This rare species was hitherto known only from a spring in Virginia (Kenk, 1935) and from a crayfish burrow in Florida (Hyman, 1945). Another Florida specimen has been received for identification from the United States National Museum. This was taken in a well near Plant City, Hillsboro County, Florida, by J. O. Armor, December 14, 1942. Eyes are wanting, as also in the Virginia specimens, whereas the other Florida specimen was provided with a pair of eyes.

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