FRESH-WATER BIOLOGY

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CHAPTER XII

THE FREE-LIVING FLATWORMS (TURBELLARIA)

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The Turbellaria or free-living flatworms are among the most interesting of the simply organized animals because of the remarkable variety shown in their reactions and behavior. They are to be found both in fresh and salt water and sometimes in moist places on land. The fresh-water forms are common in ponds and streams almost everywhere. Many of the smaller forms resemble infusoria in their minute size, shape, and movements. The larger Turbellaria are more readily recognized as worms but are often confused with leeches which they resemble superficially in color and form, although they are easily distinguished by their head-like anterior end, non-segmented body, and lack of posterior adhesive sucker.

Probably the first attempt to describe one of this group dates back to 1744 when Trembley included in his memoir on Hydra what was undoubtedly a planarian. As early as 1776 O. F. Müller separated the Turbellaria and Nemertinea from the parasitic Trematoda, but it was not until 1831 that Ehrenberg gave to these animals the name Turbellaria because of the tiny currents in the water created by the delicate cilia which cover the body. Much confusion existed in their classification until the appearance of Lang's work on structure and relationships in 1881 and in the next year of L. von Graff's monograph on the Rhabdocoelida. Since then considerable attention has been given to the morphological and physiological as well as to the systematic study of the group.

Flatworms may be either cylindrical, thread-like, spindle-shaped, or more or less flattened and leaf-like. They range in length from a fraction of a millimeter to several centimeters. The

larger fresh-water forms are usually inconspicuously colored, gray, brown, or blackish or are entirely free from pigment. The smaller forms are often brilliantly colored, yellow, orange, red, or rose; and a few appear green due to the zoochlorellae or symbiotic one-celled plants which live within the mesenchyma. The color is more or less affected by the food contained in the intestine. This is especially true of the non-pigmented or very transparent forms and in many cases examination with a lens will be necessary to show whether pigment is actually present or not.

The anterior end is often modified so as to suggest the form of a head, either by the presence of the various special sense organs, a pair of lobes or cephalic appendages, or by a groove or constriction separating it from the rest of the body. Eyes may or may not be present. If present, the usual number is two, though some forms have four and one genus of planarians, *Polycelis*, is characterized by the possession of a large number of eyes. Accessory eyes or pigment spots are common among certain species. The normal eyes are usually bean-shaped and are black in color although there are many exceptions. Accessory eyes are usually more or less irregular in shape as well as in position.

A pair of sensory pits occurs in the anterior region in many forms. These may be round, oblong, or slit-shaped, and very shallow or deeply sunken. They are connected with special brain ganglia, are usually provided with long cilia, and are regarded as olfactory organs. A few forms possess a statocyst (otocyst) or balancing organ. It consists of a membranous sac filled with a fluid in which a strongly light-refracting statolith (otolith) is suspended. The non-pigmented, light-refracting organs found in *Stenostomum* posterior to the brain and connected with it by nerves are of three types. They may consist (1) of a variable number of spherical bodies arranged in the form of a convex organ, the so-called saucer-shaped or patelliform organ, (2) of a vesicle which contains a strongly light-refracting lens-shaped body on its wall, or (3) of a hollow capsule-like vesicle.

The epidermis consists of a single layer of ciliated cells. The cilia are conspicuous in the rhabdocoels, which are enabled

thereby to move freely through the water, and to the unaided eye look much like infusoria. Planarians have a uniform gliding movement but do not swim about unsupported. In addition to the cilia, remarkably long sensory hairs are present in a few forms. The Turbellaria are richly supplied with various kinds of glands. Slime glands occur all over the body and are especially numerous near the anterior and posterior ends. Other glands form the rod-shaped bodies or rhabdites which are either homogeneous and uniformly light-refracting (rhabdoids), or consist of a hyaline outer layer enclosing a fine granular substance (rhammites). The former are extremely variable in shape (spindle-, egg-, rod-, or club-shaped) and originate either in dermal gland cells or in single-celled glands within the mesenchyma, especially in the anterior end where the tracts through which they pass to the surface may appear as conspicuous lines. The rhammites are found only in the mesenchyma. Still other glands produce the pseudo-rhabdites which are irregular in shape, granulated in structure, and have a low light-refracting power. A few forms have nematocysts, or stinging cells, similar to those of the coelenterates, in place of rhabdites. Adhesive cells and adhesive papillae are present in many forms, especially at the posterior end of the body. The external openings, mouth, genital pore, and excretory pores, are extremely variable in position.

In place of the usual body cavity of higher animals, the space between the body and internal organs is filled with a peculiar connective tissue called mesenchyma (parenchyma). In the smaller forms this tissue consists of a few scattered suspensory strands and the space between is filled with fluid. In others there is a network which encloses spaces filled with fluid and richly supplied with cells. The cells may be vacuolated or otherwise modified. The musculature includes bands of circular, longitudinal, and diagonal muscles in the body wall. There are also muscles which extend through the mesenchyma or connect with the internal organs. The digestive apparatus includes the mouth, pharynx, and intestine, all of which play an important part in classification and furnish a ready means of distinguishing the two great groups of fresh-water Turbellaria.

In rhabdocoels (Fig. 589) which include smaller forms, the mouth may be placed at the anterior end or at various points on the ventral surface. The pharynx is represented by three general types, simple, bulbous, and plicate. In the bulbous type a muscular membrane divides the pharynx from the surrounding mesenchyma; the plicate form does not have the dividing membrane, but consists of a cylindrical tube lying within a pharyngeal cavity which opens to the exterior through the mouth. The simple and plicate types of pharynx lie more or less lengthwise and the organ appears as a tube parallel with the surface of the body. The bulbous pharynx is more variable and includes three types, the rosette-shaped, the cask-shaped (dolioliform), and the variable. The intestine has the form of a simple sac; it consists of a blind cylindrical tube, median in position. It is sometimes provided with short lateral diverticula. The walls are thin.

In triclads (Fig. 590) the mouth is on the ventral surface usually just posterior to the middle of the body. The pharyngeal region ordinarily shows externally about the middle of the body, either as a more heavily pigmented or as a lighter colored area. The pharynx is a cylindrical, very muscular tube which lies within the pharyngeal cavity except when protruded while feeding. In a single genus, *Phagocata*, there are many pharyngeal tubes instead of one. The intestine is thin-walled as in the rhabdocoels but has three main branches, a single one extending forward, and two passing back, one on either side of the pharynx to the posterior end of the body. Numerous lateral diverticula are found especially in the anterior region. These may anastomose with each other or remain distinct.

The protonephridial system (water-vascular system or simple kidney) possesses one, two, or four principal canals, with a general antero-posterior direction. The number and position of the openings is variable. The nervous system includes two principal brain ganglia and two main longitudinal nerves with numerous lateral branches. In many forms the longitudinal nerves may be seen as two light lines on the ventral surface.

Reproduction is both sexual and asexual. The Turbellaria are hermaphroditic with the female organs distinct from the male.

Both sets of organs have a common genital pore or are provided with separate external openings. In many cases the male organs mature earlier than the female and degenerate as the latter develop so that a study of various stages of growth is necessary to give complete knowledge of the organs. The rhabdocoels show great diversity in structure ranging from those with simple ovaries and testes to those with an elaborate system of accessory glands and ducts that much resemble those of the triclads. The male copulatory apparatus or cirrus is often remarkably complex and may, as in *Dallyellia*, present the chief characters for identification of species.

Some rhabdocoels produce two kinds of eggs, the thin-walled transparent summer eggs which may undergo development within the body of the parent, and the thick-walled winter eggs which have a hard, brown shell and develop in the outer world. In other species only the hard-shelled eggs are produced. In the Catenulidae asexual reproduction by the formation of buds or zooids at the posterior end of the body is met with commonly. More than one bud may be produced before separation takes place.

Planarians (Fig. 590) show less variation in the structure of the sexual organs. The testes, usually numerous, lie both above and below the digestive tract and extend from anterior to posterior end. The seminal vesicle opens into the muscular bulb-like cirrus, the apex of which projects into the male genital atrium, which in turn leads into the common atrium. Two ovaries are placed far forward. The numerous yolk glands open into the oviducts as they pass back and either unite to form a common duct which enters the genital atrium or open separately into the posterior part of the uterine duct. Fertilization apparently occurs in the uterus which lies just back of the pharynx.

Some triclads manifest only sexual reproduction; others have regular alternating periods of sexual and asexual reproduction; while a number do not have a definite life cycle since sexual maturity occurs at irregular intervals and often only among a limited number of individuals. In these forms reproduction is ordinarily asexual. *Dendrocoelum lacteum* attains sexual maturity and deposits its cocoons during the winter months. In *Planaria maculata*

and *Planaria agilis* sexual organs begin to develop early in the autumn and mature in the spring. After the cocoons are deposited the reproductive organs degenerate and reproduction is again carried on by transverse division into two pieces with subsequent regeneration of the missing parts in each piece. The division plane in most planarians passes just back of the pharynx. In *Planaria velata* there is a division into pieces of various sizes which encyst in a slime layer in response to unfavorable conditions. This slime layer hardens into a shell-like covering. Entire animals may also encyst. Asexual reproduction among planarians may occur at any time of the year and in many species is the usual method of propagation. The factors which control the development of sexual maturity are not fully understood although the food supply unquestionably plays an important part.

Turbellaria undergo no metamorphosis during development but emerge from the egg, resembling the parent except in the lack of sexual organs. In viviparous forms the young develop within the mesenchyma of the parent and make their way to the exterior through the body wall in the posterior region.

Flatworms are extremely responsive to external influences and the larger forms especially give interesting and specific reactions to various kinds of stimuli. If a dish in which they are quietly gliding about is jarred even very slightly, it will cause them to stop and contract until quiet is restored, or if at rest and the dish is moved they respond by becoming active as soon as the disturbance ceases. Violent disturbance induces a highly excited condition with a loss of their more delicate reactions. After being disturbed the animals continue moving about for some time, this period depending on the strength of the stimulus and the physiological condition of the animal. Naturally it depends also upon the species since some are more active than others. They come to rest in some sheltered spot, normally in groups. Light plays an important part in determining their resting place as they show decided negative *photokinesis*. The length of time of the resting period varies greatly. The animals are much more active at night than in day time; this is probably due to their feeding habits.

If the worm is in a normal condition a delicate mechanical stimulus induces a positive reaction, *i.e.*, the animal pauses momentarily, then turns towards the source of the stimulus and glides forward in that direction. A negative reaction is usually given in response to a strong mechanical stimulus. In this case the animal turns away from the source of the stimulus. The positive and negative reactions are given not only in response to weak and strong mechanical stimuli but to changes in temperature and to various chemical stimuli. The food reaction is essentially a positive one. If food is placed in a dish where planarians are gliding about, as they pass near enough to receive the stimulus supplied by the juices of the tissues, they give a positive reaction similar to that following delicate mechanical stimuli. This reaction brings them to the food and as they pass over it the anterior end closes over the food as if testing it. This process completed, the animal moves ahead sufficiently to bring the mouth opening over the food. The pharynx is extruded and the feeding process begins. An interesting reaction is given where a planarian falls dorsal side down, as it rights itself by forming a more or less complete spiral.

There is a constant secretion of slime over the entire body and especially on the ventral surface. Irritation causes an increase in the quantity discharged. The slime layer and rhabdites probably serve the purpose of protection to some extent and aid in holding the prey.

Some Turbellaria occur in shallow quiet pools only; others in larger ponds, lakes, or rivers, while a few species seem to prefer swiftly flowing spring-fed brooks and streams. They are found not only in all kinds of water but under varying temperature conditions as well, since they may be collected during the winter from beneath the ice and also are found in hot springs with a temperature of 47° C. They collect on the under side of stones, sticks, and leaves, conceal themselves among algae and in debris, or cling to the stems of *Chara*, *Ceratophyllum*, and other hydrophytic plants. Certain forms are found near the surface in comparatively open water, and others in the mud or sediment at the bottom of ponds or lakes. Peat bogs and swampy places often furnish a large number of forms.

The regions occupied by different species of planarians are apparently determined by temperature and food supply to a very great extent. Those species which are adapted to low temperatures become sluggish and inactive in higher temperatures, or the reverse, and so will be less likely to find food than forms especially adapted to that temperature. If the food supply is limited this will necessarily lead to a crowding out of those less perfectly adapted to the environment. The development of any one species in a particular region is consequently limited by competition with other species already established in the area. In some cases two or more species may be found in almost equal numbers in the same pond as *Planaria maculata* and *Dendrocoelum lacteum*. In such cases a variety of food usually seems to be abundant, thus reducing the competition which would otherwise lead to the elimination of the weaker. Cannibalism sometimes occurs among individuals of the same species when food is scarce and different species are especially likely to prey upon each other. *Planaria agilis* is a voracious feeder, and will exterminate a culture of *Planaria velata* or *Planaria maculata* in a comparatively short time even if other food is provided. This may account in part for the fact that certain species are always found alone.

Ordinarily a pond or stream shows no evidence of the presence of Planaria even though large numbers of them may be hidden away under stones or leaves. However, one sometimes finds them moving restlessly about in great masses, either all in one general direction or in disorder. Voigt has conducted some interesting experiments with European forms under natural conditions which would indicate that these apparently concerted movements are the result of a response to some stimulus which may promise food, and cannot be regarded as indicating the possession of any inherited tendency toward periodical wanderings. The marine Turbellaria, like the fresh-water forms, hide under stones and among seaweeds. Some find shelter within the shells of molluscs and a few are parasitic.

The land planarians are in general characteristic of tropical and sub-tropical regions where they attain a considerable length and are usually brilliantly colored. In this country one may

sometimes find them in greenhouses and gardens, under flower pots or boxes, in moist woods under bark and old logs, or in any moist sheltered place. They are easily overlooked because of the similarity in their appearance to young snails.

Rhabdocoels are especially abundant in pools or ponds which contain much algal or other vegetation. A lens is often necessary to distinguish them from other minute organisms. They may be collected by means of a Birge net or other apparatus used in collecting small animals or simply by gathering carefully plant material, sediment, or debris from the ponds where they live and exposing this material in shallow dishes in the laboratory. The larger triclads are easily collected as they cling to the stone or leaf which conceals them when it is lifted from the water and they may then be removed with the point of a knife, or washed off into a large-mouthed jar. When algae or debris which contains them is disturbed, they contract, remain motionless until the disturbance ceases, and then come to the surface and crawl about excitedly, thus being easily picked up with a large-mouthed pipette.

Most Turbellaria are easily kept in cultures if the water is kept pure. Rhabdocoels should have a supply of unicellular and filamentous algae such as diatoms, *Spirogyra*, etc., and small animals like rotifers, crustacea, and insect larvae, as they use both plant and animal food. Planarians are largely, if not entirely, carnivorous and thrive in aquaria which are supplied with running water so that they may be given a constant supply of food. If this is not possible, they may be kept in ordinary aquarium jars or shallow dishes with or without algae. They will live for weeks without food but become greatly reduced in size. They take food readily, especially at night, and should be fed once or twice a week on earthworms, snails, liver, or almost any soft fleshy animal tissue. The water should be changed after each feeding.

Small forms are easily studied under the microscope if slightly compressed by the cover glass through the absorption of the surplus water with filter paper. A few quince seeds added to the water are of great assistance as they form a jelly which retards movement without injury to the animal. Cells or hollow

slides are convenient for work with large forms. Anesthesia may be induced by the use of a solution of one-tenth of one per cent of chloretone, or even less with some species. For preservation hot corrosive sublimate may be used, or a cold solution of the sublimate to which five per cent of glacial acetic acid has been added. Lang's fluid, Chichkoff's mixture, and 30% HNO_3 followed after one minute with 70% alcohol, are all useful killing reagents. Formol is useful for preservation of external characters since the animals retain their shape and color in it better than in most reagents. The larger planarians are especially valuable for study in laboratories where attention is given to animal behavior. Certain forms also afford excellent training in exactness of observation.

The lack of well defined and unvarying external characteristics makes it difficult to identify many Turbellaria. A large part of the material ordinarily collected is sexually immature whereas, as has been noted above, a knowledge of the structure of the sex organs is necessary in certain genera for identification. Preserved material if immature is especially difficult to identify since the body becomes distorted in shape and the color is usually so modified as to be unreliable. The differences in color and form between several of the species of planarians while definite are so slight as to be apparent only after a comparison of living material. In other cases there is a wide variation in color between individuals of the same species.

Until comparatively recently descriptions of many species of Turbellaria were extremely meager. The confusion which has arisen as a result is due to the lack of conspicuous external characteristics which would serve for identification.

KEY TO NORTH AMERICAN FRESH-WATER TURBELLARIA

Including the Land Planarians

1 (78) Intestine a single blind tube, median in position.

Order **Rhabdocoelida** . . 2

The intestine consists of a simple rod-shaped or sac cavity which rarely has lateral diverticula and never is divided into two distinct post-pharyngeal branches. Mostly small forms, never more than a few millimeters in length. The following figures (Figs. 589 and 590) facilitate a comparison of structure in the two great orders, Rhabdocoelida and Tricladida (p. 354).

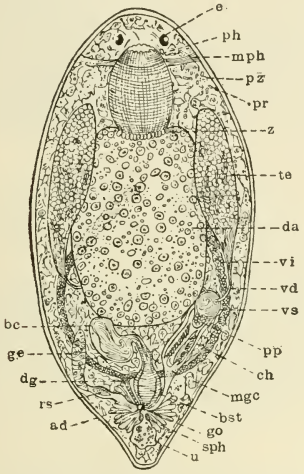


Fig. 589. Structure of a Rhabdocoel. *Dalyellia rossi*. Compressed. *ad*, atrial glands; *bc*, bursa copulatrix; *bst*, duct leading from bursa copulatrix; *ch*, chitinous part of the male copulatory organ; *da*, intestine; *dg*, duct of yolk gland; *ge*, ovary; *go*, genital pore; *mgc*, male genital canal; *mph*, retractor muscles of pharynx; *ph*, pharynx; *pp*, cirrus; *pr*, reddish reticular pigment; *pz*, yellow pigment cell; *rs*, receptaculum seminis; *sph*, sphinctor muscle of the uterus; *te*, testes; *vd*, vas deferens; *vs*, seminal vesicle; *vi*, yolk gland; *z*, esophageal cells; *e*, eye; *u*, uterus. × 50. (After von Graff.)

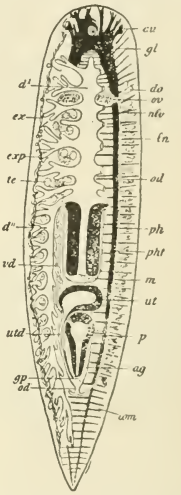


Fig. 590. Structure of a Triclad. Diagram of a Planarian. *ag*, genital atrium; *au*, eye; *com*, cross commissures of nervous system; *d'*, anterior, and *d''*, posterior branches of intestines; *do*, yolk gland; *ex*, excretory canal; *exp*, excretory pore; *gl*, brain; *gp*, genital pore; *ln*, longitudinal nerve; *m*, mouth; *od*, oviduct; *od'*, common oviduct; *ov*, ovary; *p*, cirrus; *ph*, pharynx; *pht*, pharyngeal pocket; *te*, testes; *ut*, uterus; *utd*, uterine duct; *vd*, vas deferens. (After Böhmig.)

2 (77) Pharynx simple, cask-shaped or rosette-shaped. Connective tissue of body cavity poorly developed.

Suborder **Rhabdocoela** . . 3

The mesenchyma often consists of but a few strands of connective tissue and contains large spaces filled with a perivisceral fluid.

3 (30) Reproductive organs simple. Female organs consist of ovary only.

Section Hysterophora . . 4

These forms possess no accessory female organs, *i.e.*, no separate yolk glands, uterus, female copulatory apparatus, etc. Asexual reproduction among rhabdocoels is found only in this section of the order.

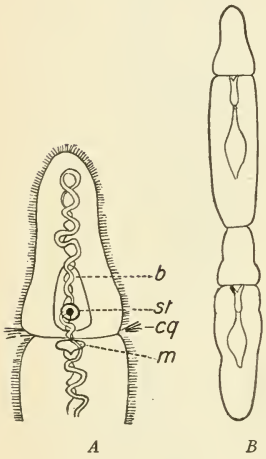
4 (27) Pharynx simple. 5

5 (20) Protonephridia with one principal branch, median dorsal in position. Family CATENULIDAE . . 6

Without eyes but with ciliated pits, non-pigmented light-refracting organs, and in one genus a statocyst. The mouth lies on the ventral side of the anterior end. The pharynx opens into the anterior end of the intestine. Asexual reproduction by budding, thus forming chains of zooids, known for most species. Testes in front of ovary. Both testes and ovary may consist of one or more lobes.

6 (7) With one statocyst and pre-oval circular groove. . . . . *Catenula*. But one species supposed to occur in America.

Catenula lemnae (Anton Dugès) 1832.



Length of single specimen 1 mm. Rarely 2 to 4 or 8 zooids in a chain. Delicate, white thread-like. Head region set off by a circular groove lined with long cilia. Intestine short and not continuous through chain of zooids.

Graff regards the European species *C. lemnae* as probably identical with the species which was collected in the vicinity of Philadelphia and very incompletely described by Leidy under the name *Anortha gracilis*. Until further collections of the Philadelphia form have been made this must of necessity be a matter open to question, and *C. lemnae* be admitted to the list of American species tentatively.

FIG. 591. *Catenula lemnae*. (*A*) anterior end: *b*, brain; *cg*, ciliated groove; *m*, mouth; *st*, statocyst. × 75. (After von Graff.) (*B*) Chain of two zooids. × 30. (After Mrazek.)

7 (6) Without statocyst or pre-oral circular groove. With ciliated pits. . 8

8 (19) Ciliated pits well developed. Without proboscis. *Stenostomum* . . 9

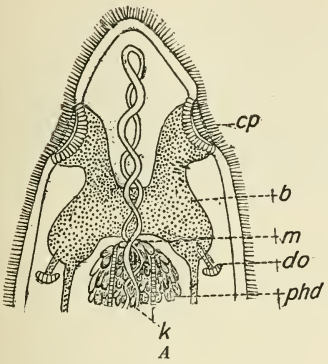
9 (18) Head region not at all or only slightly set off from rest of body. . 10

10 (17) Integument colorless. 11

11 (14) Wall of digestive tract free from pigment. 12

12 (13) Anterior end bluntly pointed, ciliated pits about as far from end of body as width of body at that point. Posterior end tapering uniformly to a blunt point.

Stenostomum leucops (Anton Dugès) 1828.



Length of single individuals 0.5 to 1.5 mm. Asexual reproduction by budding 2 to 4 zooids common, rarely 9 zooids. Intestine continuous through zooids. Rhabdites small, numerous. Two patelliform organs which consist of numerous spherical bodies. Male sexual organs mature in August, female in September. At this time the animal becomes large, sluggish, and somewhat reddish-brown in color. The six-lobed ovary lies under the intestine. The oval-shaped testes which consist of many closely compacted lobes, lie above the pharynx and open into the seminal vesicle which leads through a short canal to the opening on the dorsal surface. Abundant on plants in quiet water such as small lakes or ponds. Mass., N. Y., Ill., Mich., Neb.

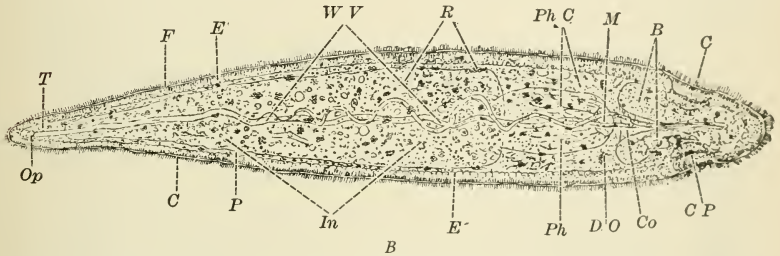


Fig. 592. *Stenostomum leucops*. (*A*) dorsal view of anterior end: *b*, brain; *m*, mouth; *k*, protonephridium; *phd*, pharyngeal glands; *do*, patelliform organ; *cp*, ciliated pit. × 200. (*B*) Entire worm. *cp*, ciliated pit; *c*, cilia; *b*, brain; *m*, mouth; *ph*, pharynx; *in*, intestine; *wv*, protonephridium; *op*, external pore of protonephridium. × 100. (After Ott.)

13 (12) Anterior end very bluntly rounded with ciliated pits very near the end. Posterior end of body narrow and forming a long slender tail, somewhat spatulate in shape, except where division has recently taken place, in which case the tail is shorter and more pointed. . . . *Stenostomum speciosum* Stringer 1913.

Length 2.25 mm. A large rhabdocoel which moves rather slowly and very gracefully. The ciliated pits are placed close to the blunt anterior end, much farther forward than in *S. leucops*, also are deeper and narrower than in the latter form. The mouth is about as far from the anterior end as the diameter of the body at that point, and is surrounded by glands. The pharynx has delicate longitudinal striations. The intestine shows many large highly refractive colorless bodies, probably fat globules. Nothing definite can be said of the light-refracting organs which were difficult to identify because of the unusual size of the animal. A few specimens collected from pond with *S. leucops*. Lincoln, Neb.

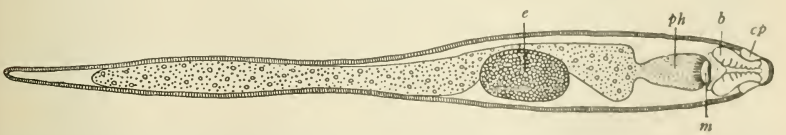


Fig. 593. *Stenostomum speciosum*. *cp*, ciliated pit; *b*, brain; *ph*, pharynx; *m*, mouth with surrounding glands; *e*, egg. × 45. (Original)

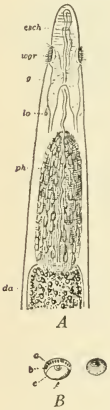
14 (11) Wall of digestive tract pigmented. 15

15 (16) Pharynx yellowish-brown. Intestine except gland cells bright yellow. *Stenostomum tenuicauda* von Graff 1911.

Length in chains of 4 zooids 1.5 mm. Slender. Posterior end tapering to a slender tail ($\frac{1}{7}$ to $\frac{1}{9}$ of entire length). Point of tail set with adhesive cells. Integument colorless and contains masses of small rhabdites measuring up to 4 μM. in length. Excretory pore nearer to intestine than end of body. Two patelliform organs 12 μ across and composed of loosely joined spherical bodies. Rochester and Cold Spring Harbor, Long Island, N. Y.

FIG. 594. *Stenostomum tenuicauda*. An undivided chain of four zooids: *rh*, rhabdites; *ig*, intestinal glands; *ep*, excretory pore; *ph I, II*, pharynx. × 40. (After von Graff.)

16 (15) Intestine yellowish-green between the round glistening oil drops. *Stenostomum agile* (Silliman) 1885.



Length of single individual 0.75 mm. Chains of two zooids measure 1.5 mm., those of five, 4 mm. Light-refracting organs lens-shaped. Rhabdites small. Posterior end bears adhesive cells. Pharynx long and provided with glands throughout its entire length. Sexual organs similar to *S. leucops*. Monroe Co., N. Y.

FIG. 595. *Stenostomum agile*. (*A*) Anterior end extended; *wgr*, ciliated pit; *lo*, lens-shaped organ; *esch*, protonephridium; *ph*, pharynx; *da*, intestine; *g*, brain. × 65. (*B*) Lens-shaped organ. × 125. (After von Graff.)

17 (10) Integument bright yellow. . . . *Stenostomum grande* (Child) 1902.

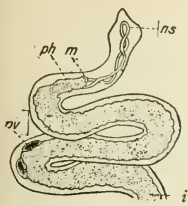
Length of chains of 4 to 6 zooids 2 to 2.2 mm. Pre-oral region, especially the rounded beak-like portion, white. Integument bright yellow, pharynx somewhat darker yellow, intestine deep orange-yellow. Rhabdites small, especially numerous in anterior end.

Two patelliform organs composed of about 25 spherical bodies. Posterior portion of nearly cylindrical muscular pharynx sometimes shows folds as a result of contraction. Intestine slightly lobed. Rochester, N. Y. Brackish water, Falmouth, Mass.

FIG. 596. *Stenostomum grande*. (*A*) Anterior end: *wgr*, ciliated pit; *so*, patelliform organ; *ph*, pharynx; *da*, intestine. (*B*) posterior end: *eö*, excretory pore. × 55. (After von Graff.)

18 (9) Head region distinct from rest of body.

Stenostomum coluber Leydig 1854.



Length 6 mm. Width about one-thirtieth the length. Very slender, white, thread-like with snake-like movements. Head region broader than the rest of the body with blunt point at anterior end. Posterior end abruptly rounded. Asexual reproduction not known. Brackish water, Falmouth, Mass.

FIG. 597. *Stenostomum coluber*. Anterior end: *m*, mouth; *ph*, pharynx; *in*, intestine; *ov*, egg (?); *ns*, protonephridium. × 20. (After Leydig.)

- (8) Ciliated pits shallow. A club-shaped proboscis is present.

Rhynchoscolex.

Only one species. . . . . *Rhynchoscolex simplex* Leidy 1851.

Length 4 to 7 mm. Color yellowish-white opaque. Anteriorly abruptly attenuated into a long cylindrical clavate proboscis; anterior end abruptly narrowed, obtusely rounded. Proboscis shows longitudinal and numerous transverse marks. Mouth ventral, at the base of the proboscis. Intestine straight and capacious. A small wriggling worm found among yellowish fragments of vegetable matter and confervae at the bottom of clear brooks in the vicinity of Philadelphia.

Von Graff regards the European species *R. vejdovski* Sekera 1888 as probably identical with this American form.

20 (5) With two lateral branches of the protonephridium.

Family MICROSTOMIDAE . . 21

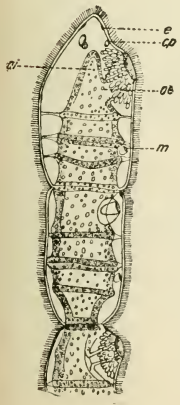
Mouth a longitudinal slit on ventral surface, intestine occasionally with side lobes. Protonephridial branches open in anterior end. Testes and ovary either paired or unpaired, with two ventral sexual pores, the male posterior to the female. With or without eyes and ciliated pits.

21 (24) The intestine extends dorsally and anteriorly beyond the junction with the pharynx. . . . . Subfamily MICROSTOMINAE.

Only one genus. . . . . *Microstomum* . . 22

22 (23) With two reddish-yellow pigmented eye spots.

Microstomum lineare (Müller) 1773.



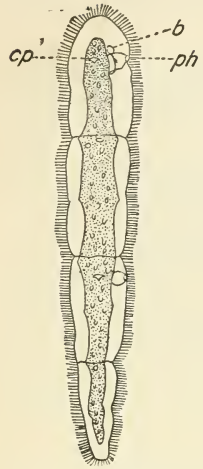
A

B

Length of single individuals 1.8 mm. In chains up to 18 zooids with a length of 9 to 11 mm. Slender. Very active. Color yellowish to grayish-brown, rarely rose-colored, with the intestine always darker than the body. Pre-oral portion of intestine short. Two small ciliated pits. Nettle cells or nematocysts in place of rhabdites. Male sexual organs with paired testes; slender chitinous spicule of copulatory organ with curved point. Ovary unpaired and median in position. In fresh and brackish water. Monroe Co. and Ontario Beach, N. Y.; West Twin Lake and Round Lake, Mich.

FIG. 598. *Microstomum lineare*. (*A*) anterior portion of a chain: *e*, eyes; *cp*, ciliated pit; *ai*, pre-oral portion of intestine; *m*, mouth; *oe*, esophagus. × 10. (After von Graff.) (*B*) Chitinous portion of cirrus. Much enlarged. (After Schultze.)

23 (22) Without eyes. . . . . *Microstomum caudatum* Leidy.

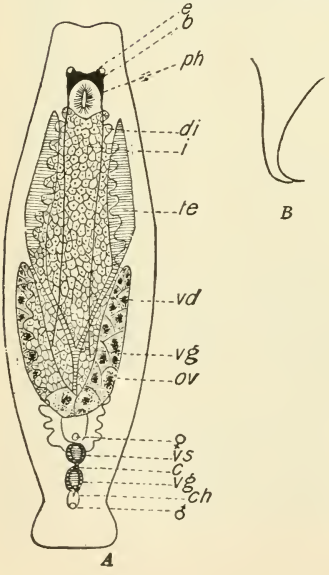


Length 1.5 to 3 mm. Commonly in chains of 2 to 8 zooids. Nematocysts in place of rhabdites. Color of integument white, intestine yellow. Ciliated pits directly dorsal to mouth. Pre-oral portion of intestine short. Anterior end bluntly rounded. Posterior end narrower, bluntly pointed, tail-like, elevated. In standing water and small brooks, Monroe Co., N. Y.; near Philadelphia, and in West Twin Lake, Charlevoix, Mich.

FIG. 599. *Microstomum caudatum*. *b*, brain; *ph*, pharynx; *cp*, ciliated pit. (After Silliman.)

24 (21) Pharynx opens into anterior end of the intestine, which has short lateral diverticula. . . . . Subfamily MACROSTOMINAE. Only one genus. . . . . *Macrostomum* . . 25

25 (26) Chitinous portion of copulatory organ a broad straight funnel with the slender point bent at a right angle or nearly so and bearing on its convex side the small opening. Vesicula seminalis and vesicula granulorum connected by a narrow tube. . *Macrostomum appendiculatum* (O. Fabricius) 1826.



This is the form known as *M. hystrix* Oersted 1843. Length 2 mm. Unpigmented, transparent. Body flattened especially at the ends. The spatulate posterior end set with adhesive papillae. Rhabdoids and long sensory hairs conspicuous. Two eyes, black. Protonephridial tubes open on median dorsal side back of the slit-like mouth. Testes and ovary both paired. Asexual reproduction not known. In running and standing water. Monroe Co., N. Y.; Lincoln, Neb.

FIG. 600. *Macrostomum appendiculatum*. (*A*) Entire worm: *b*, brain; *e*, eye; *ph*, pharynx; *di*, diverticulum of intestine; *i*, intestine; *te*, testes; *vd*, vas deferens; *vg*, ductus seminalis; *vs*, seminal vesicle; *vg*, vesicula granulorum; *ch*, chitinous spicule of cirrus; ♂ and ♀, male and female genital pores; *ov*, ovary. × 35. (After von Graff.) (*B*) Chitinous spicule enlarged. × 350. (After Luther.)

26 (25) Chitinous spicule of cirrus a straight narrow tube tapering to a somewhat variably curved point. Vesicula seminalis and vesicula granulorum separated by a short constriction.
Macrostomum sensitivum (Silliman) 1885.

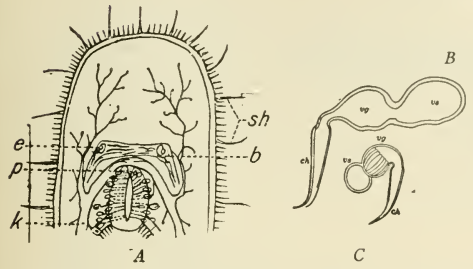


FIG. 601. *Macrostomum sensitivum*. (*A*) Anterior end: *b*, brain; *e*, eye with lens; *k*, protonephridium which opens through the pore (*p*) into the mouth cavity; *sh*, sensory hairs. × 150. (After Silliman.) (*B*) Male copulatory organ subjected to pressure. (*C*) Male copulatory organ not under pressure: *vs*, vesicula seminalis; *vg*, vesicula granulorum; *ch*, chitinous point. Much enlarged. (*B*, *C*, after von Graff.)

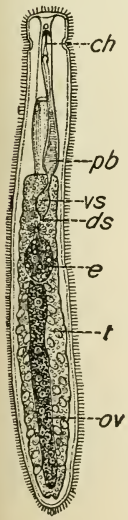
Length 1.5 mm. Color grayish-white. Intestine yellowish. Broadest through middle. Posterior end narrowed. Rhabdites present in integument in large numbers, either singly or in twos and threes. Rhabdite tracts conspicuous in anterior end. Intestine with lateral diverticula. Protonephridium communicates through a pore with mouth cavity. Chitinous organ somewhat variable. Monroe Co., N. Y.; brackish water, Falmouth, Mass.

27 (4) With a long cylindrical bulbous pharynx. . Family PRORHYNCHIDAE.

The pharynx is remarkably large. The mouth is in the anterior end. Testes with numerous follicles. Ovary not paired. Two sexual pores, the female pore on the ventral side. The male sexual organs open near the mouth or unite with it.

Only one genus. . . . . *Prorhynchus* M. Schultze . . 28

28 (29) Without eyes. . . . . *Prorhynchus stagnalis* M. Schultze 1851.



Length to 6 mm., commonly much smaller. White, thread-like. Two ciliated pits. With numerous pear-shaped glands in the integument. Pharynx about $\frac{1}{8}$ of total length of body. Protonephridium with four principal branches, two dorsal and two ventral. Chitinous portion of cirrus straight and stiletto-shaped. Monroe Co., N. Y.; brackish water, Falmouth, Mass.

FIG. 602. *Prorhynchus stagnalis*. *ch*, chitinous stiletto; *pb*, bulb-like cirrus; *vs*, seminal vesicle; *ds*, ductus seminalis; *t*, testis follicle; opening of male sexual organs into pharyngeal pocket; *ov*, ovary; *e*, mature egg. × 15. (After von Graff.)

29 (28) With two very small eyes, yellowish by transmitted light, whitish by reflected light, lying just before the brain in the widest region of the pharynx. . *Prorhynchus applanatus* Kennel 1888.

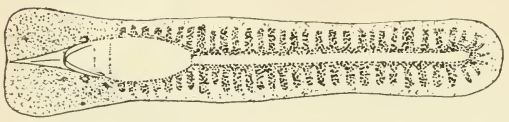


FIG. 603. *Prorhynchus applanatus*. From life. × 20. (After Kennel.)

Length 4 mm. White. Body much flattened at both ends. Pharynx very muscular. Intestine a slender straight tube with one diverticulum extending anteriorly under the pharynx and numerous slender very closely set lateral diverticula. Greenhouse, University of Nebraska, Lincoln, Neb.

30 (3) Female sexual organs divided into ovary and yolk glands. Male sex organs complex. . . . . Section LECITHOPHORA . . 31

Ovary in general small and simple. Yolk glands extremely variable, elongated, lobed, or forming a network which anastomoses. Chitinous portion of male copulatory organ very complicated and variable in form.

31 (74) Proboscis either lacking entirely or if present without a definite sheath. . . . . Subsection LIPORHYNCHIA . . 32

This division contains the greater part of the fresh-water Turbellaria.

32 (61) With a cask-shaped pharynx parallel to the ventral surface or slightly inclined and with the end directed forward. But one genital pore. . . . . Family DALYELLIDAE . . 33

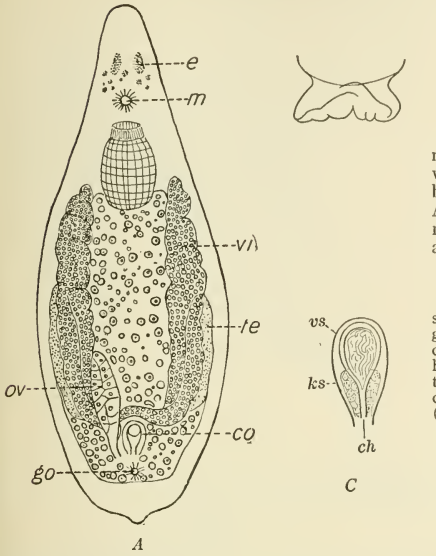
With the exception of the genus *Opistomum*, which is not represented in this country, the pharynx is typically cask-shaped and opens into the anterior end of the intestine. The genital pore opens on the ventral surface posterior to the mouth. Ovary simple. Yolk glands variable, female receptaculum seminis and a simple uterus are present. Testes always paired. Chitinous portion of male copulatory organ often very complex. Pigment eyes usually present, but without other sense organs. Protonephridium consists of two principal branches which open on the ventral surface. Rhabdoids and glands of integument prominent.

33 (60) Without a separate pocket for the chitinous part of the cirrus. . 34

34 (59) Sexual pore in posterior third of body. The paired yolk glands unbranched and separate. . *Dalyellia* Fleming 1822 . . 35

This is the one commonly known as *Vortex* Ehrenberg 1831.

35 (36) The chitinous portion of the male copulatory organ is represented merely by the chitinous tube of the ductus ejaculatorius.
Dalyellia inermis von Graff 1911.



Length 0.6 mm. Flattened. Posterior end modified into a kind of adhesive disk. Color white by reflected light. Intestine very broad and yellow in color. Eyes dull yellow. Accessory pigment spots irregularly grouped near the eyes. The locomotor movements are very quick. Rochester, N. Y.

FIG. 604. *Dalyellia inermis*. (*A*) Ventral view, slightly compressed: *e*, eye; *m*, mouth; *vi*, yolk gland; *ov*, ovary; *go*, genital pore; *co*, male copulatory organ; *te*, testes. ×115. (*B*) Adhesive disk of posterior end. (*C*) Male copulatory organ enlarged: *ch*, chitinous tube; *ks*, vesicula granulorum; *vs* vesicula seminalis. ×300. (After von Graff.)

36 (35) Provided with true chitinous organ. 37

37 (38) Chitinous portion of cirrus consists of a single chitinous spine.
Dalyellia rochesteriana von Graff 1911.

Scarcely 1 mm. long. Closely resembles *D. rheesi*. Colorless, transparent with very small dermal rhabdites. Brownish mesenchymatous pigment not so abundant as in *D. rheesi*. Intestine reddish-ocher-yellow. Sexual pore lies just posterior to the intestine in the beginning of the last third of the body. Rochester, N. Y.

FIG. 605. *Dalyellia rochesteriana*. Male copulatory organ enlarged: *ch*, chitinous spine; *vs*, vesicula seminalis; *ks*, vesicula granulorum. (After von Graff.)

38 (37) Chitinous portion of cirrus consists of more than one piece. . . 39

39 (44) Chitinous portion of cirrus consists of a number of transverse spines arranged in a row. 40

40 (41) Spines of unequal size and shape set in a basal piece.
Dalyellia dodgei von Graff 1911.

Length rarely more than 1 mm Integument colorless. Intestine greenish from contained algae. Mesenchyma mottled with sepia-brown pigment. Eyes black. Found very commonly. Rochester, N. Y.

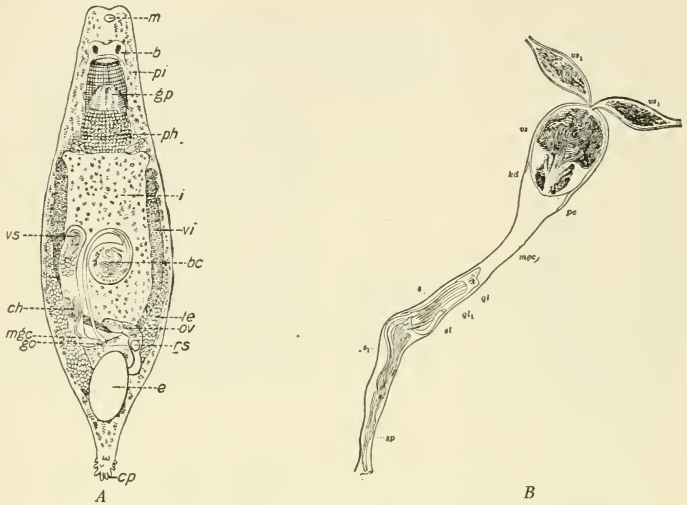
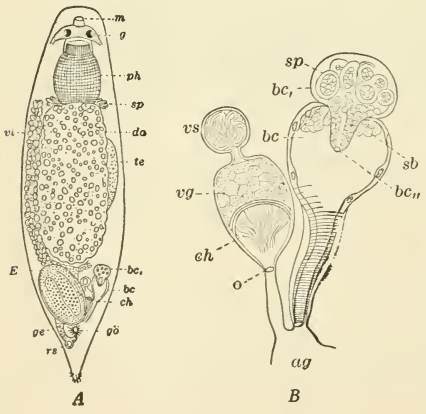


FIG. 606. *Dalyellia dodgei.* (*A*) Ventral view slightly compressed. × 65. (*B*) Male copulatory organ strongly compressed. Explanation of figures: *bc*, bursa copulatrix; *ch*, chitinous organ; *cp*, adhesive papillae; *i*, intestine; *e*, egg; *b*, brain; *ov*, ovary; *go* genital pore; *gp*, grasping papillae of pharynx; *vg*, vesicula granulorum; *m*, mouth; *mgc*, male genital canal; *ph*, pharynx; *pe*, cirrus; *pi*, mesenchyma pigment; *rs*, receptaculum seminalis; *sp*, sperm masses; *te*, testes; *vi*, yolk gland, *vs*, vesicula seminalis. Much enlarged. (After von Graff.)

41 (40) Spines of same size and shape, arranged loosely in a ring without a basal piece. 42

42 (43) With a crown of about 16 spines, tapering from base to the point.
Dalyellia eastmani von Graff 1911.

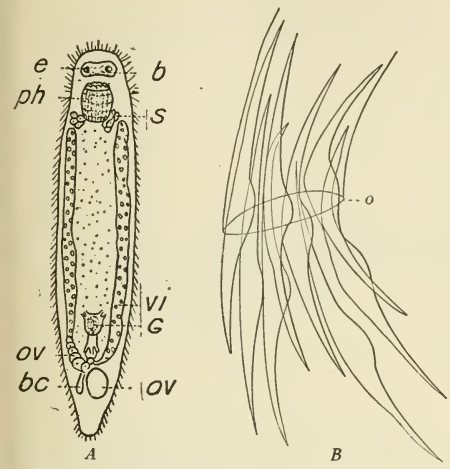


Length 0.3 to 0.5 mm. Color of mesenchymatous fluid pale yellow with spherical bodies which contain cinnamon-brown granules in a clear brown fluid. Rhabdites short and relatively thick and rounded at both ends. Rochester, N. Y.

FIG. 607. *Dalyellia eastmani.* (*A*) Ventral view uncompressed. × 100. (*B*) Male copulatory apparatus. × 600. Explanation of figures: *bc*, bursa copulatrix; $bc_{,}$, blind sack of bursa; $bc_{,,}$, opening of blind sac; *e*, egg; *g*, brain; *m*, mouth; *ge*, ovary; *go*, genital pore; *rs*, receptaculum seminis; *vs*, vesicula seminalis; *te*, testes; *vi*, yolk gland; *ag*, common atrium; *o*, opening of the male copulatory organs into genital canal; *vg*, vesicula granulorum; *sp*, sperm mass; *ch*, chitinous crown of spines; *da*, intestine; *ph*, pharynx; *sb*, granules of secretion. (After von Graff.)

43 (42) With a crown of 8 spines, thickened near the middle and tapering to fine points at both ends.

Dalyellia blodgetti (Silliman) 1885.



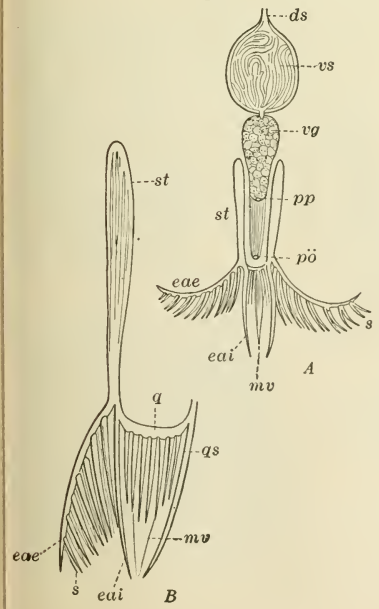
Length 0.6 mm. Color light brown. A number of sensory hairs on anterior end. Basal piece of the tube which encloses the spines is not chitinous but membranous and placed in the male genital canal which opens into the atrium. Erie canal, Rochester, and Monroe Co., N. Y.

FIG. 608. *Dalyellia blodgetti*. (*A*) Entire: *b*, brain; *vi*, yolk gland; *g*, cirrus; *e*, eye; *ov*, ovary; *bc*, bursa copulatrix; *ph*, pharynx; *s*, salivary gland. ×90. (After Silliman.) (*B*) Crown of spines from chitinous portion of male copulatory organ with opening (*o*) into the genital canal. From a strongly compressed preparation. Very much enlarged. (After von Graff.)

44 (39) Chitinous portion of cirrus bears two longitudinally placed stalks on one end of which either one or two longitudinal terminal branches are set. The terminal branches may be set with spines. 45

45 (46) Each chitinous stalk bears two terminal branches, one set with spines and one with no spines.

Dalyellia fairchildi von Graff 1911.



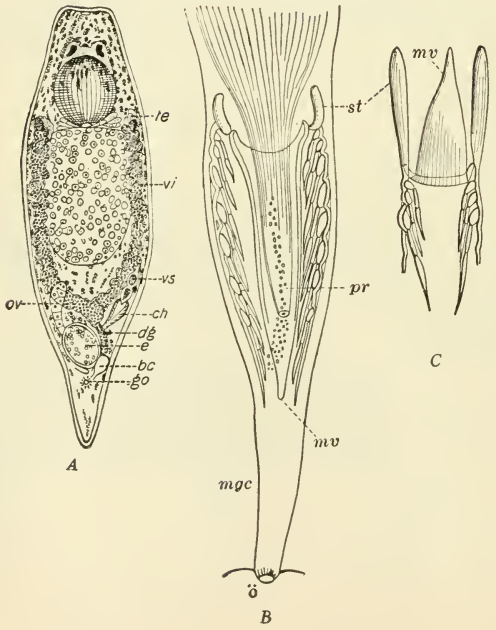
Similar in size and color to *D. rheesi* but more slender, with a longer tail and the uterus lies posterior to the sexual pore. The egg is round to oval in shape and measures 108 to 140 μ. Yolk glands open as in *D. rheesi* through a common yolk duct but are not lobed, barely notched.

FIG. 609. *Dalyellia fairchildi*. (*A*) Male copulatory apparatus. ×430. (*B*) Chitinous piece enlarged. ×850. *ds*, ductus seminalis; *eae*, outer branch with spines folded; *eai*, inner branch with no spines; *mv*, median projection; *pö*, opening of cirrus sheath; *pp*, cirrus papillae; *s*, double row of spines; *st*, stalk; *vg*, vesicula granulorum; *vs*, vesicula seminalis; *q*, transverse bar; *qs*, transverse spines. (After von Graff.)

46 (45) Each chitinous stalk bears a single terminal branch set with spines. 47

47 (50) The spines on the terminal branch are jointed. 48

48 (49) Each spine consists of three joints. Stalk long, somewhat variable in shape. . . . . *Dalyellia rheesi* von Graff 1911.



Length 1 mm. When swimming freely the anterior end is broadly rounded, in crawling, truncated as shown in figure. Integument colorless with numerous delicate rhabdites. Mesenchyma colored by sepia-brown to cinnamon-red granules in a clear yellow fluid. In the living animal the brain region appears clear white and the ventral surface lighter in color than the dorsal, eyes black. In pools along Erie canal.

FIG. 610. *Dalyellia rheesi*. (*A*) slightly compressed: *te*, testes; *vi*, yolk gland; *vs*, vesicula seminalis; *ch*, chitinous portion of cirrus; *dg*, duct of yolk gland; *bc*, bursa copulatrix; *go*, genital pore; *e*, egg; *ov*, ovary. × 60. (*B*) Male copulatory apparatus: *pr*, cirrus tube; *mcg*, male genital canal; *ö*, opening of genital canal into common atrium; *st*, short stalk of chitinous piece. × 600. (*C*) Median ventral grooved piece (*mv*) turned back; *st*, variation in stalk. ×600. (After von Graff.)

49 (48) Each spine consists of two joints. Stalk much reduced and variable in shape. . . . . *Dalyellia articulata* von Graff 1911.

Similar to *D. rheesi* in color and general structure. Sexual organs differ as shown by a comparison of Figs. 610 and 611. Same localities as *D. rheesi*.

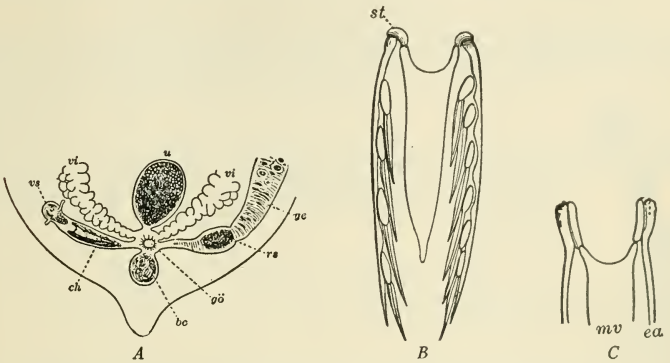
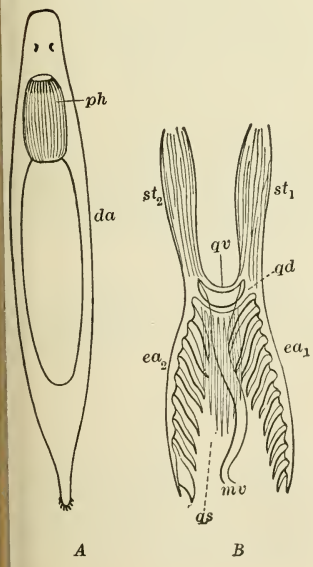


Fig. 611. *Dalyellia articulata*. (*A*) Posterior end with sex organs from a strongly compressed specimen: *bc*, bursa copulatrix; *ch*, chitinous part of male organs; *ge*, ovary; *gö*, genital pore; *rs*, receptaculum seminis; *u*, uterus with egg; *vi*, yolk gland; *vs*, vesicula seminalis. (*B*) Chitinous organ with the reduced stalk (*st*). (*C*) Chitinous portion of cirrus showing variation from (*B*). Much enlarged. (After von Graff.)

50 (47) The reduced spines on the terminal branch are unjointed and consist of but one piece. 51

51 (52) The dorsal transverse bar bears a row of fine spines. *Dalyellia mohicana* von Graff 1911.



Free swimming, of extremely slender form, similar to *D. rossi*. Anterior end of the chitinous portion of cirrus not sharply defined. Differs from *D. rossi* chiefly in structure of the chitinous organ, the stalk of which is not so broad or flat as in that form. One terminal branch of this organ bears eleven curved teeth, the other seven of the same type and one which is larger and three sided. The transverse bar bears a row of straight, sharply pointed spines. Brackish water, Falmouth, Mass.

Fig. 612. *Dalyellia mohicana*. (*A*) The animal swimming. × 60. (*B*) Chitinous part of cirrus. Much enlarged. *ea*, end branch with a row of spines; *st*, stalk; *qd*, dorsal transverse connecting bar, with a row of spines, *qs*; *qv*, ventral transverse bar; *mv*, median projecting piece. (After von Graff.)

52 (48) The dorsal transverse piece between the longitudinal stalks has a single median chitinous spine. 53

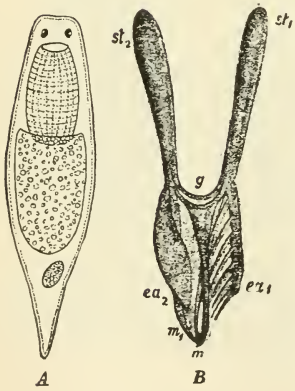
53 (54) The median point is rudimentary; much shorter than the terminal branches. . . . . *Dalyellia viridis* (G. Shaw) 1791.

Length 5 mm. Unpigmented except during the maturing of the eggs when there is a brownish pigment, but with a continuous layer of zoochlorellae under the integument giving the characteristic green color. Rochester, N. Y.

FIG. 613. *Dalyellia viridis*. Chitinous portion of cirrus: *st*, two-parted stalk; *ea*, terminal branch. Much enlarged. (After von Graff.)

54 (53) The median point is as long as the terminal branches. 55

55 (56) One terminal branch is not jointed but consists of a single piece shaped like a plow-share, and does not have spines. *Dalyellia armigera* (O. Schmidt) 1861.

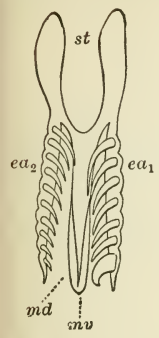


Length 0.6 to 1.5 mm. Color yellowish, reddish, or brownish-gray. Pharynx very large, almost one-fourth of entire length of body. Anterior end blunt, tail with adhesive papillae. Swims actively at the surface of standing and running water. Brooks, Monroe Co., N. Y.; Lake St. Clair, Mich.

FIG. 614. *Dalyellia armigera*. (*A*) living, uncompressed. × 50. (*B*) chitinous portion of cirrus: *m*, median point; *ea*, terminal branch with 3 to 9 (mostly 7 or 8) spines; ea_2, terminal branch shaped like a plow-share; *g*, dorsal and ventral cross pieces; *st*, stalk. × 500. (After von Graff.)

56 (55) Both terminal branches bear a row of plates or spines. 57

57 (58) Terminal spine of only one terminal branch unlike the others in shape. . . . . *Dalyellia rossi* von Graff 1911.

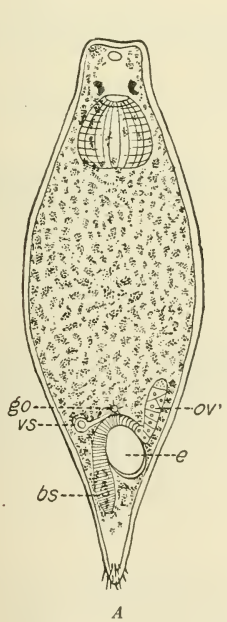


Length a little over 1 mm. Similar in form to *D. rheesi*. Color of mesenchyma bright or dark reddish-yellow to cinnamon-brown. Eyes brown or black. Intestine brownish-yellow. Adhesive cells on short tail. Common at Rochester, N. Y. In brackish water, Falmouth, Mass. See Fig. 589 for view of entire animal.

Fig. 615. *Dalyellia rossi*. Chitinous part of male copulatory organs. *st*, chitinous stalk; ea_1 and ea_2, terminal branches with spines; *mv* and *md*, median ventral and dorsal projections. × 285. (After von Graff.)

58 (57) Terminal spines on both terminal branches unlike the others in shape. *Dalyellia sillimani* von Graff 1911.

Length 1 mm. Integument colorless with small rhabdites. In heavily pigmented specimens the mesenchyma appears dark brown; those with less pigment show cells filled with yellow fluid and containing brown pigment granules. Intestine ocher-yellow. Eyes black. Rochester, N. Y., in brooks and pools.



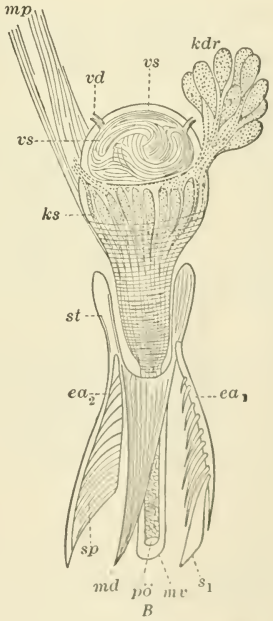
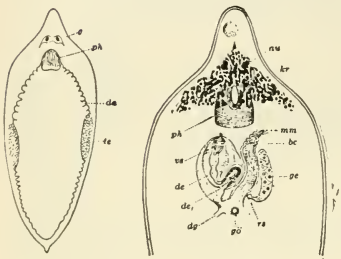


Fig. 616. *Dalyellia sillimani*. (*A*) slightly compressed: *bs*, bursa seminalis; *e*, egg; *ov*, ovary; *go*, sexual pore; *vs*, vesicula seminalis. × 70. (*B*) Male copulatory organ: ea_1 and ea_2, terminal branches of chitinous organ; *kdr*, granular glands of one side; *ks*, granular secretion; *md*, median dorsal chitinous point; *mp*, retractor muscles; *mv*, median ventral grooved chitinous piece; *po*, cirrus opening; *vd*, vas deferens; *vs*, vesicula seminalis; s_1, last chitinous plate of right terminal branch; *sp*, last chitinous plate of left terminal branch; *st*, stalk. × 330. (After von Graff.)

59 (34) Sexual pore anterior to the middle of the body. Yolk glands branched and either separate or united to form a network.
Phaenocora Ehrenberg 1836.

This is the genus formerly known as *Derostomum* Oersted 1843.

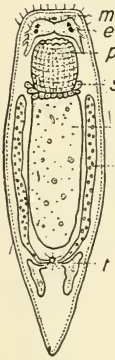
Only one species known in this country.
Phaenocora agassizi von Graff 1911.

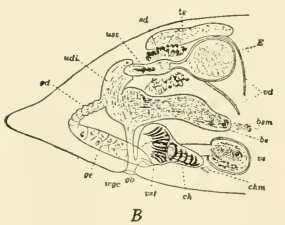


Length 1 to 2 mm. Milk-white. Intestine greenish-yellow. Eyes reddish-yellow. Between the eyes and the pharynx or extending over the anterior end of it there is a zone of so-called crystalloids which appear clear or grayish-brown in transmitted light. This species is an exception for the genus in that it possesses rhabdites. Pharynx cask-shaped, intestine more or less deeply lobed. In pool, Rochester, N. Y.

FIG. 617. *Phaenocora agassizi*. (*A*) slightly compressed: *te*, testes; *da*, intestine; *ph*, pharynx. × 22. (*B*) Anterior part, enlarged: *kr*, crystalloids; *bc*, bursa copulatrix; *mm*, muscles of bursa; de_1, proximal, and de_2, distal part of ductus ejaculatorius; *dg*, duct of yolk gland; *ge*, ovary; *gö*, genital pore; *rs*, receptaculum seminis; *au*, eye. × 70. (After von Graff.)

60 (33) With a separate pocket for the chitinous portion of male copulatory organ. Sexual pore lies in last third of body . . *Jensenia*.
Only one species known in this country.
Jensenia pinguis (Silliman) 1885.





Length about 1.5 mm. Color brown to reddish, darkest in middle of body. Male genital canal divided at its connection with the common atrium, one branch forming the pocket for the chitinous organ while the other leads to the seminal vesicle. Rochester, N. Y.

FIG. 618. *Jensenia pinguis*. (*A*) Entire: *m*, mouth; *vi*, yolk glands; *t*, testes; *e*, eye; *ph*, pharynx; *s*, glands; *i*, intestine. × 30. (After Silliman.) (*B*) Sexual organs from animal compressed from side: *bs*, bursa seminalis; *bsm*, retractor muscles of same; *ch*, pocket which contains chitinous organ; *chm*, one of four muscles for same; *e*, egg; *gd*, oviduct; *ge*, ovary; *gö*, genital pore; *sd*, shell glands; *te*, testes; *udi*, uterus diverticulum of atrium; *ust*, duct of uterus; *vd*, vasa deferentia; *vs*, vesicula seminalis; *vst*, duct from same; *vgc*, female genital canal. × 60. (After von Graff.)

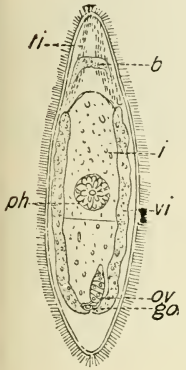
61 (32) Pharynx rosette-shaped, standing perpendicular to the ventral surface. . . . . Family TYPHLOPLANIDAE . . 62

The genital pore lies back of the mouth. Ovary one, testes paired. Other parts of sexual organs variable. Protonephridium with two main branches which may have either one or two openings on the ventral surface or may lead to the surface through the mouth or sexual pore. Eyes, non-pigmented light-refracting organs; ciliated pits may be present. Rhabdoids play an important part in classification. Both summer and winter eggs produced in some species.

62 (63) Genital pore in posterior third of body. . . Tribe OLISTHANELLINI

Excretory system opens on dorsal surface with one asymmetrical or two symmetrically placed openings. Testes dorsal to the yolk glands. Without atrial copulatory organ.

Single genus thus far reported in America. . . . . *Olisthanella*.
Only one species in this country. . *Olisthanella caeca* (Silliman) 1885.



Length 1.3 mm. Without eyes. Without long sensory hairs. Color grayish-white. Sometimes apparently colored, due to food in intestine. Pharynx rosette-shaped and nearly central in position. Intestine large. Rhabdites and tracts prominent. Female organs only are known. Sluggish and found only in mud under stones. Monroe Co., N. Y.

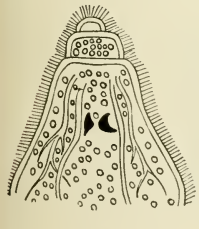
FIG. 619. *Olisthanella caeca*. *ph*, pharynx; *i*, intestine; *b*, brain; *vi*, yolk gland; *ov*, ovary; *go*, genital pore; *ti*, rhabdite tracts. × 35. (After Silliman.)

63 (62) Genital pore in anterior two-thirds. 64

64 (71) Testes ventral to the yolk glands. Rhabdites only in mesenchyma tracts. . . . . Tribe TYPHLOPLANINI . . 65

Protonephridia with two main branches which communicate with the exterior through a transverse branch which leads either to the mouth or to the genital atrium. With or without atrial copulatory organs.

65 (66) Anterior end of body a retractile proboscis. . . *Rhynchomesostoma*.
Only one species. . . . *Rhynchomesostoma rostratum* (Müller) 1773.


A


B

Length 2 mm. European specimens reach a length of 5 mm. when extended. Very transparent. Body fluid rose or yellowish-red in color. Intestine contains yellowish-red oil droplets. Ventral surface flat, dorsal convex. Anterior end of body like a telescopic tube. Pharynx small, lying somewhat before the middle of the body. Rochester, N. Y.

FIG. 620. *Rhynchomesostoma rostratum*. (*A*) Proboscis partly extended. (*B*) Fully contracted. × 40. (After von Graff.)

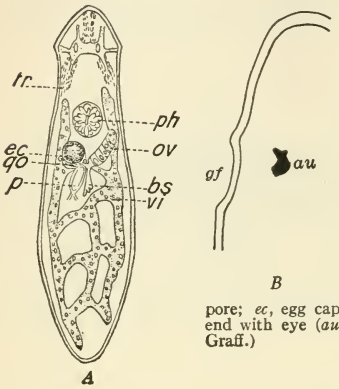
66 (65) Anterior end of body without retractile proboscis. 67

67 (70) Without atrial copulatory apparatus. 68

68 (69) With a separate receptaculum seminis, whose short duct is closed by a muscular ring. Dermal rhabdites present. . . *Strongylostoma.*

Only one species known in this country.

Strongylostoma gonocephalum (Silliman) 1885.



Length 1.2 mm. Mesenchyma yellowish, intestine with yellowish oil droplets. Eyes carmine red. Small rhabdites are present. This form differs from the widely distributed European form, *Strongylostoma radiatum* Müller chiefly in the possession of two shallow oval pits which lie close behind the eyes at the side. The integument is slightly raised around them and each bears vacuoles and rhabdoids. Excretory pore opens into mouth. Erie Canal, Monroe Co., N. Y.

FIG. 621. *Strongylostoma gonocephalum.* (*A*) Entire animal: *tr*, tracts of rhabdites; *ph*, pharynx; *ov*, ovary; *bs*, bursa seminalis; *vi*, yolk glands; *p*, cirrus; *go*, genital pore; *ec*, egg capsule. ×40. (After Silliman.) (*B*) Out- line of anterior end with eye (*au*) and shallow pit (*gf*) of one side. Enlarged. (After von Graff.)

69 (68) Without a separate receptaculum seminis. . . . . *Typhloplana.*

Only one species known in this country.

Typhloplana viridata (Abildgaard) 1790.

Length 0.5 to 1 mm. Transparent. Zoochlorellae in the mesenchyma give it a grass-green color. Tapering at both ends. Without eyes. Anterior end bluntly pointed, posterior end pointed. Pharynx just anterior to center. Sexual pore close behind pharynx. Viviparous. The summer eggs develop within the body of the parent. Winter eggs are as many as ten in number and yellowish-brown in color.

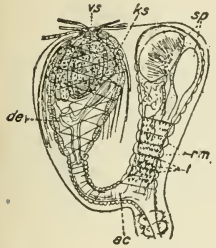
The pear-shaped bulbous cirrus contains a straight chitinous tube, the ductus ejaculatorius. The male genital canal is set with small spines; the small egg-shaped or somewhat elongated testes lie near or back of the pharynx.

Luther and von Graff regard the form collected from Monroe Co., N. Y., and described by Silliman under the name of *Mesostoma viviparum*, also those collected from West Twin Lakes and Old Channel Round Lake, Charlevoix, Mich., and described by Woodworth under the names *M. viviparum* and *M. vividatum*, as identical with the European species. There seems to be no doubt that this is the case. *Typhloplana viridata* was collected by von Graff at Rochester, N. Y.

FIG. 622. *Typhloplana viridata.* *pi*, Zoochlorellae; *ph*, pharynx; ♂, ♀, male and female genital pore; *pe*, cirrus. ×70. (After von Graff.)

70 (67) With atrial copulatory apparatus.

Castrada hofmanni (M. Braun) 1885.



Length 1.5 mm. Unpigmented. Colored green from zoochlorellae in mesenchyma. Cylindrical. Anterior end rounded, posterior end running out to a blunt point. Without eyes. Large rhabdoids in tracts. Pharynx somewhat before the middle of the body with genital pore shortly back of it. Testes are elongated oval to pear-shaped. Yolk glands are deeply lobed. The male copulatory organ and bursa copulatrix are entirely enclosed by the muscular mantle of the atrium copulatorium. Rochester, N. Y.

FIG. 623. *Castrada hofmanni.* Cirrus, bursa copulatrix, and atrium copulatorium. Diagram from preparations subjected to pressure: *vs*, vesicula seminalis; *ks*, granular secretions; *sp*, spermatophore; *rm*, circular muscles; *t*, teeth-like spines; *ac*, atrium copulatorium; *de*, ductus ejaculatorius. Much enlarged. (After Luther.)

71 (64) Testes dorsal or lateral to the yolk glands. Mesenchyma with rhabdoids outside of tracts. . Tribe MESOSTOMATINI . . 72

Sexual pore lies in anterior two-thirds of body. Protonephridial ducts open through mouth to exterior as in most Typhloplanini and in some cases, mouth, protonephridia, and genital organs have a common external opening. Rhabdites play a very important part in classification. The larger rhabdocoels belong to this group.

72 (73) With a ventral epidermal pouch and a ductus spermaticus which connects the bursa copulatrix with the female genital canal.

Bothromesostoma.

Only one species known in this country.

Bothromesostoma personatum (O. Schmidt) 1848.

Length 7 mm. Color on anterior and posterior ends and on lateral margins and ventral side a clear brown. In mature specimens the pigment is so massed that together with the dark color of the intestine it gives a dark brown to bluish-black color to the dorsal surface above the intestine. Some specimens show a mixture of brown and black. The oval eyes are about as far distant from the lateral margins as from each other. They are perceptible only in the lighter pigmented specimens. The ventral epidermal pouch occurs somewhat posterior to the eyes. The common opening for mouth, protonephridial ducts, and genital pore is located about the middle of the ventral surface. Both summer and winter eggs are produced. The former produce the viviparous young. Ann Arbor, Mich.

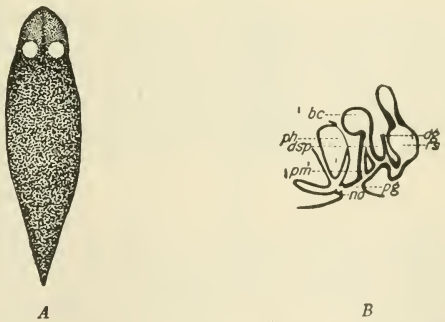
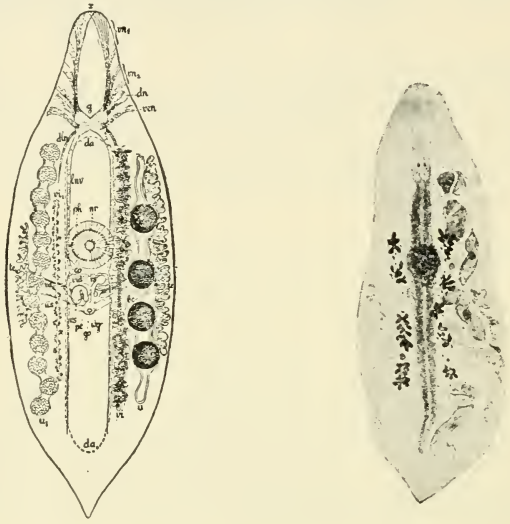


FIG. 624. *Bothromesostoma personatum.* (*A*) entire animal. × 5. (After Schmidt.) (*B*) Diagram of sexual organs: *bc*, bursa copulatrix; *dsp*, ductus spermaticus; *pm*, opening of cirrus; *rs*, receptaculum seminis; *pg*, genital pore; *dg*, duct of yolk gland; *ph*, pharynx; *no*, opening of protonephridium. Much enlarged. (After Luther.)

73 (72) Without a ventral epidermal pouch and ductus spermaticus.
Mesostoma.

Only one species known in America.
Mesostoma ehrenbergii (Focke) 1836.

This species attains a length of 12 to 15 mm. in Europe. Greatest length recorded for American specimens is 6 mm. Very transparent. Color pale yellowish to brownish. Intestine yellowish-brown. Thin, flat, and leaf-like in outline. Anterior end tapering, conical. Posterior end tapering sharply and terminating in an acute caudal process. Conspicuous tracts of rhabdites lead to the anterior end. Eyes black. Two shallow pits occur on the dorsal surface of the anterior end, one on either side. Both summer and winter eggs are produced but rarely at the same time. The summer eggs develop and the young embryos may be seen within the body of the parent. From Illinois River; Lake St. Clair, Mich.; Ohio; and Elkhorn River, Neb.



A *B*

FIG. 625. *Mesostoma ehrenbergii.* (*A*) Diagram from ventral side showing nervous, digestive, and reproductive systems. Left side shows summer eggs, the right, winter eggs: *bc*, bursa copulatrix; *da*, anterior branch of intestine; da_1, posterior branch of intestine; *go*, genital pore; *k*, ovary; *pe*, cirrus; *ph*, pharynx; *rs*, receptaculum seminis; *te*, testes; *u*, uterus; *vd*, vas deferens; *vi*, yolk gland; *vs*, vesicula seminalis; *wgc*, female genital canal; *co*, subesophageal commissure of ventral nerves; *dln*, dorsal longitudinal nerve; *dn*, dorsal nerve of brain; *g*, brain; *lnv*, ventral longitudinal nerve; *nr*, pharyngeal nerve ring; *us*, duct of uterus; *ven*, ventral nerve of brain; *vid*, duct of yolk gland; vn_1 and vn_2, the two pairs of anterior nerves of brain; *x*, chiasma of anterior nerves. × 6. (After von Graff, Vogt, Fuhrmann, and Luther.) (*B*) From life, showing young worms in left uterus. × 9. (After Woodworth.)

74 (31) With a genuine proboscis which lies within a sheath and communicates with the exterior through an opening at the anterior end. Pharynx rosette-shaped.
Subsection CALYPTORHYNCHIA . . 75

A small group easily recognized by the genuine proboscis. A bursa copulatrix is present. The cirrus is divided into vesicula seminalis and vesicula granulorum. The rosette-shaped pharynx lies on the ventral surface.

75 (76) With a single sexual pore. . . . . Family POLYCYSTIDIDAE.

Two ovaries, two yolk glands with finger-like lobes, and two compact testes. Bursa copulatrix small and without a separate external opening.

Single genus thus far found in America. . . . . *Polycystis*.

Only one species known in America. . *Polycystis roosevelti* von Graff 1911.

Length 2 mm. Anterior end of body transparent, the rest of the body faintly reddish. A subcutaneous brown pigment between the longitudinal muscle fibers gives a more or less striated appearance. The extremely flexible proboscis lies within its sheath just in front of the brain at the anterior end. The mouth and pharynx lie in the beginning of the second third of the body and the genital pore lies between the second and last third of the body. Posterior end very bluntly rounded, anterior end somewhat narrower. Closely resembles the European species *P. gaetti* Bresslau except in the structure of the chitinous portion of male copulatory organ.

FIG. 626. *Polycystis roosevelti*. Chitinous cirrus tube with bulb (*b*), ductus seminali (*ds*), and the ducts leading from the granular glands (*kd*). × 400. (After von Graff.)

76 (75) With two sexual pores, the male posterior to the female.

Family GYRATRICIDAE.

One or two ovaries, with yolk glands and one compact testes which lies on the left side.

Only one genus known. . . . . *Gyratrix*.

Single species known in America.

Gyratrix hermaphroditus Ehrenberg 1831.

Length 2 mm. White in reflected light. Eyes black. Without rhabdoids or pigment. Capable of contracting into a ball, or extending to almost double its length as long as it remains actively swimming. Stiletto-sheath of male copulatory organ a short wide tube. The very large bursa copulatrix has a separate dorsal opening to the exterior. Egg capsule oval. From peat bog, Rochester, Monroe Co., N. Y.

One subspecies *Gyratrix hermaphroditus hermaphroditus* Ehrenberg. Stiletto-sheath with a hook on the end. The egg capsule is gradually reduced to its stalk and is much elongated. Rhabdoids occur in the terminal cone of the proboscis.

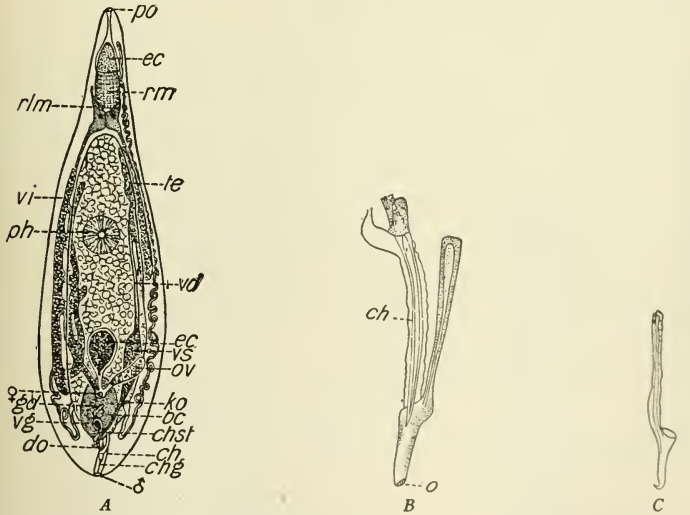


FIG. 627. *Gyratrix hermaphroditus*. (*A*) Ventral view of compressed specimen. *do*, dorsal opening of; *bc*, bursa copulatrix; *ch*, chitinous tube; *chst*, stalk of chitinous tube; *chg*, chitinous stiletto leading from vesicula granulorum; *ec*, egg capsule in uterus; *ov*, ovary; *gd*, granular secretory glands; *ko*, external opening of kidney; *ph*, pharynx; *rlm*, attachment of the long proboscis retractor muscles; *ec*, end cone of proboscis; *rm*, muscular portion of proboscis; *po*, external opening of proboscis sheath; *te*, testes; *vd*, vas deferens; *vg*, vesicula granulorum; *vi*, yolk glands; *vs*, vesicula seminalis; ♂, male and ♀, female genital pores. × 30. (After von Graff.) (*B*) Stiletto-sheath with straight tube. *o*, opening of stiletto sheath; *ch*, chitinous stiletto of cirrus. Much enlarged. (After Hallez.) (*C*) *Gyratrix hermaphroditus hermaphroditus*. Stiletto-sheath with curved point. Much enlarged. (After von Graff.)

77 (2) Pharynx either variable or cylindrical and lying within a pharyngeal pocket. Connective tissue well developed.
Suborder **Alloeocoela.**

The intestine is an irregular sac mostly with side lobes and an anterior and posterior branch. It divides to form a ring in the median ventral region, thus enclosing the slender cylindrical pharynx which is similar in position and appearance to that of the planarians.

No fresh-water representative of this Suborder has been definitely established for this country. It seems clear that some must exist in this region and be found on further study of the American fauna.

78 (1) Intestine consists of three main branches, one an anterior branch median in position, and two running to the posterior end of the body, one on either side of the pharyngeal region.
Order **Tricladida** . . 79

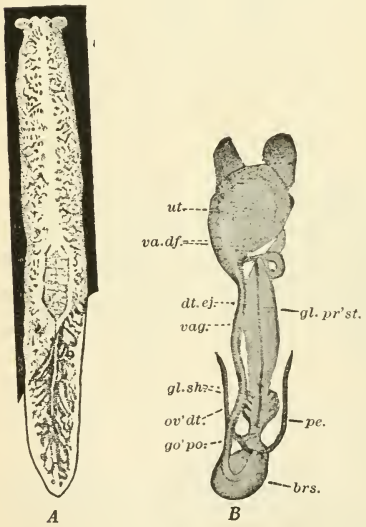
Mostly larger than in the preceding order. Pharynx usually median ventral in position, elongated, cylindrical, and lying within a pharyngeal pocket with the free end directed posteriorly. Compare figures of a typical Triclad (Fig. 590) and Rhabdocoel given on page 333.

79 (104) Found in fresh-water ponds or streams. . . Suborder **Paludicola.**
Only one family. . . . . PLANARIIDAE . . 80

Body elongated, flattened, often with conspicuous cephalic appendages. Inconspicuously colored.

80 (103) Pharynx one. 81

81 (82) With an adhesive disk on anterior end. . . . . *Dendrocoelum.*
Only one species known in this country.
Dendrocoelum lacteum Oersted 1844.



Greatest length 22 mm., breadth 2 to 3 mm. Color milk-white, creamy, yellowish, or in larger older specimens sometimes roseate. No pigment except in eye spots. Very translucent. Intestine colored by contained food. A slight constriction just behind the plane of the eyes sets off the head and produces the rounded, cephalic appendages. Posterior end rounded. Lateral margins nearly parallel when at rest or contracted. Median adhesive disk extremely variable. Usually about one-third of the broadest diameter of the head. Inconspicuous in small specimens. It is not a true sucker but consists of a depression into which the glands open and with the margin somewhat raised. Two eyes normally but from one to six accessory eyes are common. Mass., Mich., Penn., Wis.

What is probably a variety of this species is described as a non-pigmented eyeless *Dendrocoelum* collected from Mammoth Cave and adjoining caves in Kentucky.

FIG. 628. *Dendrocoelum lacteum.* (*A*) From life. × 4. (*B*) Sex organs, dorsal view: *brs*, copulatory bursa; *dt ej*, ductus ejaculatorius; *gl sh*, shell gland; *gl prst*, prostate gland; *go po*, genital pore; *ov dt*, oviduct; *pe*, cirrus; *ut*, uterus; *va df*, vas deferens; *vag*, vagina. × 14. (After Woodworth.)

82 (81) Without an adhesive disk on anterior end. 83

83 (102) Normal eyes two or none. . . . . *Planaria* . . 84

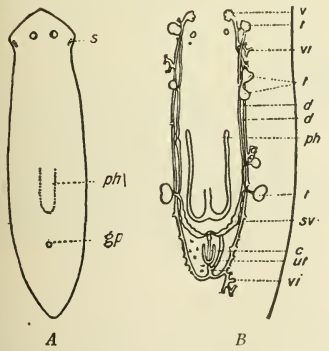
84 (101) With two normal eyes (sometimes with one or more irregularly placed accessory eyes). 85

85 (94) Anterior end more or less pointed with angular cephalic appendages. 86

86 (91) Anterior end bluntly pointed, angle formed by lateral margins of head not less than 60°. Cephalic appendages blunt. Body about as wide just back of appendages as immediately in front of them. 87

87 (88) Angle formed by lateral margins of head much greater than 60°. Cephalic appendages very inconspicuous, almost entirely wanting in young specimens.

Planaria foremanii (Girard) 1852.



Length of mature specimens 7 to 15 mm., breadth 2 to 4 mm. Color nearly uniform seal-brown or dark gray to slate-black, with an inconspicuous gray area on each cephalic appendage. Eyes gray with a crescent of black pigment on the median side. Body comparatively thick. Ovaries two, ventral, somewhat lobed and situated about halfway from anterior end to pharynx. Testes four or five on each side, unpaired, dorsal and irregularly distributed from region of ovaries to posterior end of pharynx. Does not multiply by fission. Found in small streams in Mass., Penn., Md., Va., and near Washington, D. C.

The species described by Curtis (1900) under the name *Planaria simplicissima* and later by Stevens under the same name clearly must be regarded as synonymous with the species established by Girard in 1852 under the name *P. foremannii*. This species also appears under the name *P. lugubris* in various papers dealing with the physiology of planarians.

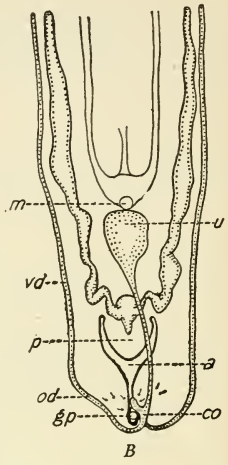
FIG. 629. *Planaria foremanii*. (*A*) Outline sketch of large mature specimen: *gp*, genital pore; *ph*, pharynx; *s*, sensory area on cephalic appendages. × 4. (After Stevens.) (*B*) Sexual organs, longitudinal section, dorsal view: *c*, cirrus; *d*, oviduct; *ph*, pharynx; *sv*, seminal vesicles; *t*, testes; *ut*, uterus; *v*, ovary; *vi*, yolk glands; *vt*, vas deferens. × 20. (After Curtis.)

88 (87) Angle formed by lateral margins of head about 60°. Cephalic appendages distinct. Anterior margin of cephalic appendages of about same length as posterior margin. 89

89 (90) Color blackish to purplish or brownish by reflected light, blackish or gray by transmitted light. With many irregular spots entirely free from pigment. . *Planaria maculata* Leidy 1848.

Length 15 mm. Immature specimens average about 8 to 11 mm. In small specimens the pigment occurs in isolated patches and spots. In larger specimens the pigment patches are confluent chiefly in the median region leaving the clear irregular areas which give a very spotted appearance to the animal. Smaller spots of deep brown or black scattered among the larger patches. Frequently with a light median streak. Posterior half of cephalic appendages with non-pigmented spots. Ventral surface much lighter than dorsal, almost entirely free from pigment. Reproduces freely by transverse fission posterior to pharynx. Sexually mature specimens not common in most localities. Sluggish. Much less active than those nearly related species which might be confused with it. Found commonly among algae and water plants or under stones where water is comparatively quiet. Mass., Penn., Ill., Mich., Neb.

A



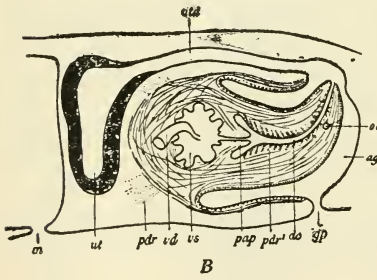
B

FIG. 630. *Planaria maculata*. (*A*) From life. × 6. (After Woodworth.) (*B*) Sexual organs, dorsal view: *u*, uterus; *co*, common oviduct; *od*, oviduct; *a*, atrium; *gp*, genital pore; *p*, cirrus; *vd*, vas deferens; *m*, mouth. × about 35. (After Curtis.)

90 (89) Color dark reddish-brown to grayish-brown. Uniformly pigmented. *Planaria gonocephala* Dugès 1830.

A

Greatest length 25 mm. Usually not over 15 mm. Girard describes the color of this species as often of a blackish-brown. Posterior margins of auricular appendages free from pigment. Much lighter on ventral than on dorsal side. Eyes in a plane joining the apices of the auricles. Clear areas around eyes sometimes elongated in an antero-posterior direction. Reproduction asexually common. Mich., Ill.



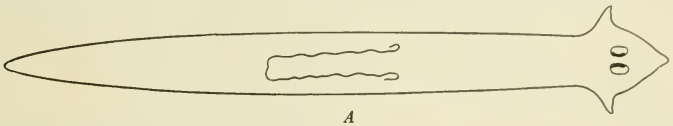
B

FIG. 631. *Planaria gonocephala*. (*A*) From life. × 5. (After Woodworth.) (*B*) Sexual organs, longitudinal section side view: *ut*, uterus; *od*, oviduct; *de*, ductus ejaculatorius; *pap*, papilla; *vd*, vas deferens; *ag*, genital atrium; *vs*, vesicula seminalis; *m*, mouth; *utd*, duct of uterus; *pdr*, cirrus glands; *pdr*¹, ducts of cirrus glands; *gp*, genital pore. Much enlarged. (After Böhmig.)

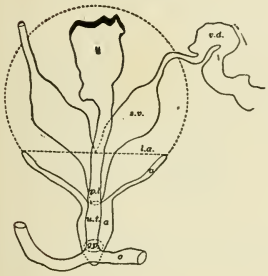
91 (86) Anterior end rather sharply pointed. Angle formed by lateral margins of head not more than 60°. Cephalic appendages long, slender, sharply pointed, with anterior margin shorter than posterior margin. Body distinctly narrower back of cephalic appendages than just in front. 92

92 (93) Angle of head 50° to 60°. Color a very dark sepia-brown almost black by reflected light. . . *Planaria agilis* Stringer 1909.

Length of immature worms usually not over 18 mm. Mature specimens collected have measured 30 mm. Well fed specimens in aquaria have attained a length of 55 mm. Color usually very uniform. Ventral surface but little lighter than dorsal. One variety found only in one locality and with uniformly colored specimens, shows sharply defined non-pigmented spots. Under lens a clear light-brown ground with fine dark brown, almost black pigment granules, either quite uniformly distributed or arranged so as to give the appearance of a very close net work. Circum-ocular spaces either oval or slightly pointed at outer anterior region and placed just in front of or in line with the anterior margins of cephalic appendages. Some with light areas on posterior margins of cephalic appendages, others with auricles uniformly pigmented. A light median streak sometimes present. Lateral margin of head with a distinct inward curve just back of tip, also at junction of head with cephalic appendages. Wider just in front of appendages than at any point posterior to them except in large specimens which are of about same width through pharyngeal region. Mature specimens much broader proportionally than immature. Asexual reproduction the usual method of propagation in most localities. Very restless and active. Collected from small ponds and spring-fed brooks either among algae or on sandy bottom and often where water flows swiftly. Neb., Mo., S. Dak., Wis., and Cal.



A



B

Fig. 632. *Planaria agilis*. (*A*) Immature specimen from life. ×8. (*B*) Sexual organs, dorsal view: *u*, uterus; *ut*, uterus tube; *o*, oviduct; *gp*, genital pore; *a*, atrium; *sv*, seminal vesicle; *vd*, vas deferens; *pl*, cirrus lumen; *la*, limit of atrium. Much enlarged. (After Stringer.)

93 (92) Angle of head about 45°. Color reddish to yellowish-brown. *Planaria dorotocephala* Woodworth 1897.

Length of immature specimens 13 mm. Head about one-sixth of total length of body. Uniformly colored. Posterior margins of auricular appendages free from pigment. Sometimes a narrow light median streak. Pigment in spots or patches, not a network or evenly distributed as in *P. agilis;* ventral side much lighter than dorsal. Eyes just anterior to plane joining auricles. Intestine usually with accessory posterior intestinal trunks which arise either at the root of the pharynx like the two normal posterior trunks or exist as parallel branches of the latter. Those of a side usually unite with each other near their posterior terminations. Very active and restless. Sexual organs have not been described. Ill., Mich.

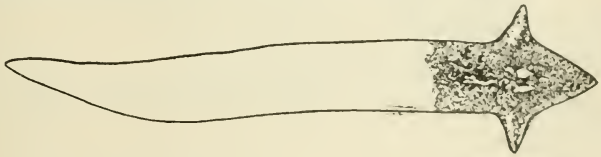


Fig. 633. *Planaria dorotocephala* from life. × 7. (After Woodworth.)

94 (85) Anterior end clearly not pointed. 95

95 (100) Anterior end truncated. 96

96 (99) Margin of anterior end with a median anterior and two lateral rounded projections giving a sinuous outline. 97

97 (98) Color gray. . . . . *Planaria velata* Stringer 1909.

Length of mature specimens 15 mm. Color of dorsal side to unaided eye varies from almost white to a very dark gray almost black. Under lens, a colorless groundwork with black pigment granules extremely variable in number. Much lighter in front of eyes and over cephalic appendages. Lighter on ventral surface, over pharynx, and near lateral margins. Preserved material often appears colorless and oval in shape. Encystment of the entire animal or division into a variable number of pieces followed by encystment of the pieces occurs in response to unfavorable conditions. The cysts resemble egg cocoons in appearance and are provided with a shell. Cilia conspicuous. Crete and Omaha, Neb.

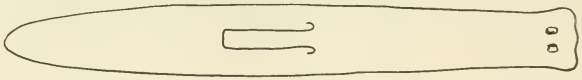


Fig. 634. *Planaria velata* from life. × 12. (After Stringer.)

98 (97) Color brownish-red mottled with purplish dots except at margins. *Planaria unionicola* Woodworth 1897.

Length of the one specimen (preserved) from which the description was made 2.8 mm., breadth 1.8 mm. Probably 8 to 10 mm. long when alive and extended. Purple dots occur in masses. Red color absent over an elongated posterior median area extending nearly to the posterior axis of the animal. Appearance of posterior end suggests an injury or transverse division. Color of alcoholic material a deep rusty red. Found creeping on the mantle of *Unio alatus* in Illinois River.

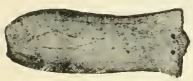


Fig. 635. *Planaria unionicola* from life. About × 3. (After Woodworth.)

99 (96) Margin of anterior end uniformly curved, not sinuous. Color white. *Planaria truncata* Leidy 1851.

Length 10 to 12 mm. Thickness slight. Translucent. Digestive tract variously colored by food. Two crescent-shaped eyes situated far back and near together. Pharynx much elongated and central in position in sexually mature specimens. Intestine with little anastomosis of branches. Ovaries two, sometimes lobed. Testes many. Uterus large with stalk running to left side, dorsal to vasa deferentia and oviducts and entering atrium laterally. Asexual reproduction by fission. Small stream Bryn Mawr campus; rivulet at Newark, Delaware.

A comparison of descriptions of *P. truncata* Leidy and *P. morgani* Stevens and Boring leaves but little doubt that they are identical. The blackish-white color mentioned by Leidy evidently was due to food contained in the digestive tract and not to body pigment since the margin is described as translucent.

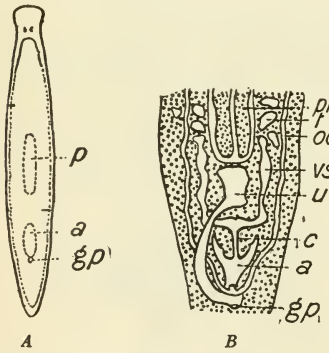


Fig. 636. *Planaria truncata*. (*A*) From life. × 4. (*B*) Dorsal view of sexual organs: *a*, atrium; *c*, cirrus; *gp*, genital pore; *od*, oviduct; *ph*, pharynx; *t*, testes; *u*, uterus; *vs*, vas deferens. × 7. (After Stevens.)

100 (95) Anterior end rounded in preserved condition (living condition not known). . . . . *Planaria simplex* Woodworth 1897.

Length 4 mm., greatest diameter 1.8 mm. Color of alcoholic specimen ocher-yellow. Pigment located in spots of nearly uniform size, distributed uniformly over all parts of the body; no clear areas surrounding eyes or at sides of head. General shape ovate. Broadest at one-fifth the total length from the anterior end, tapering from here to rounded posterior extremity. Anterior end rounded, set off from the rest of the body by slight lateral indentions at the level of the eyes. No evidence of cephalic appendages. Mouth one-third of total length from posterior

end. Eye spots elongated, crescentic, facing outward and forward at an angle of 45° to the chief axis of the worm. Intestine of the simple triclad type; no fusion or anastomoses of posterior stems.

This description is from a single immature alcoholic specimen. (It is quite possible that the apparent lack of cephalic appendages is due to the effect of the killing fluid.) Collected off N. Y. Point, Lake Mich.

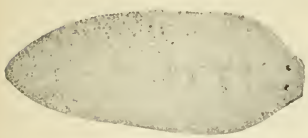


Fig. 637. *Planaria simplex*. From preserved material. × 10. (After Woodworth.)

101 (84) Without eyes. . . . . *Planaria fuliginosus* Leidy 1851.

Length about 5 mm., breadth 4 mm. Body oval, dilated; inferiorly flat, superiorly moderately convex, fuliginous. Eyes none; in their ordinary position a slightly greater accumulation of black pigment upon the upper surface. Mouth a little posterior to the center. Esophagus simple. Rancocas Creek near Pemberton, New Jersey.

102 (83) Normal eyes many, arranged so as to suggest a coronet near the margin of truncated head and extending back near the lateral margins to a somewhat variable distance. . *Polycelis.*

Only one species known in this country.

Polycelis coronata (Girard) 1891.

Length 8 mm., breadth 2 mm. Color fuliginous or sooty, uniform, somewhat darker on the median dorsal region than on margins. Elongated lanceolate. Anterior margin truncated, weakly bilobed or undulating. The numerous eyes are arranged as a coronet or as an arc of a circle, the arrangement being dependent to some extent on size. Pharynx elongated, central. Collected near Fort Bridger, Wyoming. It is quite possible, as Hallez notes, that this is a synonym of the European *Polycelis nigra*.

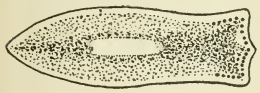


Fig. 638. *Polycelis coronata*. From life. × 5. (After Girard.)

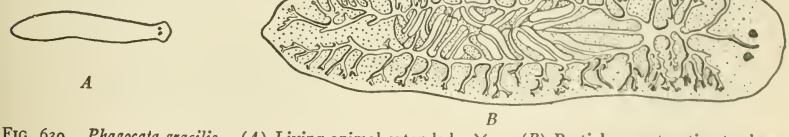
103 (80) Pharynges numerous. . . . . *Phagocata.*

Only one species known in this country.

Phagocata gracilis (Haldeman) 1840.

This species was found and recorded by Haldeman; it was first adequately described by Leidy to whom it is ordinarily attributed.

Largest specimens 35 mm. long, 4.5 mm. wide. Color shiny black by reflected light, greenish-gray by transmitted light. Varies from black to a reddish-brown on one hand or to a light gray on the other. Small specimens at times almost milky-white. Ventral side lighter than dorsal. Lateral margins nearly parallel. Widest through pharyngeal region. Anteriorly sides converge slightly up to about the region of eyes where the diameter increases to form the head with its rounded cephalic appendages. Posteriorly sides converge to a point. Eyes two with elongated circum-ocular areas. The numerous pharyngeal tubes lie in a common chamber and open separately into the intestinal tract. When extruded they reach the exterior through a single orifice. Pools and rivulets, Mass., Penn., Ohio, Wis.



A *B*

Fig. 639. *Phagocata gracilis*. (*A*) Living animal extended. × 4. (*B*) Partial reconstruction to show pharynges and their relation to the intestinal tract. × about 8. (After Woodworth.)

104 (79) Found in moist places on land. . . Suborder **Terricola** . . 105

The so-called land planarians are forms which in a biological sense stand very near the water-living species. They occur only in very moist localities and under circumstances may be taken for fresh-water forms. In general appearance they resemble minute, delicate slugs. When examined under the microscope the structure appears clearly to be that of a flatworm rather than of a mollusk. The few known species are widely and sparsely distributed. They

are likely to be transported in tropical or subtropical vegetation and to make their appearance suddenly and in considerable numbers in greenhouses or in moist shady nooks that have been planted with exotic species. Of one form indeed the proper habitat is not known. Walton has worked out a key and synopsis of the few species reported from North America and adjacent islands. In modified form this is followed here. Almost no records of the occurrence of these forms on this continent have been published, and their numbers as well as their range are sure to be considerably extended when attention is directed to them.

105 (110) Eyes either absent or numerous; length more than 40 mm. . . 106

106 (109) Head anteriorly not broader than remainder of body.
Family GEOPLANIDAE . . 107

107 (108) Posterior part of head with eyes in two rows; sides margined with orange. . . . . *Geoplana nigrofusca* (Darwin) 1844.

Length 50 mm. Found in Mexico; reported also from South America.

108 (107) Posterior part of head with eyes in one row; sides margined with light brown. . . . . *Geoplana stolli* (von Graff) 1899.

Length 60 mm. Thus far known only from a single specimen collected in Guatemala.

109 (106) Head anteriorly broader than the body. . . . Family BIPALIDAE. Only one species. . . . . *Placocephalus kewense* (Moseley) 1878.

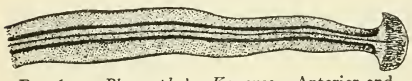


FIG. 640. *Placocephalus Kewense.* Anterior end. × 1. (After von Graff.)

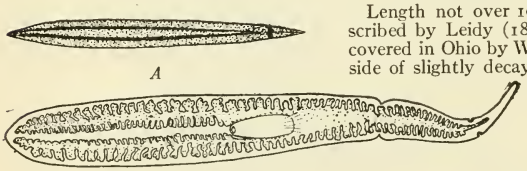
Color dorsally yellow or greenish-yellow with five dark violet longitudinal lines. Length 80 to 250 mm. An introduced species found in hot houses. Its original home is unknown.

110 (105) Eyes two in number; ventral suckers absent; length less than 30 mm. 111

Rarely the eyes are apparently absent but even here they may be demonstrated in sections. Ventral suckers do occur in the related family Cotyplanidae. Known from Africa and New Zealand.

111 (114) Eyes small, marginal sense organs present.
Family RHYNCHODEMIDAE . . 112

112 (113) Color dorsally light brown with two darker longitudinal stripes and transverse area at posterior two-thirds of body.
Rhynchodemus sylvaticus (Leidy) 1851.



A

B

Length not over 10 mm. Common in places described by Leidy (1851) in Pennsylvania and rediscovered in Ohio by Walton (1904). Frequents under side of slightly decayed boards, sticks, etc., in company with snails, the young forms of which it closely resembles. Range, Eastern United States.

FIG. 641. *Rhynchodemus sylvaticus.* (*A*) Dorsal view of individual from Philadelphia, Pa. × 5. (*B*) Individual from Newport, R. I., showing arrangement of esophagus and structure of intestine. × about 5. (After Girard.)

113 (112) Color dorsally uniformly dark blue.
Rhynchodemus atrocyaneus Walton 1912.

Length 20 mm. Only two specimens of this form have been reported. Found at Gambier, Ohio, under decayed boards.

114 (111) Eyes well developed; marginal sense organs absent.
Amblyplana cockerelli von Graff 1899.

Color dorsally bluish-black with light yellow median stripe longitudinally and yellow "neck band." Length 17 mm. Represented only by two known specimens found in Jamaica.

The following is a list of those forms which are not sufficiently well known to be given their proper place in the key.

Order **Rhabdocoelida**

Section I Hysterophora

Family Catenulidae

Microstomum philadelphicum Leidy 1851
Microstomum variabile Leidy 1851

Section II Lecithophora

Subsection Liporhynchia

Family Typhloplanidae

Typhloplanid from Canandaigua Lake, N. Y., von Graff 1911
Typhloplanid from Irondequoit, N. Y., von Graff 1911
Mesostoma pattersoni Silliman 1885

Family Dalyellidae

Dalyellia bilineata (Woodworth) 1896
Dalyellia marginatum (Leidy) 1847
Derostoma elongatum Schmarda 1859

Subsection Calyptorhynchia

Rhynchoprobolus papillosus Schmarda 1859

The following Rhabdocoels are of very doubtful position and relationships

Vortex (?) *cavicolens* Packard 1883
Plagiostoma (?) *planum* Silliman 1885
Acmostomum crenulatum Schmarda 1859

Order **Tricladida**

Dendrocoelum sp. Pearl 1903

A brief description of these doubtful species will serve to promote their rediscovery and further study. Each description is taken from the original account of the species which is also the only record of it yet published.

Microstomum philadelphicum Leidy 1851.

Body linear, slightly attenuated posteriorly; head conoidal with the apex surmounted by a small oval papilla; tail obtusely rounded. Respiratory fovea subhemispherical, placed at the base of the cone of the head. Mouth oval, projectile; esophagus keg-shaped, intestine narrowed, cylindroid, dilated at the commencement. Colorless, translucent, ciliated, increasing by transverse segmentation, always observed in the process of forming two segments. Length 0.9 mm. Found in water of marshes and ditches near Philadelphia.

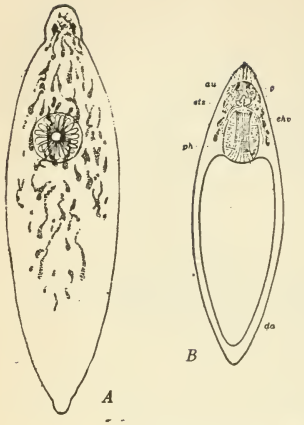
Microstomum variable Leidy 1851.

Body broad, linear; anteriorly and posteriorly obtusely rounded. Respiratory fovea longitudinally oval, lateral. Intestine very broad. Colorless, increasing by twos. Length from 0.3 to 1 mm. No nematocysts or rhabdites. Found with *Microstomum philadelphicum*. Also a chain of 4 individuals was collected in algae culture from shore, Charlevoix, Mich., by Dr. H. B. Ward.

Typhloplanid from Lake Canandaigua, N. Y., von Graff 1911.

Length 1 mm. Anterior end set off from the rest of the body by depressions at the sides, probably sensory pits. Broadest through middle of body which measures about one-fourth the length. Spindle-shaped rhabdites in glands and tracts of anterior end. Pigment is present in the form of large reddish-brown granules which mostly lie lengthwise of the body, sometimes branched, and enlarged at posterior end. The pigment forms a reticulation between and passes over the irregularly shaped eyes. Eyes twice as far apart as they are distant from the margin of the body. Pigment of eyes the same as that of the body, only much closer compacted so that they are deeper in color.

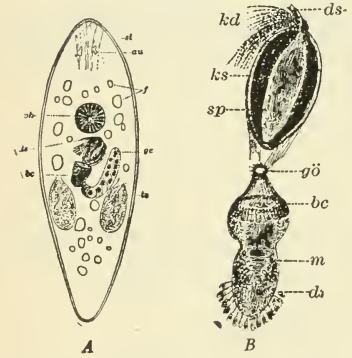
The mouth lies in the anterior third of the body. In the uncompressed animal the pharynx



shows as a typical rosette-shaped pharynx. This form is unusual in that the rosette-shaped pharynx does not lead into the intestine from its ventral side, but opens into its anterior end so that when compressed its axis becomes directed forward. Intestine yellowish and extending almost to the posterior end, and having the general shape of the body.

FIG. 642. Typhloplanid from Lake Canandaigua, N. Y. (*A*) Swimming freely, showing the dorsal pigmentation. × 55. (*B*) Slightly compressed with pharynx directed forward. × 40. *au*, eyes; *da*, intestine; *ehv*, anterior branches of protonephridium; *g*, brain; *ph*, pharynx; *stz*, rhabdite glands. (After von Graff.)

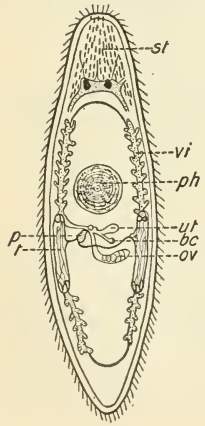
Typhloplanid from Irondequoit, N. Y., von Graff 1911.



Length 0.5 mm. Without pigment and colorless apart from the brownish-red eyes and the oil drops of the intestine. Eyes irregular in shape and almost twice as far from the side of the body as from each other. The mouth lies on the boundary between the first and second thirds of the body. The anterior end shows many tracts of rhabdites. Collected from a reedy swamp.

FIG. 643. Typhloplanid from Irondequoit, N. Y. (*A*) The animal slightly compressed. × 80. (*B*) Male copulatory organ. × 320. *au*, eye; *bc*, bursa copulatrix; *dr*, gland cells; *ds*, ductus seminalis; *f*, fat drops; *ge*, ovary; *gö*, genital pore; *kd*, granular glands; *ks*, granular secretion; *m*, muscles; *ph*, pharynx; *st*, tracts of rhabdites; *te*, testes. (After von Graff.)

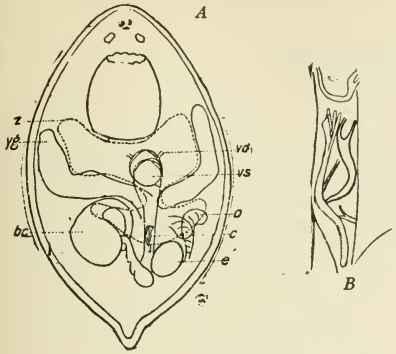
Mesostoma pattersoni Schmarda 1885.



Length 3 to 3.5 mm., 0.6 mm. broad through middle. Color in reflected light brownish except anterior to the eyes which appears grayish from the rhabdites. Intestine yellowish. Body fluid with many cells which contain granules. Eyes directly above the brain. Pharynx rosette-shaped, not far from middle of body.

FIG. 644. *Mesostoma pattersoni*. *st*, tracts of rhabdites; *ph*, pharynx; *vi*, yolk gland; *ut*, uterus; *bc*, bursa copulatrix; *ov*, ovary; *p*, cirrus; *t*, testes. × 20. (After Silliman.)

Dalyellia bilineata (Woodworth) 1896.



Length 0.96 mm., breadth 0.24–0.32 mm. Anterior end truncated, posterior end pointed. Pharynx dolioliform, in anterior third of body, traversed by two prominent, lateral, nearly longitudinal bands of light chocolate-brown, and numerous other pale indistinct longitudinal lines. Zoochlorellae in central part of the body, posterior fifth free from them, transparent-brown. Egg dark chocolate, 120 μ × 80 μ.

The figures given here are those which were in possession of Woodworth with the material when the description was written and the species named.

Fig. 645. *Dalyellia bilineata*. *A*, compressed. × about 50. *vd*, vas deferens; *vs*, vesicula seminalis; *o*, ovary; *c*, chitinous portion of cirrus; *e*, egg; *bc*, bursa copulatrix; *yg*, yolk gland. *B*, chitinous piece. × about 200. (Unpublished sketch by Ward.)

Dalyellia marginatum (Leidy) 1847.

Blackish, narrow lanceolate, anteriorly truncate; marginate margin delicately striate; mouth large; pharynx large and oblong; eyes two, anterior, distant, each consisting of two round masses of black pigment in contact with each other and of which one is larger than the other; generative orifice one-fourth the length of the body from the posterior extremity. Length 2 mm. A single specimen found in ditches near Philadelphia, Pa. Digestive cavity consists of a large capacious sac extending as far back as the posterior third of the body and having a cecum upon each side of the proboscis. The cirrus has a yellow color and consists of a round granular mass with a moderately long and bent spiculum projecting from its posterior part. This is the form described by Leidy under the name *Prostoma marginatum*.

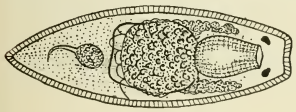


Fig. 646. *Dalyellia marginatum*. × about 20. (After Girard.)

Derostoma elongatum Schmarda 1859.

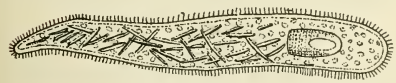


Fig. 647. *Derostoma elongatum*. × about 25. (After Schmarda.)

The body is long, ribbon-shaped, flattened. Posteriorly uniformly tapering. Color reddish-gray. Length 2 mm. Without eyes. Mouth opening elliptical. Pharynx long, cask-shaped. From brackish water in swamp, New Orleans, La.

Rhynchoprobolus papillosus Schmarda 1859.

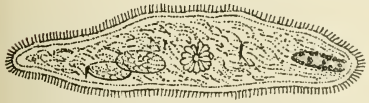


Fig. 648. *Rhynchoprobolus papillosus*. × about 9. (After Schmarda.)

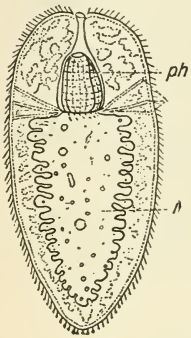
Body somewhat compressed, anteriorly rounded, posteriorly gradually tapering. Color clear yellow. Length 5 mm. Without eyes. Proboscis short, round, externally set with small papillae. Mouth opening central. Pharynx rosette-shaped. From brackish water, Hoboken, N. J.

Vortex (?) *cavicolens* Packard 1883.

Found in X cave, one of the Carter caves, Kentucky. Body flat, elongated, narrow lanceolate-oval, contracting in width much more than is usual in *Vortex* (Dalyellia). Pharynx is situated much farther back from anterior end of body than is usual in *Vortex*, being placed a little in front of the middle of the body; it is moderately long, being oval in outline. The body behind suddenly contracts just before the somewhat pointed end. The genital outlet

is about one-half as wide as the pharynx and orbicular in outline. Apparently eyeless. White. Length 4 mm., breadth 1.5 mm. Brooks, Carter Caves, Kentucky.

Plagiostoma (?) *planum* Silliman 1885.



Length 1.5 mm., breadth 0.7 mm. Mouth opening in anterior end. Pharynx lies within a sheath and has both longitudinal and transverse muscle layers. Radial muscle fibers pass from the base of the pharynx to the body wall. Without eyes or other sense organs. The poorly developed brain lies in front of the pharynx as a transverse band. The intestine is capacious and has short lateral diverticula. This species probably belongs to the genus *Prorhynchus*.

FIG. 649. *Plagiostoma* (?) *planum*. *ph*, pharynx; *d*, intestine. × about 30. (After Silliman.)

Acmostomum crenulatum Schmarda 1859.

The body is cylindrical, yellowish, 1 mm. long. Pharynx cylindrical, protractile with six deep lobes on its margin. Otolith large and spherical contained within a transparent capsule which is located at the end of the first third of the body. The ovaries form a large spherical mass in the posterior part of the body. The cirrus is short knife-shaped and has a slight double curve. Found in brackish water, Hoboken, N. J.

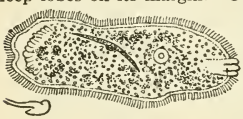


FIG. 650. *Acmostomum crenulatum*. From life. × about 30. (After Schmarda.)

Dendrocoelum sp. Pearl 1903.

Agrees with description of *Dendrocoelum lacteum*, except in respect to the color. Color ranges from a light grey to nearly black, and is uniform. Found about Ann Arbor, Mich.

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