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**THE FRESH-WATER TRICLADS  
OF MICHIGAN**

BY  
ROMAN KENK

ANN ARBOR  
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JANUARY 18, 1944

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FREDERICK M. GAIGE  
Director of the Museum of Zoology  
University of Michigan

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# THE FRESH-WATER TRICLADS OF MICHIGAN

## INTRODUCTION

THE triclad fauna of Michigan has so far received only scant attention. The earliest author to record a fresh-water triclad or planarian from Michigan was Ward (1894), who reported *Planaria maculata* (*Dugesia tigrina*) from J. E. Reighard's investigation of Lake St. Clair. Woodworth (1896*b* and *c*), studying the Turbellaria collected by the Michigan Fish Commission during 1893 and 1894, identified *Planaria maculata* (*Dugesia tigrina*), *Procotyla fluviatilis*, and "*Planaria simplex*" from Michigan lakes. Pearl's (1903) well-known studies of the movements and reactions of planarians were on several species obtained in the vicinity of Ann Arbor. No further data are available in literature, except for short notes by Hyman (1925, 1931*a*) and Kenk (1941) concerning the occurrence of *Planaria lata* (*Dugesia tigrina*) and *Phagocata velata* in Michigan.

The entire group of fresh-water triclads has never been studied monographically. Information on the American representatives of the group is scattered in numerous publications, many of which are available in only few libraries. Moreover, the taxonomy of the planarians has recently undergone considerable revision, as an attempt has been made to base the classification on anatomical rather than external characteristics. This and a strict application of the International Rules of Zoological Nomenclature have made it necessary to change the scientific names of many species. Great advances in the knowledge of the morphology and distribution of American planarians have been made in recent years by the studies of L. H. Hyman (see Literature Cited).

The present report is the result of a preliminary survey of the triclads of Michigan. Within the limited time at my disposal it was not possible to cover the entire territory of the state evenly. Field collections were made mainly within a one-day radius of the Biological Station of the University of Michigan on Douglas Lake, near Cheboygan, and in the vicinity of Ann Arbor. Considerable areas of the Lower Peninsula as well as most of the Upper Peninsula could not be included in the study.

In view of the present state of the knowledge of the American triclads and the absence of a suitable monograph of the group, it appeared to be advisable to include herein the synonymy as well as the taxonomic characteristics of each of the species concerned. This involved, to some extent, a repetition of data already well-established in literature, but it is believed that it will render this report useful to a wider circle of workers.

The investigations were carried out at the Biological Station at Cheboygan, and in the Mollusk Division of the Museum of Zoology of the University

of Michigan. I wish to express my indebtedness to Mr. Calvin Goodrich and Professors George R. LaRue, Peter Okkelberg, and Carl L. Hubbs, who kindly placed at my disposal the facilities of their departments and laboratories, and to all who assisted in procuring material for this study.

#### FAMILY PLANARIIDAE

The family Planariidae comprises all the fresh-water triclads in which the inner muscle zone of the pharynx consists of two distinct layers, a longitudinal and a circular one.

#### *Curtisia foremani* (Girard, 1852) Hyman, 1931a

*Dugesia Foremanii* Girard, 1852.

*Planaria foremanii* Stringer, 1918.

*Planaria simplicissima* Curtis, 1900.

*Planaria simplicissima* Stevens, 1907.

*Planaria lugubris* Morgan, 1901, etc. (*non* Schmidt, 1861).

*Curtisia simplicissima* Graff, 1916.

**EXTERNAL FEATURES** (Pl. I, Fig. 1).—Mature animals attain a length of 7–15 mm. and a width of 1.5–4 mm. The general shape is rather broad, the body comparatively thick. The anterior end is bluntly triangular, with a pair of rounded and only slightly protruding lateral appendages (auricles). The color of the dorsal side appears almost uniform to the naked eye and may be of various shades of brown or gray, sometimes almost black. The area above the pharynx and the margins of the body are slightly lighter than the general surface. In the postpharyngeal region a darker median streak may be developed. Under low magnification the pigment appears somewhat spotted or cloudy. The ventral side is lighter (grayish). Two spots above the eyes, an oblique dash on the dorsal side of each auricle, a spot at the mouth opening, and one at the genital pore are free from pigment (white). The eyes, normally two (one to four supernumerary eyes occasionally occur), are situated immediately in front of the level of the auricles; their distance from each other is somewhat less than one-third the width of the head at the level of the eyes. The base of the pharynx lies near the middle of the body, and its length is about one-sixth the body length. The pharynx is unpigmented (white). The genital aperture is closer to the mouth than to the posterior end.

**ANATOMICAL FEATURES.**<sup>1</sup>—The very few testes are dorsal, irregularly scattered, one to six to each side of the mid-line from the region of the ovaries to the level of the mouth. The copulatory apparatus is small, with a single atrial cavity. The penis has a small, feebly muscular bulb and a straight, cylindrical or finger-shaped, papilla. The bulb contains a rounded seminal vesicle into which the two vasa deferentia open separately from both

<sup>1</sup> Cf. Curtis, 1900; Stevens, 1904: 210; Kenk, 1935: 80–82.

sides. From the vesicle a narrow, straight ejaculatory duct runs along the axis of the papilla to open at its point. The bursa stalk starts from the posterior and dorsal side of the atrium, runs first dorsally to form a widened part (vagina), then as a narrow tube anteriorly, and finally connects with one or two branches of the posterior intestinal trunks to the right or left, or to both sides. The absence of a bursa is particularly characteristic of the species. The oviducts unite posteriorly to the copulatory organs and open from behind into the widened part of the bursa stalk, which also receives the ducts of numerous eosinophilic shell glands.

The round cocoon or egg capsule is attached to the substratum by a thin, flexible stalk.

ECOLOGY.—*Curtisia foremani* is a typical inhabitant of small creeks and rivers that do not warm up very much in the summer. Cold springs, warm rivers, and stagnant water are apparently not suitable for the animal. Therefore, as a rule, it is not found in streams that drain shallow lakes. In favorable environments it is present, sometimes in large numbers, on the undersurfaces of stones, where the egg capsules may also be found, anchored by means of their stalks. Sexually mature individuals can be collected at any season of the year. No agamic reproduction has been observed in this species.

DISTRIBUTION.—*Curtisia foremani* has been collected in many localities in Michigan:

1. Big Stone Creek (Pl. III, Fig. 1), in Wilderness State Park (northwest of Carp Lake), Emmet County. Water clear, current mostly sluggish, but in some places rapid; bottom, mud and stones. June 29, 1940: one cocoon. July 3, 1940, water temperature, 17.7° C.: many mature and immature specimens and numerous cocoons of *C. foremani* collected under stones (and several *Procotyla fluviatilis*).

2. Maple River (Pl. III, Fig. 2), greater part in Emmet County. East Branch, northeast of Pellston, July 15, 1940: two immature specimens on wood (coll. R. I. Sailer); July 22, 1940, 29.5° C.: several mature and immature individuals under stones. East Branch, north of Pellston, July 22, 1940, 23.4° C.: numerous specimens, young and mature, and hundreds of cocoons under stones. West Branch, south of Pellston, July 22, 1940, 21.7° C.: two immature animals and two cocoons under stones.

3. Lancaster Creek, about one-fourth mile above Lancaster Lake, Cheboygan County. Warm, clear, colored water, moderate current; bottom, mud and sand, few stones. July 27, 1940, 18.1° C.: in small rapids numerous specimens, mature and young, and cocoons under stones.

4. Fisher Creek, tributary of Black Lake, Cheboygan County. Water clear, swift current, at the lowest bridge, about one-fourth mile from the mouth; bottom, sand and few stones. August 7, 1940, 21.9° C.: exceedingly numerous; the majority immature; several cocoons under stones.

5. Milliken Creek (Pl. II, Fig. 2), tributary of Black River, southwest of Black Lake, Cheboygan County. Current swift; bottom, sand and mud, with stones. August 7, 1940, 21.8° C. (at the bridge of U. S. Highway 23): two planarians and two cocoons under stones.

6. Stoney Creek, tributary of Black Lake, on the boundary line of Cheboygan and Presque Isle counties. Water clear; moderate current; bottom, sand and stones, partly mud. July 10, 1940, 13.5° C.: several specimens, mature and young, and cocoons.

7. Ocuqueoc River, Presque Isle County, at the bridges of U. S. Highway 23. Water clear, swift. Bottom, sand, mud, and stones. July 30, 1940, 27° C.: one planarian and two cocoons under stones.

8. Silver River, east of Eagle Harbor, Keweenaw County. Current swift; bottom, mud and stones. August 18, 1940, 14.5° C. (at the bridge of Michigan Highway 26): one stalked cocoon, apparently belonging to *Curtisia foremani*, under a stone.

9. Jackson's Creek (Pl. II, Fig. 1), about four miles northeast of Wakefield, Gogebic County. Water clear, highly colored, current rapid. August 19, 1940, 16.2° C. (at the bridge of Michigan Highway 28): under stones, several planarians and cocoons.

10. Iron River, Ontonagon County. Water clear, highly colored, moderate current, local rapids; bottom, mud and stones, much algal vegetation. August 19, 1940, 17.5° C. (at the bridge of Michigan Highway 28, west southwest of Bergland): several specimens (mature and immature) and cocoons under stones.

11. Little Iron River, Ontonagon County. Water clear, cool, current rapid. August 19, 1940 (near the mouth of the river): planarians and cocoons under stones.

12. Mineral River, Ontonagon County. Water clear, moderate current; bottom, sand and stones. August 19, 1940, 17° C. (at the bridge of Michigan Highway 64, about two miles south of White Pine): planarians and cocoons under stones.

13. A creek on Loch Alpine golf course, on Huron River Drive, near Delhi, six miles northwest of Ann Arbor, Washtenaw County. Water clear, current swift. October 28, 1940 (on the golf course above the artificial lakes): young and mature *Curtisia foremani* (and *Dugesia tigrina*) under stones.

14. A small stream on the north bank of Huron River, about one mile east of Dexter, Washtenaw County. Sluggish current; bottom with many decaying leaves and dense algal growth. February 12, 1941, 6° C.: one specimen on a dead leaf. February 26 and 28, 1941: samples of leaves and mud brought to the laboratory contained numerous mature and young of *Curtisia foremani* (and *Phagocata velata*).

15. A stream on Geddes Road, about two miles east of Ann Arbor, Washtenaw County. Water clear, current swift. April 26, 1941, 16° C.: six specimens, mature and young, and one cocoon, under stones. The animals have a very light brown color, and some of them have exceedingly small eyes.

16. "Huron River near Ann Arbor," Washtenaw County. Pearl (1903: 526) collected his material of "*Planaria gonocephala*" mainly in this locality. It is practically certain that Pearl's *P. gonocephala* is *Curtisia foremani*. I have not found this species in the Huron River itself, but I have secured it in several tributaries in the vicinity of Ann Arbor (localities 13, 14, and 15).

17. A tributary of Williamsville Lake, Livingston County. Water clear, current rapid; bottom, sand and stones. April 7, 1941 (at the bridge about four miles east of Stockbridge, Ingham County): two mature specimens under stones.

*Curtisia foremani* has so far been recorded from Maryland, Massachusetts, Michigan, New York, North Carolina, Pennsylvania, Rhode Island, Tennessee, Virginia, and from Ontario, Canada. It is very probable that the geographical gap between Michigan and the main area of distribution in the eastern and southern states is only an apparent one and that the species occurs in a continuous range from the east coast to Michigan and even farther west.

*Dugesia tigrina* (Girard, 1850) Hyman, 1939

*Planaria maculata* Leidy, 1848 (*non* Fabricius, 1826; *non* Darwin, 1844; *non* Dalyell, 1853).

*Dugesia maculata* Girard, 1851.

*Planaria tigrina* Girard, 1850.

*Planaria lata* Sivickis, 1923.

*Euplanaria maculata + lata* Kenk, 1930.

*Euplanaria tigrina* Kenk, 1935.

*Euplanaria novangliae* Hyman, 1931a.

EXTERNAL FEATURES (Pl. I, Figs. 2-3). Length of mature specimens, 6-18 mm.; width, 1-3 mm. (asexual animals may reach a length of 25 mm.). The head of the quietly gliding animal is triangular, with the anterior angle formed by the bluntly pointed or somewhat rounded<sup>2</sup> anterior end, and the lateral angles by the short and broad auricles. The coloration of the animal has an exceedingly wide range of patterns and shades. A yellowish color and various hues of brown to almost black pigment often are present in one and the same individual. To the naked eye the coloration of the dorsal side appears more or less spotted, though specimens may be found in which the pigment spots are discernible only with the help of a hand lens. The color

<sup>2</sup> This depends somewhat on the activity of the animal.

patterns were analyzed and depicted by Hyman (1939: 267-70): there are two principal ones, the spotted and the striped. In the first (Pl. I, Fig. 2), spots of varying sizes and varying shades of brown form a ground on which white (unpigmented) splotches are dispersed irregularly. The striped pattern is characterized by two dark brown, continuous or disrupted streaks, respectively, to the right and left of the dorsal mid-line. The median stripe enclosed by these streaks may be of the same color as, or lighter than, the general ground, or may be entirely devoid of pigment (white). An extreme case of striped pigmentation was observed in animals from the bottom of Douglas Lake (Pl. I, Fig. 3). As a rule, specimens from one locality have more or less the same general pattern, though different shades and different grades of spottiness are usually represented. Occasionally, however, both spotted and striped animals may be found in the same locality. Two areas above the eyes and at least the posterior surface of the auricles are always without pigment. The ventral side is lighter, more or less grayish. It seems that it lacks pigment and that the grayish appearance is due to the pigment shining through from the dorsal side (in specimens collected in the southern part of Michigan, no pigment could be discovered ventrally in the living animal under a dissecting microscope). Eyes are normally two, situated at a short distance in front of the level of the auricular tips. Their distance from each other amounts to about one-fourth or one-fifth of the width of the head at eye level. The situation of the pharynx is usually well discernible from the dorsal as well as from the ventral side. The pharynx has a peculiar pattern of pigmentation: a grayish pigment covers the greater part of its surface, leaving free a distal (posterior) zone (one-fifth to one-third of the length of the pharynx). The arrangement of the pigment generally follows the pattern of the external surface. It is spotted if the animal shows a coarse spotted pattern and is almost uniform or cloudy if the surface color is more even. Frequently, the pigment granules are arranged in separate, rounded or more irregular, spots, each spot apparently corresponding to a separate pigment cell (Fig. 1). The proportion between

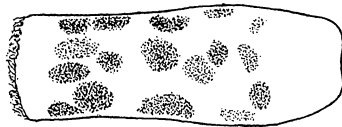


FIG. 1. *Dugesia tigrina*, pharynx extirpated from the living animal to show the peculiar pigmentation.  $\times 22$ .

the length of the pharynx and that of the body is subject to considerable variation, particularly during the periods of asexual reproduction.

ANATOMICAL FEATURES.<sup>3</sup>—Testes numerous, ventral, arranged in two lon-

<sup>3</sup> Cf. Curtis, 1902: 543-46; Sivickis, 1923: 116; Kenk, 1935: 85-86.



gitudinal zones, one to each side of the mid-line, extending from the region of the ovaries almost to the posterior end. Genital atrium divided into a posterior common atrium and a male atrium. Penis with a spherical bulb and a short conical papilla, which is directed caudad and ventrad. The two vasa deferentia enter the bulb from the sides and above, then turn ventrally and posteriorly. In traversing the tissues of the bulb, each one widens to form a spindle-shaped enlargement; the two finally unite in a canal, the ejaculatory duct, which opens at the free end of the penis papilla. The anterior part of this canal and the end parts of the vasa deferentia are often so much extended that they appear as a more or less spherical cavity (seminal vesicle). It seems, however, that the appearance of a spherical penis lumen is only transitory, corresponding to a particular phase of the reproductive activity. The bursa stalk starts from the dorsal side of the common atrium, runs first dorsally (vagina), then turns in an angle anteriorly to open into the sac-shaped bursa. At the angle of the bursa stalk, the two oviducts open close together (or after fusing, according to some authors) from the posterolateral sides. Ventrally to the openings of the oviducts, the outlets of numerous shell glands penetrate the epithelium of the bursa stalk. Large parts of the epithelia of the copulatory complex have depressed nuclei: the common and male atria, the posterior part of the bursa stalk, and the greater part of the surface of the penis.

The egg capsule is spherical and stalked.

TAXONOMY.—The great variation in the external appearance of *Dugesia tigrina*, as well as different physiological characteristics observed in lots of different origin, induced some authors to attempt to split the species into several distinct species. No appreciable differences, however, have been discovered in the reproductive organs of animals from different localities. It is very probable, as Hyman (1939: 270) pointed out, that *Dugesia tigrina* is a species in process of evolution into several species, but that the physiological and morphological differences between the different lots are not of a rank to justify the establishment of separate species.

ECOLOGY.—*Dugesia tigrina* is the most common planarian in Michigan. It lives in ponds, lakes, rivers, and creeks, particularly those that drain larger bodies of stagnant water. It is absent in cold springs and spring-fed ponds. One finds it commonly along the shores of lakes on the undersides of stones (Pl. IV, Fig. 1), or among water plants, but also in deeper water away from shore. The species reproduces either agamically, by fission, or sexually, by egg capsules. Fission occurs in nature mainly during the warmer season, sexual reproduction commonly in late spring and early summer. It is well known (Curtis, 1902; Kenk, 1937, 1940; Hyman, 1939: 271-72, 1941, 1943; Goldsmith, 1942) that lots from different localities have different reproductive habits, and that in certain localities *Dugesia tigrina* propagates exclusively by fission.

DISTRIBUTION.—1. "Lake St. Clair" (Ward, 1894: 50). Woodworth (1896*b*: 94, and 1896*c*: 240) also reported a specimen from Lake St. Clair at New Baltimore, Macomb County.

2. "Twin Lakes" and "West Twin Lake," Charlevoix County. "On leaves of *Nymphaea*" and from "Utricularia washings" (Woodworth, 1896*b*: 94; and 1896*c*: 240).

3. Douglas Lake, Cheboygan County. On the west side of South Fishtail Bay, under stones along the shore (Pl. IV, Fig. 1). June 25 and 26, 1940: numerous asexual specimens of the spotted color pattern in full agamic reproduction.

4. Douglas Lake, Cheboygan County. In the central interdepression area of Fishtail Bay, at a depth of 4-5 m. July 17 and 29 (coll. F. E. Eggleton), and August 8, 1940: numerous specimens of the striped (Pl. I, Fig. 3), the spotted, and intermediary types, many of them mature, and one cocoon collected among vegetation (*Chara*). The small size of the animals is remarkable (smallest mature specimen, 6 mm.; largest, 11 mm.). An earlier note by me (Kenk, 1941: 56, footnote) refers to this collection.

5. A sedge pool on North Fishtail Bay, Douglas Lake, Cheboygan County, a few feet from the lake shore. July 8, 1940: several immature specimens among vegetation (coll. C. O. Berg).

6. Bessey Creek (lower part of Lancaster Creek, between Lancaster Lake and Douglas Lake), Cheboygan County. Sluggish stream; bottom, mud, dense vegetation. July 13, 18° C., July 25 (coll. R. I. Sailer), and July 27, 1940, 26.8° C.: several agamic specimens of the spotted type.

7. Munro Lake, north of Douglas Lake, Cheboygan County. A shallow lake; bottom, mud and sand. July 23, 1940: on the east shore, in shallow water, 27.5° C., very numerous animals and cocoons under pieces of wood, on the undersurfaces of stones, and on water plants. Most specimens are immature, some with signs of recent fission. Among about one hundred animals (all of the spotted type) were four sexually mature ones. July 25, 1940: in the southwest corner of the lake, 25.5° C., several immature animals, and cocoons, under fallen timber.

8. Lancaster Lake (north of Douglas Lake), Cheboygan County. July 25 and 27, 1940: both sexual and asexual animals, and cocoons, collected under stones along the east shore (Pl. IV, Fig. 2). Some specimens had recently fissioned.

9. Black Lake, Cheboygan County. In a narrow bay on the west side of the lake; bottom, mud and stones, dense vegetation of algae and higher plants. August 7, 1940, 23° C.: planarians and cocoons numerous under stones.

10. Maple River, Emmet County. East Branch, at the bridge northeast of Pellston (Pl. III, Fig. 2). Current swift. July 22, 1940, 29.5° C.: one

specimen of *Dugesia tigrina* and several specimens of *Curtisia foremani*. West Branch, half-way between Larks Lake and Pellston. August 14, 1940: two specimens (coll. Jack S. Dendy).

11. Carp Lake River, Emmet County. Near the source of the river at Carp Lake, at the dam; bottom, sand and mud, many stones. August 10, 1940: numerous asexual animals of different sizes under stones (coll. Arlene I. Whittemore).

12. Larks Lake (or Round Lake), Emmet County. On the north bank of the lake; bottom, sand and stones. August 12, 1940: ten asexual specimens and one mature specimen under stones (coll. Harry K. Phinney).

13. Ocqueoc Lake, Presque Isle County. Along the east shore. Water clear, somewhat colored; bottom, mud and stones. July 30, 1940, 27° C.: very numerous planarians under stones, shells, pieces of wood, and on water plants. Most animals asexual, one mature.

14. Tahquamenon River, Luce County, below the Upper Falls. Water warm, clear, highly colored, current sluggish; bottom, sand and clay, with stones. August 12, 1940: several large, asexual specimens of the spotted type, under stones (coll. Stephen P. Hatchett).

15. Eliza Creek, at Eagle Harbor, Keweenaw County. Water almost stagnant; bottom, sand, mud, and stones. August 18, 1940, 19.3° C.: two asexual specimens under stones.

16. Huron River, three miles southwest of Milford, Oakland County. Moderate current. May 18, 1941, 20.1° C.: two immature, spotted specimens under stones.

17. Huron River, Washtenaw County. At the Delhi dam (about mid-way between Dexter and Ann Arbor), swift current. September 28, 1940: several asexual specimens of the spotted type under stones. April 8, 1941: at Ann Arbor, below the dam near the railroad station. Very numerous specimens under stones, all of the spotted pattern, but with varying amounts of spottiness, and different tones of brown. Ten individuals in more than one hundred were sexual. These were rather small (6-8 mm. long). Some of the asexual animals were much larger. *Dugesia tigrina* ("*Planaria maculata*") was reported also by Pearl (1903: 526) from the Huron River near Ann Arbor. Hyman (1925: 53) identified material from this locality as "*Planaria lata*."

18. Portage Lake, Washtenaw County. Near the southwest bank, along Michigan Highway 132. Water warm, exposed to waves; bottom, stones and mud. September 22, 1940: several asexual specimens of the spotted type under stones.

19. The outlet of Portage Lake (tributary of Huron River), Washtenaw County. Immediately below the stone dam. Water warm, current swift;

bottom, stones and sand. September 22, 1940: many asexual spotted specimens under stones.

20. A backwater pond of the Huron River, south of Huron River Drive, about three miles east of Ann Arbor, Washtenaw County. October 8, 1940: one immature, spotted specimen on floating water plants.

21. Fleming's Creek, on Geddes Road, four miles east of Ann Arbor, Washtenaw County. Below the bridge, rapid current. May 16 and 19, 1941: several spotted specimens, all asexual, under stones.

22. A creek on Loch Alpine golf course, on Huron River Drive, near Delhi, six miles northwest of Ann Arbor, Washtenaw County. October 28, 1940: several asexual specimens of the spotted type (and *Curtisia foremani*) under stones.

23. Honey Creek (tributary of Huron River), about four miles west-northwest of Ann Arbor, Washtenaw County. February 12, 1941: several immature specimens under stones.

24. Honey Creek near Pinckney, Livingston County. April 7, 1941: about one-half mile southeast of Pinckney, two specimens under stones. Three miles west of Pinckney, two specimens taken with samples of water plants.

25. A pond one and one-half miles west of Grape, Monroe County. April 25, 1941: three immature individuals with spotted pattern, under stones.

26. Stoney Creek near Brest, northeast of Monroe, Monroe County. At the bridge of Michigan Highway 56. Clear, swiftly running water. Much vegetation on stones. April 25, 1941, 14.9° C.: seventeen specimens, one of them mature, all with spotted coloration, under stones.

*Dugesia tigrina* is very widely distributed in the United States. It is recorded in the literature from California, Connecticut, Florida, Georgia, Illinois, Indiana, Iowa, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Nebraska, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, Tennessee, Virginia, Washington, and Wisconsin. Its range comprises the eastern and southern states, the Middle West, and localities along the Pacific coast. The distribution is probably continuous from the east to the west coast of the continent, possibly interrupted by the Rocky Mountains. It is to be kept in mind, however, that the planarian fauna of the West has been very little studied and that, upon closer investigation, *Dugesia tigrina* will certainly be discovered in many more localities. Its range extends also farther north into Ontario, Canada.

*Dugesia dorotocephala* (Woodworth, 1897) Hyman 1939

*Planaria dorotocephala* Woodworth, 1897.

*Planaria agilis* Stringer, 1909.

*Euplanaria dorotocephala* + *agilis* Kenk, 1930.

*Dugesia agilis* Hyman, 1939.

*Euplanaria philadelphica* Hyman, 1931a.

EXTERNAL FEATURES (Pl. I, Fig. 4).—Length of the animal, under natural conditions, up to 25, rarely 30 mm.; width about 3.5 mm. (specimens collected in Michigan were usually less than 20 mm. long). In the laboratory, well-fed animals may reach a maximum length of 55 mm. The head is triangular, with slightly convex sides. The lateral auricles are elongated and are sharply pointed when the animal moves along quietly. Behind the auricles the body is usually narrower than the head. The dorsal surface is brown to almost black (animals kept in laboratory culture become lighter) and appears to be uniform to the naked eye. Under magnification, various patterns of pigment arrangement have been observed (Hyman, 1925: 59–60). All specimens collected in Michigan corresponded to Hyman's description of the "spotted pattern": an irregular mixture of pigment spots and short streaks of various shades of brown, with dispersed small white spots (Pl. I, Fig. 4). Besides the two nonpigmented areas above the eyes, a white spot or stripe may occur on the dorsal side of the auricles, or on their posterior margin. A pale middorsal stripe in the anterior part of the body and a faint middorsal black streak in the postpharyngeal region are reported to occur occasionally. The ventral side has the same color as the dorsal surface, or a somewhat lighter and more grayish hue. The eyes, normally two, are placed just anterior to the level of the auricles. Their distance from each other is about one-fifth the width of the head. The pharynx is almost uniformly pigmented (gray), with a small white zone near the tip (this white area, in Michigan material, amounted to approximately one-eighth of the length of the pharynx).

ANATOMICAL FEATURES.<sup>4</sup>—The reproductive system resembles very closely that of *Dugesia tigrina*. Testes numerous, ventral, arranged in two longitudinal rows laterally to, or to both sides of, the ventral nerve cords. They extend from the level of the ovaries to the posterior end of the animal. Genital atrium divided into two chambers, the common and male atria. Penis with a spherical, muscular bulb and a short, cone-shaped or finger-shaped papilla, which points obliquely ventrocaudad. Vasa deferentia entering the bulb separately from the dorsolateral sides, then bending ventrally toward the axis of the penis. Each vas deferens expands within the bulb to form a seminal vesicle. The two vesicles fuse into a canal, which opens at the point of the penis papilla. This shape of the penis lumen appears to be the normal one. Frequently, however, the two vasa deferentia and part of the canal are expanded to such an extent that a round cavity with two horns is formed (similar conditions were noted for *Dugesia tigrina*). The stalk of the bursa copulatrix opens into the common atrium from the dorsal side. It

<sup>4</sup> Cf. Hyman, 1925, 1929, 1931b: 337.

is more evenly curved than it is in *D. tigrina* and receives the separate openings of the two oviducts from the caudolateral sides. Ventrally to these openings, shell glands connect with the end part of the bursa stalk.

The anatomical differences between *Dugesia dorotocephala* and *D. tigrina* are not very significant. They concern mainly the shape of the bursa stalk (curved in *dorotocephala*, bent in an angle in *tigrina*), the openings of the oviducts (clearly separate in *dorotocephala*, very close together in *tigrina*), and the epithelia of the copulatory apparatus (with depressed nuclei in *tigrina* at full maturity, with normal epithelium in most parts in *dorotocephala*).

The egg capsule is round and attached to the substratum by a stalk.

**TAXONOMY.**—The species *Dugesia dorotocephala* is considered to comprise several closely related forms which were described by former writers under different names, *Planaria dorotocephala* Woodworth, *P. agilis* Stringer, and *Euplanaria philadelphica* Hyman. *Dugesia dorotocephala* and *D. agilis* are still considered separate species by Hyman (1939), though a very close relationship admittedly exists between them. *D. dorotocephala* in the narrower sense differs from *D. agilis* by having "perhaps a trifle more elongated and pointed" auricles, which are held at a different angle, and by having a lighter ventral surface. No important differences that could not be interpreted as the results of muscular contraction were discovered in the anatomy of the copulatory apparatus. The animals from Michigan agree better with the description of *D. agilis* than with that of *D. dorotocephala*. The two forms may be safely united to one single species (Kenk, 1935: 88; De Beauchamp, 1939: 62). At most, *D. agilis* could be given the rank of a subspecies, *Dugesia dorotocephala agilis*.

In a recent publication, De Beauchamp (1939), studying planarians from Lake Titicaca (Bolivia and Peru), came to the conclusion that *D. dorotocephala* is a synonym of *Planaria aurita*, described first by Kennel (1888: 464-68) from the island of Trinidad, and later, under separate names, by several authors from various localities in South America. De Beauchamp based his opinion on a comparative study of preserved animals of the Titicaca form and on North American material. He described certain differences in the color pattern and in the situation of the testes among the animals studied. So far the arrangement of the testes, ventral or dorsal, has been considered a reliable specific characteristic in the planarians. De Beauchamp assumed that in his animals the testes originate in a ventral position and that later, when the yolk glands differentiate, they migrate toward the dorsal side. This assertion, should it prove true, would indeed be of great interest to the taxonomist. For the North American form, all data in the literature (Hyman, 1925: 69; 1929: 410; 1931b: 337) and my observations

on specimens from Virginia invariably indicate a ventral position of the testes. De Beauchamp's conclusions, if confirmed, would make necessary another change of the name of *Dugesia dorotocephala*. They would be well worth an experimental reinvestigation. For the time being, however, it is advisable to retain the name *D. dorotocephala* for the North American form.

ECOLOGY.—*Dugesia dorotocephala* is known to be an inhabitant of cool, unpolluted springs, creeks, and spring-fed marshes and lakes. It occurs under stones or among water plants. The few localities at which it was taken in Michigan are not very typical habitats of the species. Commonly, the animals reproduce asexually, by fission, and only rarely are sexually mature individuals found in nature.

DISTRIBUTION IN MICHIGAN.—*D. dorotocephala* was found in only a few places, all in the southern part of the Lower Peninsula :

1. Huron River at Ann Arbor, Washtenaw County. Below the dam near the railroad station. April 8, 1941 : under stones, one immature specimen of this species with more than one hundred *D. tigrina*. Dr. Arthur E. Woodhead informed me that in this place the species has repeatedly been collected in larger numbers. Pearl (1903 : 526) and Mast (1903 : 178) obtained their material of *D. dorotocephala* from the same locality. Hyman (1925 : 53) stated that Pearl's and Mast's records need further confirmation, as the species is confined to spring-fed habitats and the Huron River does not receive spring water near Ann Arbor. The Huron River, though a sluggish stream in its lower part, develops rapids at artificial dams. Smaller creeks inhabited by *D. dorotocephala* open into the river below and above Ann Arbor (localities 2 and 3). It is quite conceivable that this rheophilic species, when washed into the river accidentally, migrates upstream and settles in places where the current is swift. It may also be that during the cold season, when the temperature of the river is favorable to this cold-adapted form, it may enter the river actively.

2. Fleming's Creek, on Geddes Road, four miles east of Ann Arbor, Washtenaw County. Below the bridge, swift current. May 16 and 19, 1941 : twelve immature specimens under stones (besides *D. tigrina*).

3. A stream near Delhi, on Huron River Drive, six-tenths of a mile west of Delhi Mills (six miles northwest of Ann Arbor), Washtenaw County. Short stream fed by seepage springs below two small ponds. October 27, 1940, and April 12 and July 8, 1941 : numerous asexual specimens under stones.

The geographic range of *Dugesia dorotocephala*, as far as it is known at present, comprises the following states : Arkansas, California, Colorado, Illinois, Indiana, Kansas, Michigan, Missouri, Nebraska, New Mexico, Oregon, Pennsylvania, South Dakota, Texas, Virginia, Wisconsin, and Wyoming.

*Phagocata vernalis*, new species

EXTERNAL FEATURES (Pl. I, Fig. 5).—*Phagocata vernalis* resembles very closely *P. velata* and by former writers has been confused with that species. Indeed, it is not possible to distinguish between the two species with certainty by their external appearance alone. The maximum length observed in the new species was 12 mm. and the width about 1.5 mm. During undisturbed movement, the truncated anterior end is somewhat variable in shape. The frontal margin is slightly convex, often with a faint, transitory, median projection. The lateral lobes (auricular appendages) are rounded, projecting very little laterally. Behind these lobes, the body narrows insignificantly (forming a "neck"), then the lateral margins diverge gradually until the greatest width is attained in the pharyngeal region. Behind the pharynx they converge again and meet in the more or less rounded posterior end. The color of the dorsal side is a variable shade of gray, often with a brownish hue, and appears uniform or somewhat cloudy to the unaided eye. Occasionally, darker longitudinal streaks may be present, one on each side of the pharynx, and one in the middorsal line behind the pharynx. Pigment is lacking only in the small ocular spaces. The ventral side is somewhat lighter than the dorsal surface. The mouth opening and, in mature specimens, the genital pore are seen as round white spots. Animals kept in laboratory culture for a prolonged time lose their pigment gradually. Specimens freshly hatched from cysts are likewise almost devoid of body pigment, but darken within a few days. Eyes are two, their distance from each other amounting to about one-fourth the width of the head at the eye level. Their distance from the frontal margin is somewhat larger than that from the lateral margins. The pharynx, in immature animals, is situated in the posterior half of the body.

ANATOMICAL FEATURES.—The structure of the pharynx corresponds to the arrangement typical for the family Planariidae: the inner muscle zone consists of two separate layers, a circular and a longitudinal one. The intestinal trunks bear lateral branches which are but little ramified. Five to six branches were counted on each side of the anterior trunk, about fifteen to seventeen on each of the two posterior rami.

Reproductive system. Only one sexually mature specimen, and one apparently overmature animal in which parts of the genital system were already degenerating, were available for the study of the genital organs. The following description refers to the mature specimen.

Testes are few, situated ventrally along the medial margins of the ventral nerve cords, extending from the region of the third or fourth side branch of the anterior intestinal trunk to about the level of the pharynx. Two testes, however, were found lateral to the nerve cord on one side of the



body. The medial testes are arranged in a single longitudinal row on each side and are fused with each other to such an extent that a continuous elongated structure results. Only the lobed medial and lateral profiles of this compound testis reveal the number of fused units (12–15 lobes). Of the two lateral testes mentioned above, at least one is connected, by a bridge crossing the nerve cord above the oviduct, with the medial testes of the same side. The lumen of each compound testis is continuous (Fig. 2), and the sperm produced in the anterior parts have to pass through the entire length of the organ to reach the vas deferens. The latter is a simple posterior continuation of the wall of the testis. It starts as a wide tube running posteriorly along the side of the pharynx. This part of the vas deferens corresponds to a "false seminal vesicle" and is twisted only little. In the region of the penis, the duct narrows and ascends toward the penis bulb.

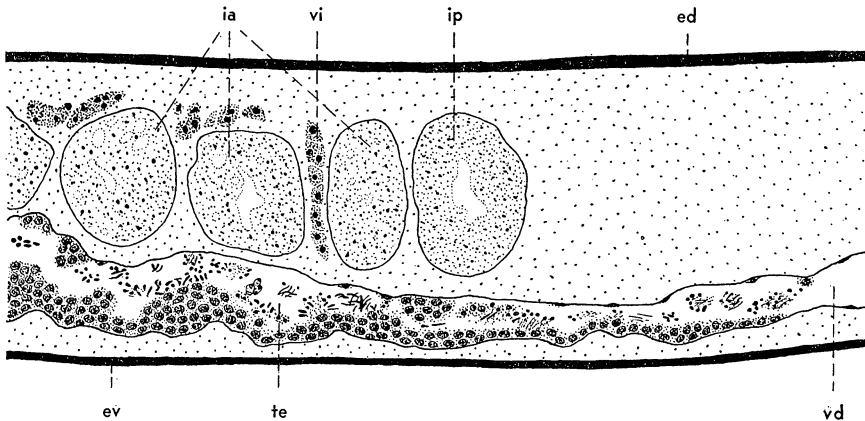


FIG. 2. *Phagocata vernalis*, part of a sagittal section in the region of the pharynx, showing the relation of the vas deferens to the testes,  $\times 104$ . *ed*, dorsal surface epithelium; *ev*, ventral surface epithelium; *ia*, branches of the anterior intestinal ramus; *ip*, section of posterior intestinal ramus; *te*, fused testes; *vd*, vas deferens; *vi*, yolk glands.

The ovaries are at the level of the first or second branch of the intestine, close to the medial side of the nerve cords. Adjacent to each ovary on its dorsolateral side is a mass of undifferentiated cells, apparently a parovarium. The two oviducts accompany the nerve cords posteriorly up to the region of the copulatory organs, then turn medially and dorsally, and unite in the space between the atrium and the stalk of the bursa copulatrix.

The well-developed yolk glands occupy the spaces of the parenchyma throughout the length of the body with the exception of the head. They are found above the intestinal branches, in the "septa" between these branches, and in the ventral parenchyma laterally to the testes.

Copulatory complex (Fig. 3). The genital aperture (*pg*) leads into a not very spacious genital atrium, which is indistinctly divided into a small

posterior chamber, the common atrium (*ac*), and a larger, anterior, male atrium (*am*). Both atria are lined with a cubical epithelium beneath which are the usual two layers of muscle fibers, a circular and a longitudinal layer. The penis consists of a rather small bulb (*bp*) and a large papilla (*pp*) projecting into the male atrium. The muscle layers of these parts are indicated in Figure 3. It seems that numerous gland ducts enter the bulb from the surrounding parenchyma. Unfortunately, they do not show in the slide with sufficient clarity to permit their further analysis. The two

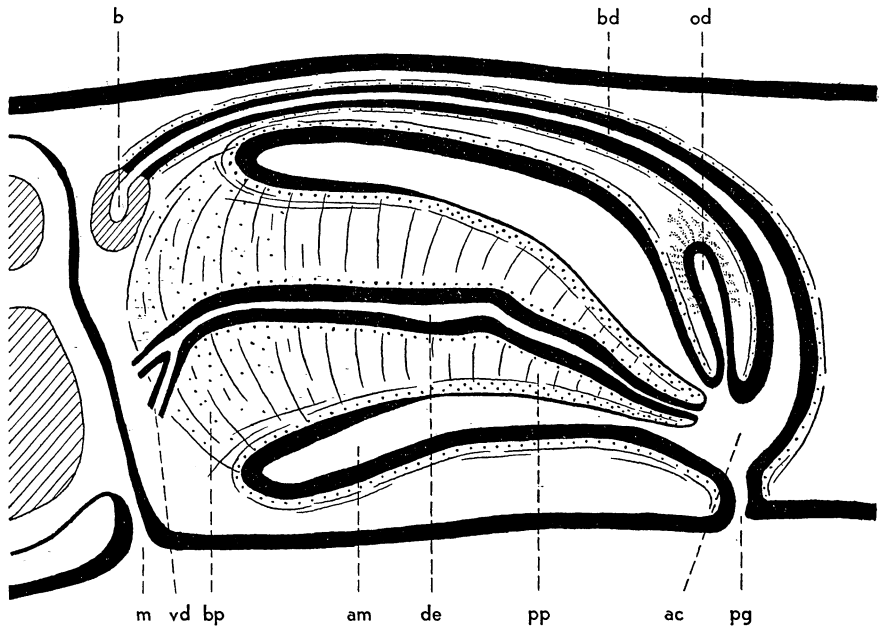


FIG. 3. *Phagocata vernalis*, diagram of the copulatory organs in longitudinal section,  $\times 180$ . *ac*, common atrium; *am*, male atrium; *b*, bursa; *bd*, bursa stalk; *bp*, penis bulb; *de*, ejaculatory duct; *m*, mouth; *od*, common oviduct; *pg*, genital pore; *pp*, penis papilla; *vd*, vas deferens.

vasa deferentia (*vd*) penetrate into the penis bulb separately and unite to a narrow canal, the ejaculatory duct (*de*). This canal passes posteriorly, almost straight, approximately in the axis of the papilla, and opens at the point of the penis. No enlarged cavity or seminal vesicle is developed. The common oviduct (*od*) opens from the dorsal side on the boundary between the common and male atria. The end portions of the two separate oviducts, from the point where they depart from the nerve cords, and the upper half of the common oviduct are connected with very numerous ducts of eosinophilic shell glands.

The bursa copulatrix has a remarkable shape. In a median section it appears as a small sac (*b*) at the end of the bursa stalk (*bd*). Laterally to

the mid-line, it widens somewhat and extends obliquely in an anteroventral direction and ends blindly below the intestine. The entire shape of the bursa, when seen from above, resembles a U. The bursa stalk (*bd*) starts from the posterodorsal side of the common atrium as a wide canal, then curves anteriorly and becomes gradually narrower, running in the mid-line above the penis, and finally connects with the copulatory bursa. The canal is coated with the usual layers of circular and longitudinal muscle fibers.

No egg capsules were seen. It may be safely assumed that the cocoon of *Phagocata vernalis* is ellipsoidal (or spherical) and unstalked, as in other species of the genus.

ECOLOGY.—*Phagocata vernalis* was taken from two shallow, temporary ponds near Ann Arbor, which dry up in summer and fill again in late autumn, so that they contain water during the greater part of the year. One of them is an open grassy pond, the other is situated at the edge of a hardwood forest. The first appearance of young animals was observed in December, shortly after the pond had filled up. More animals were taken in winter, often under a thick cover of ice. About one month after the ice had melted and the water temperature had begun to rise rapidly, the animals disappeared from the ponds (in May). In laboratory cultures, specimens could be maintained in a refrigerator several weeks longer. Fragmentation and encystment, preceded by loss of pigment, were observed to occur in the same way as has been described for *Phagocata velata* (Stringer, 1909: 259; Alexander and Price, 1926; Castle, 1927 and 1928; Castle and Hyman, 1934: 157). In fact, parallel cultures of both species exhibited a practically identical behavior. In either species encystment could be induced easily by placing a few specimens in a thermos bottle filled with cold water and keeping the bottle at indoor temperature, without any further attention. After a few days the first fragments were observed and in three to four weeks all specimens had fragmented, and the fragments had encysted on the walls and the bottom of the bottle.

It is my opinion that some of the investigations of the life cycle of "*Planaria velata*" were actually performed on *Phagocata vernalis*. This is highly probable for Child's (1913 and 1914) studies on the planarians from temporary pools near Chicago, where the animals were never seen in a sexual state and the reproduction in the laboratory was entirely agamic through many generations. It has been observed that "*Phagocata velata*" occurs in two types of habitat of very different nature; that is, in springs and in temporary ponds (Higley, 1918: 216; Castle, 1927, etc.). I assume that the species found in temporary pools is *P. vernalis* and that the form inhabiting springs and spring-fed ponds is *P. velata*.

The life history of *Phagocata vernalis* in Michigan is, in the general outline, the same as that described by Child (1913) for what is probably the

same species near Chicago. The cysts which survive the dry season on the bottom of a temporary pool, hatch soon after the pool fills up. The young animals are very active and grow rapidly. When the water of the pool becomes warmer, fragmentation begins. The animals detach from their posterior ends small pieces of tissues, which assume a rounded shape, secrete a cover of slime, and transform into cysts. The active animals decrease in number and, finally, even before the pool dries up, disappear entirely. There seems to be a difference in the time of hatching in different localities. In Michigan the first young specimens were found in December, the last active animals in April. Child (1913: 181) and Castle and Hyman (1934: 157) stated that the Chicago animals hatch in spring. Probably the time of hatching depends on the season in which the ponds fill with water. The two Michigan ponds in question belong to the type classified as vernal-autumnal ponds. In vernal pools, which contain no water in winter, the active phase of the life cycle will necessarily be retarded.

Commonly, the animals are found in the asexual state, and the great majority of them never become sexual. In Michigan a total of 106 specimens were collected, and only two of them had sexual organs. In laboratory cultures no sexual animals have been observed. In the main, the life cycle appears to be purely agamic.

TAXONOMY.—It is a rare coincidence that two different species of triclads occur in the same area and are not distinguishable from each other externally, both exhibiting reproduction by fragmentation, followed by encystment, which is an exceptional phenomenon among the triclads. The anatomy of the reproductive systems of the two forms shows clearly that they are independent species. When she first described *Planaria velata* from "small springs and ponds" near Crete, Nebraska, Stringer (1909) may actually have seen material belonging to both species. She stated that none of the animals was sexually mature. It is justifiable, however, to reserve the name *velata* for the form from springs, since this was with certainty included in the original description and was the first of the two to be studied anatomically (Castle, 1928; Castle and Hyman, 1934). The most outstanding characteristic in the ecology of the pond form is the fact that it leads an active life only during the winter and spring. Shelford (1913: 176) introduced the popular name "vernal planarian" for the Chicago form. I am adopting the appellation *vernalis* as the specific name of the pond form.

The new species is clearly within the genus *Phagocata* (synonym, *Fon-ticola*, see Hyman, 1937: 300-301), which comprises all Planariidae in which the oviducts, without embracing the bursa stalk, unite to form a common oviduct, and which have two eyes or are blind and have no adenodactyl and no radial muscle plates in the anterior part of the genital atrium. In external appearance the species resembles very closely *Phagocata velata*

(Stringer), *P. gracilis* (Haldeman), *P. woodworthi* Hyman, and *Planaria dactyligera* Kenk. From the two polypharyngeal species, *P. gracilis* and *P. woodworthi*, it can be readily distinguished by the presence of only one pharynx; from *P. dactyligera*, by the absence of an adenodactyl. The differences between *P. vernalis* and *P. velata* concern mainly the reproductive system (Table I).

TABLE I

PRINCIPAL DIFFERENCES BETWEEN *Phagocata vernalis* AND *P. velata*

<i>P. vernalis</i>	<i>P. velata</i>
Testes few, prepharyngeal, fused to form a compound testis on the medial side of each ventral nerve cord	Testes numerous, independent, dorsal, extend from the ovaries to the posterior end of the body
Ejaculatory duct a narrow tube, without diverticulum	Ejaculatory duct with ventral diverticulum
Common oviduct short, only its upper half with shell glands	Common oviduct long, shell glands open into its greater part
Bursa with two anteroventral horns	Bursa simple, sac-shaped

The most striking anatomical feature of *P. vernalis* is the fusion of the testes on each side of the body and the absence of collecting tubules or vasa efferentia. Several other species of triclads exhibit conditions which may be taken as transitory stages toward a confluence and fusion of the testicular follicles. Chichkoff (1892: 86) stated that in *Crenobia alpina* ("Planaria montana") the majority of the testes sit immediately upon the vas deferens and communicate with it by large apertures, and that only the more distant testes connect with the vas deferens by thinner tubes, the vasa efferentia. In *Phagocata (Ponticola) opisthogona* (Kenk, 1936: 307) the testes form a single row on each side of the body, along the medial margin of the nerve cord. They connect with the vas deferens in such a way that each testis appears to be a dorsal expansion of the vas deferens or that the vas deferens bridges the spaces between two adjoining testes. No vasa efferentia are developed. In *Phagocata vernalis* the fusion has gone further, and each compound testis serves at the same time as gonad and as tube for the passing of sperm.

DISTRIBUTION IN MICHIGAN.—1. The type locality of the species is a temporary pond on the west side of U. S. Highway 23, about 300 m. north of the crossing of U. S. Highway 112, five and one-half miles southeast of Ann Arbor, Washtenaw County. January 3, March 5, April 2, and April 29, 1941: asexual animals were collected, among organic debris and water plants. One sexual specimen on January 3 and one overmature animal on April 29, 1941, were taken. From December to the beginning of April the pond was covered with ice of varying thickness (1–24 cm.).

2. A temporary pond on the west side of Milford Road (between Six-Mile and Seven-Mile roads), about nine miles northeast of Ann Arbor, Washtenaw County. December 17, 1940: six newly hatched (almost white)

specimens taken with a sample of dead vegetal matter, under a thin sheet of ice. February 24 and 26, March 11 and 26, 1941: a total of eighty-three asexual animals under the ice.

Pearl's (1903: 525-26) "*Dendrocoelum* sp." from Ann Arbor comprises apparently both *Phagocata vernalis* and *P. velata*. Pearl stated that his animals agreed "with the description of *Dendrocoelum lacteum*," except in respect to the coloring, which was uniform, light gray to nearly black. They were more abundant in stagnant water than in streams and had a well-marked seasonal distribution, being in considerably greater numbers in the spring than at any other time in the year. It may be assumed that the stagnant-water form, which is usually found in spring, is *P. vernalis* and that the animals taken in streams were *P. velata*.

Other localities in Michigan where asexual specimens that may possibly be *P. vernalis* were collected, but could not be identified with certainty, are listed in the account of *Phagocata velata*.

The geographical range of the species probably comprises several other areas from which "*Phagocata velata*" was reported in habitats of a nature similar to that of the Michigan ponds. I assume that the animals collected by Higley (1918: 216) in a "temporary puddle at Urbana, Illinois," by Child (1913: 181) and Shelford (1913: 176, 185, 278) in temporary ditches and pools in the Chicago region, by Castle and Hyman (1934: 156) in temporary pools around Gary, Indiana, and by Castle (1941: 88) in a vernal pond near Seekonk, Massachusetts, belong to *Phagocata vernalis*.

### *Phagocata velata* (Stringer, 1909) Hyman, 1937

*Planaria velata* Stringer, 1909.

*Fonticola velata* Kenk, 1930.

EXTERNAL FEATURES (Pl. I, Fig. 6).—In nature the animal is up to 15 mm. long (under culture conditions, up to 20 mm.); the width is about 2 mm. Most animals, however, remain smaller. The anterior end is truncated, with a slightly convex frontal margin, which frequently exhibits a small median lobe during gliding movement. The auricular appendages are rounded. Behind the head there may be a faint and shallow constriction ("neck"). The dorsal surface is usually dark gray to almost black. Young animals, and individuals before fragmentation, are lighter, even nearly white. A darker longitudinal streak may appear along the mid-line of the postpharyngeal region. Ventral surface lighter. Eyes two, separated from each other by a distance amounting to about one-fourth or one-third of the width of the head at the level of the eyes. They are farther removed from the anterior end than from the lateral margins. The root of the pharynx is, in mature and in larger immature specimens, at or little behind the middle of the body, and the length of the pharynx is approximately one-sixth to one-fifth the

total length of the animal. The genital pore is situated behind the mouth opening at a distance of from one-half to one-third of the length of the post-pharyngeal region.

In individuals which are not too darkly pigmented the intestine may be clearly visible through the body wall (Fig. 4). Its anterior trunk bears five to seven branches on each side, and on each posterior trunk fifteen to nineteen branches were counted.

ANATOMICAL FEATURES.<sup>5</sup>—Testes numerous, distributed from the level of the ovaries to almost the posterior end of the body. Commonly the majority of them occupy the dorsal parts of the parenchyma, though single

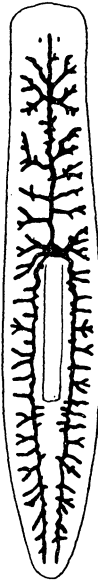


FIG. 4. *Phagocata velata*, digestive system,  $\times 9$ .

testes may have a more ventral position. They connect with the vasa deferentia by fine tubules, the vasa efferentia.

Copulatory apparatus (Fig. 5). The genital atrium is more or less clearly divided into two chambers, the common (*ac*) and male (*am*) atria. (This division is only rarely so well distinguished as it was in the specimen on which Figure 5 is based.) In fact, the shape of the atria depends somewhat on the grade of muscular contraction in the copulatory complex as well as on the contraction of the entire body. The penis has a small bulb (*bp*) and a bluntly conical papilla that almost fills the space of the male atrium. The two vasa deferentia (*vd*) enter the penis bulb from the ventrolateral sides and open separately into a cavity of varying size, the seminal vesicle

<sup>5</sup> Cf. Castle and Hyman, 1934.

(*vs*). From this cavity the ejaculatory duct (*de*) leads to the tip of the penis papilla. Shortly before its opening at the tip it connects with a ventral diverticulum (*dp*), which is lined with a tall epithelium. The epithelia of the seminal vesicle, of the ejaculatory duct, and of the diverticulum are perforated by numerous gland ducts. The secretions of these glands differ somewhat in their affinity for histological stains. After staining with hematoxylin and erythrosin, the ducts in the region of the ejaculatory duct and the diverticulum appear in various shades of red, whereas the secretions connecting with the seminal vesicle have a bluish tint. The two oviducts unite above the male atrium to a rather long and wide, and usually somewhat

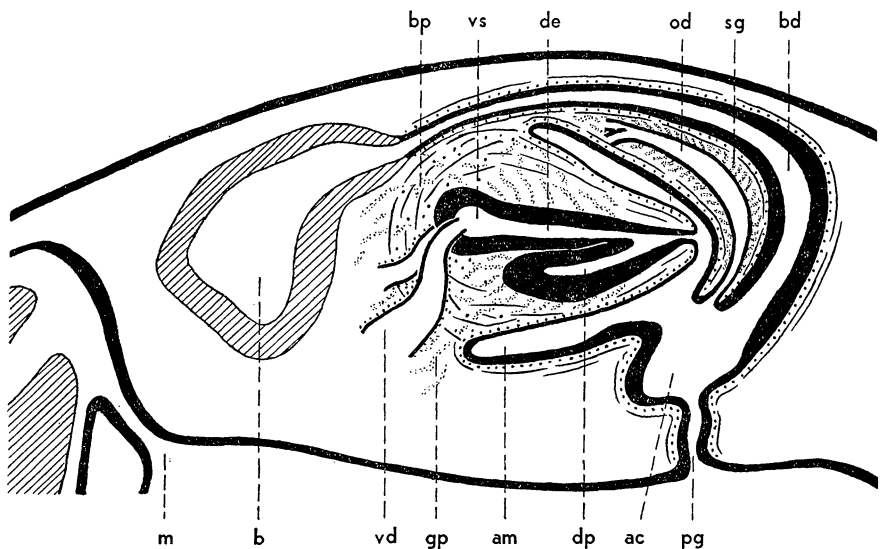


FIG. 5. *Phagocata velata*, diagram of the copulatory organs in longitudinal section,  $\times 122$ . *ac*, common atrium; *am*, male atrium; *b*, bursa; *bd*, bursa stalk; *bp*, penis bulb; *de*, ejaculatory duct; *dp*, diverticulum of the ejaculatory duct; *gp*, gland ducts entering the penis bulb; *m*, mouth; *od*, common oviduct; *pg*, genital pore; *sg*, shell glands; *vd*, vas deferens; *vs*, seminal vesicle.

curved, common oviduct (*od*), which opens from above into the common atrium. The bursa stalk, starting from the common atrium posteriorly to the opening of the oviduct, lies in its main part slightly to the right side of the median line. It connects with a sac-shaped copulatory bursa.

The egg capsule is unstaked.

The differences between *Phagocata velata* and *P. vernalis* have been noted in Table I.

ECOLOGY.—*Phagocata velata* is an inhabitant of springs and spring-fed brooks and marshes. It occurs on the undersides of stones and, in suitable places, on aquatic vegetation. Sexually mature animals are rarely collected.



There is reason to believe that the reproduction of the species in many localities is mainly an agamic one, by fragmentation with subsequent encystment. Nevertheless, sexually mature individuals are occasionally found, particularly during the colder seasons (in winter and early spring). Certain differences seem to exist in the time of breeding in different localities, as far as may be judged from the scarce data available at present. In a spring near Valparaiso, Indiana, Castle (1928: 419) found animals with sexual structures from the latter part of November to the middle of March; the height of the sexual season was during late December and early January. Helen F. Price<sup>6</sup> collected sexually mature specimens in several localities near Columbia, Missouri, from October to January, and again in June and July. In a spring near Benmiller, Ontario, mature individuals were found in November (Kenk, 1943: 5). In Michigan, sexual animals were taken in various places in February and March, but never in great numbers. The intervals between the collections were too great to permit definite conclusions regarding the life cycle of the animals.

DISTRIBUTION IN MICHIGAN.—In several localities only asexual specimens were collected, and it was not possible to verify the identification of the species through the study of the anatomy of the reproductive system. It is, however, reasonably certain that the pigmented monopharyngeal forms of *Phagocata* occurring in Michigan in springs and spring-fed habitats may be all listed as *Phagocata velata*.

1. A roadside fountain on the north side of U. S. Highway 31, near the eastern village limit of Oden, Emmet County. The fountain is fed by several artesian wells the overflow of which forms a small brook running along the highway (Pl. V). The water of the brook is clear and cool; bottom, sand and stones. June 26 and 28, July 16, 1940, 8.5° C.: numerous asexual specimens under stones. March 1 and 20, 1941: a total of fifty-three animals collected by William R. Martin. Two of them (one of each date) were mature, the rest asexual.

2. The fish hatchery west of Oden, Emmet County. The hatchery draws water from several artesian wells which discharge into two large ponds. Water clear; bottom, sand and stones. July 12, 1940, 12° C.: in the outlet of one of the ponds (Pl. VII, Fig. 1). Two immature *Phagocata velata*, in addition to more numerous *P. morgani*, under stones.

3. A creek near Conway, Emmet County. At the bridge of U. S. Highway 31, about five hundred feet south of the village limit of Conway. Water warm, sluggish, clear; bottom, sand, mud, and few stones. At a corner of the bridge, on the bank of the creek, there is a small cold spring. July 16, 1940, 7.7° C.: eleven immature specimens of *P. velata* under stones in cold water, and one *P. morgani*.

<sup>6</sup> Personal communication.

4. A small brook near Petoskey, Emmet County. Brook crossing U. S. Highway 31 at the junction with Michigan Road 131. Water clear and swift; bottom, sand, mud, and stones. July 1, 1940, 12.8° C.: one immature specimen under a stone.

5. Lancaster Lake (north of Douglas Lake), Cheboygan County. Along the sandy east shore of the lake (Pl. IV, Fig. 2) are numerous seepage springs with cold water. July 27, 1940, 14° to 18° C., measured in the sand at different depths: in one of the springs, one immature *P. velata* was collected under a stone, with many specimens of *Procotyla fluviatilis*.

6. Mill Creek, below the bridge of U. S. Highway 23 (Pl. VI, Fig. 2), about four miles southeast of Mackinaw City, Cheboygan County. Water swift, rather clear; bottom, rock, mud, and stones. June 30, 1940, 15.2° C.: seven immature *P. velata* under stones, with many specimens of *P. morgani*.

7. A spring near the mouth of Mill Creek, about four miles southeast of Mackinaw City, Cheboygan County. The spring is situated a few hundred feet west of the mouth of Mill Creek, about thirty feet from the shore of the Straits of Mackinac; bottom, sand with few stones, vegetation of mosses and algae. July 25, 1940, 8.2° C.: numerous asexual individuals under stones and on pieces of wood.

8. A brook on Redford golf course, about one mile north of Redford, northwest of Detroit, Wayne County. The brook is in the woods and has much dead vegetal matter. December 25, 1940: several immature specimens collected by Karl E. Goellner. March 26, 1941: four one-liter jars of plant material, taken by Goellner in this locality, contained 123 specimens of *P. velata*, of which ten were sexually mature.

9. A small stream on the north bank of the Huron River, about one mile east of Dexter, Washtenaw County. Sluggish current; bottom with decaying leaves and algae. February 12, 1941, 6° C.: one immature specimen on a leaf. February 26 and 28, 1941: from samples of leaves and mud brought to the laboratory there emerged two mature and four asexual examples, and many specimens of *Curtisia foremani*.

10. Otter Creek and tributaries, near La Salle, Monroe County. In three places (at La Salle and near Ida), in swift as well as sluggish parts, in cold water. April 25, 1941, 12.2°, 14.1° C.: five immature specimens under stones.

There can be little doubt that at least some of the planarians designated by Pearl (1903: 525-26) as "*Dendrocoelum* sp." were *Phagocata velata*. Unfortunately, Pearl did not state exactly the habitats where he collected his material "about Ann Arbor." He mentioned, however, that the animals were "more abundant in stagnant water than in streams," which indicates that he probably observed both *Phagocata vernalis* and *velata*.

*Phagocata* species which may be either *P. velata* or *vernalis* were collected in two more localities in Michigan:

?11. A ditch on the east bank of Snake Creek, near Manor Drive, Midland, Midland County. Stagnant pool, possibly fed by ground water; water somewhat colored. April 20, 1941, 15.5° C.: eight immature individuals on dead leaves.

?12. Hyman (1931a: 328) reported "*Fonticola velata*" from Grand Rapids, Kent County, without giving details as to the type of habitat.

In tracing the geographic range of *Phagocata velata*, it is to be kept in mind that two species were confused under this name by former authors. Only those records should be considered certain in which the identifications were backed by the study of sexually mature animals, or, in which the habitats are clearly described as springs, creeks, spring-fed ponds, or spring-fed marshes, which are the typical localities of *P. velata*. Such records exist for Illinois, Indiana, Michigan, Minnesota, Missouri, Nebraska, and Ontario, Canada. The occurrence of *P. "velata"* in Colorado, North Carolina (Hyman, 1931a: 327, 328), Wisconsin (Castle and Hyman, 1934: 156), and Massachusetts (Castle, 1941: 88) needs further verification.

*Phagocata morgani* (Stevens and Boring, 1906) Hyman, 1937

*Planaria truncata* Leidy, 1851a (non Abildgaard, 1789).

*Dendrocoelum truncatum* Girard, 1894.

*Planaria morgani* Stevens and Boring, 1906.

*Fonticola truncata* Hyman, 1931a.

*Fonticola morgani* Kenk, 1935.

**EXTERNAL FEATURES** (Pl. I, Fig. 7).—Sexually mature animals are 8–17 mm. long and 0.8–2.3 mm. wide. The head is truncated, with the frontal margin usually slightly convex, and flanked by rounded auricular appendages. Behind the head the lateral margins are insignificantly narrowed to form a "neck." The body wall lacks pigment, and the animals therefore appear white when the intestine is empty. If the intestine is filled with colored contents, the general appearance of the animals may be darker, usually of a brown, red, gray, or greenish hue. This color is, of course, restricted to the regions into which the intestinal branches extend and is always absent in the head, the margins of the body, and the regions of the pharynx and of the copulatory complex, which always remain white. Normally, there are two eyes, situated close together (at a distance of from one-fifth to one-third the width of the head at the level of the eyes) and farther removed from the frontal margin than from the sides of the head. Supernumerary eyes are not rare. The pharynx is rather long, one-fourth to one-sixth the entire body length. The length of the copulatory complex is about one-half the length of the postpharyngeal part of the body.

**ANATOMICAL FEATURES.**<sup>7</sup> Numerous testes, mainly ventral, are arranged

<sup>7</sup> Cf. Stevens and Boring, 1906; Kenk, 1935: 95–98.

on each side of the body in a longitudinal zone, which extends from the ovaries to the level of the mouth. The genital atrium has no well-defined separation into two chambers. The penis has a small bulb and a conical or more rounded papilla. Characteristic for this species is a muscular, wart-like structure, covered with a very thin epithelium, projecting from the papilla excentrically, commonly to the dorsal and right side of the tip of the penis. The vasa deferentia enter the penis bulb laterally and open into the ejaculatory duct. This duct passes posteriorly and usually opens on the ventral side of the penis papilla. No distinct seminal vesicle is developed, but the ejaculatory duct may be slightly enlarged at its anterior end or within the penis papilla. The bursa duct starts at the atrial cavity rather close to the genital pore and runs in a curve dorsally and anteriorly to one side (generally the left side) of the mid-line. The copulatory bursa is typical, sac-shaped. The oviducts unite, without embracing the bursa stalk, dorsally or posteriorly to the male part of the genital atrium to form a common oviduct. This opens into the atrium anteriorly to the base of the bursa stalk. The upper two-thirds of the common oviduct and short end parts of the separate oviducts connect with numerous eosinophilic shell glands.

The unstalked cocoon is spherical or ellipsoidal.

ECOLOGY.—*Phagocata morgani* commonly occurs in springs and the upper parts of brooks, that is, in lotic habitats with narrow temperature amplitudes. In Michigan it is frequently associated with another rheophilic and stenothermic species, *P. velata*. It may be found resting on the lower surfaces of stones or among aquatic vegetation. The species reproduces both sexually and by fission. During the summer months, fission occurs more frequently. Sexually mature animals, however, may be collected, at least in some localities, at any time in the year.

DISTRIBUTION IN MICHIGAN.—1. Mill Creek, below the bridge of U. S. Highway 23 (Pl. VI, Fig. 2), about four miles southeast of Mackinaw City, Cheboygan County. Water clear, swift current; bottom, mud and stones. June 30, 1940, 15.2° C.: about seventy specimens taken under stones. They were all asexual, some showing indications of asexual reproduction (regenerating heads or tails, postpharyngeal parts greatly varying in length). *P. velata* was also collected here.

2. Springs in "The Gorge" (source of Carp Creek), south of Douglas Lake, Cheboygan County. Numerous small springs in the woods, with swiftly running, clear water; bottom, sand, few stones, many dead leaves, and much decaying wood. July 5, 1940, temperatures of several springs situated close together, 9.0° to 11.2° C.: eleven immature specimens under stones and on pieces of wood.

3. Stoney Creek (tributary of Black Lake), above the bridge of the road dividing Cheboygan and Presque Isle counties. Clear water, moderate current; bottom, sand, mud, and stones. July 10, 1940, 13.5° C.: five specimens of *P. morgani*, one of them mature, and several specimens of *Curtisia foremani* under stones.

4. A creek flowing into Black Lake from the south side, Presque Isle County. Near the mouth of the creek, a short distance east of the boundary of Cheboygan County. July 10 and 15, 1940, 10.8° C.: about sixty-five individuals, four of them sexual, under stones.

5. A fish hatchery west of Oden, Emmet County. The hatchery draws water from several artesian wells which discharge into two large ponds. In the outlet of one of the ponds (Pl. VII, Fig. 1). Water swift and clear; bottom, sand and stones. July 12, 1940, 12° C.: eight immatures of *P. morgani* (some with signs of recent fission), and two specimens of *P. velata*.

6. A creek near Conway, Emmet County (same locality as that where *P. velata* was collected). In a small cold spring on the bank of the creek. July 16, 1940: one immature *P. morgani*.

7. Small brook near Petoskey, Emmet County. Brook crossing U. S. Highway 31 at the junction with Michigan Highway 131. Water clear, swift; bottom, sand, mud, and stones. July 1, 1940, 12.8° C.: one immature specimen under a stone, with one *P. velata*.

8. Creek northwest of Harbor Springs, Emmet County (Pl. VII, Fig. 2), tributary to Lake Michigan. Water clear, current swift; bottom, sand and stones. July 18, 1940, 12.3° C.: one immature specimen under a stone above the mouth of the creek.

9. A small creek, about one-half mile west of Cross Village, Emmet County. Clear water, swift current; bottom, sand, mud, decaying wood, and many dead leaves. July 18, 1940, 12.2° C.: one immature specimen on a piece of wood.

10. Silver River, at the bridge east of Eagle Harbor, Keweenaw County. Swift current; bottom, mud and stones. August 18, 1940, 14.5° C.: one very small individual under a stone.

11. Jacob's Creek, below the Falls, on the road between Eagle River and Eagle Harbor, Keweenaw County. Current rapid; bottom, sand and stones. August 18, 1940, 12° C.: one small immature specimen under a stone.

12. A small spring near Union Bay on Lake Superior, Ontonagon County, on the south side of Michigan Highway 107, three miles west of the junction with Michigan Highway 64. Water clear, swift; bottom muddy. August 19, 1940: three small immature specimens on a piece of wood and under a stone.

It will be noticed that so far *Phagocata morgani* has not been found in the southern part of the Lower Peninsula of Michigan. In the northern

part, and in the Upper Peninsula, it appears to be common. The species is known to occur mainly in mountainous areas and has been reported from Delaware, Massachusetts, Michigan, New York, North Carolina, Pennsylvania, Tennessee, Virginia, Wisconsin, and Ontario, Canada.

#### FAMILY DENDROCOELIDAE

The family Dendrocoelidae consists of fresh-water triclad in which the inner muscle zone of the pharynx is made up of intermingled longitudinal and circular fibers.

#### *Procotyla fluviatilis* Leidy 1858

*Dendrocoelum superbum* Leidy, 1851b (*non* Girard, 1850, which is possibly *Phagocata morgani*).

*Procotyla Leidyi* Girard, 1894.

*Dendrocoelum lacteum* Woodworth, 1896a, etc. (*non* Örsted, 1844).

*Dendrocoelum graffi* Wilhelmi, 1909.

?*Dendrocoelum pulcherrimum* Girard, 1850.

EXTERNAL FEATURES (Pl. I, Fig. 8).—Length of mature animals, 12–20 mm.; width, 2–5 mm. Body rather thin (with short dorsoventral diameter). Anterior end generally truncated, its outline somewhat variable during locomotion. A broad subterminal adhesive organ, clearly visible in the living animal, bulges out slightly in the middle of the frontal margin when the animal is gliding quietly. Lateral to this there are two rounded auricular projections. A more or less marked incurving (neck) is seen behind the auricles. Body without pigment (white), but the intestine, when filled with colored food, shows clearly through the body wall. One to eight eyes on each side of the head, commonly two to four. The eyes of one side are close together in a group, approximately at the level of the neck. The distance of the two groups from each other amounts to about one-half the width of the head. Their distance from the frontal margin is slightly greater than that from the lateral margins. The root of the pharynx is situated approximately at the middle of the body. The copulatory apparatus occupies one-third to one-half the length of the postpharyngeal region. The locomotion of the undisturbed animal is generally a smooth gliding. Upon slight stimuli, however, it readily changes to “crawling” movements in which the entire body contracts and expands very rapidly, adhering to the substratum alternately with the adhesive organ or sucker of the anterior end, and with the margins and the posterior part of the body. In this kind of locomotion, or when the animal is resting, the lateral margins of the body appear finely ruffled.

ANATOMICAL FEATURES.<sup>8</sup>—The anterior adhesive organ, a true sucker, frequently shows in longitudinal sections a cup-shaped depression and contains muscle fibers and glands.

<sup>8</sup> Cf. Woodworth, 1897: 5–6; Hyman, 1928.

The numerous testes are dorsal and are arranged in two longitudinal zones extending from the ovaries to the region of the copulatory apparatus. Each vas deferens widens at the level of the mouth to a large irregular sac, the false seminal vesicle. Posterior to this sac it proceeds caudad as a coiled tube to the region of the penis bulb, where the two vasa deferentia unite to form a common vas deferens or seminal duct, which enters the bulb at its anterior end. The genital pore leads into a very small chamber, the common atrium, from which a rather long canal proceeds anteriorly and expands into a cavity containing the free papilla of the penis, the male atrium. The penis consists of a very large, elongated (ellipsoidal or cylindrical) bulb and a short, conical, pointed papilla. The bulb has a central cavity, which in young individuals is lined with a tall cylindrical epithelium; in full maturity, the central parts of the cells have transformed into a mucous substance, which fills the lumen of the bulb cavity (prostate) almost completely.

The wall of the penis bulb is composed of several layers of different nature. The outermost coat is formed by a very thick layer of longitudinal muscle fibers. The next layer consists of fine circular fibrous elements, designated by Hyman as the external mucous layer. The histological interpretation of this layer is not easy, but the presence of fibers indicates that it is not glandular, as Hyman assumes. The fibers appear faintly pink after staining with hematoxylin and erythrosin. In the mature animal no nuclei are found between the fibers; but it is probable that the nuclei seen on the boundary between the external longitudinal muscles and the fibrous layer are to be related to the fibrous stratum. Fibrous layers have also been found in the copulatory apparatus of several other species of planarians. They probably perform a mechanical function. Central to the fibrous layer is the internal muscular layer, composed of muscle fibers, which run mainly longitudinal. Next to this layer is the lining of the central cavity of the penis bulb.

The common vas deferens, which enters the penis bulb anteroventrally, penetrates through the external muscles and the fibrous layer and then passes caudad along the ventral mid-line, imbedded in the inner muscle layer of the bulb. It opens into the penis lumen at the basis of the papilla. The main cavity of the penis bulb is, therefore, not traversed by the sperm and may be considered, on account of its secretory function, as an accessory gland or "prostate." The oviducts unite dorsally to the genital atrium and anteriorly to the base of the bursa stalk to form a common oviduct. The common oviduct opens from the dorsal side into the canal that joins the common and the male atria. Shell glands connect with the end parts of the separate oviducts and with the upper two-thirds of the common oviduct. The bursa stalk starts from the common atrium, proceeds first dor-

sally, then curves in an anterior direction to one side of the mid-line (generally to the left) and opens into the sac-shaped bursa copulatrix.

A. H. Morgan (1930: 125) described the cocoon ("hard-shelled winter egg") as being "about the size of a mustard seed, shiny, chestnut brown and raised on a tiny stalk." This statement needs confirmation, for stalked cocoons have been seen so far only in species of the genera *Curtisia* and *Dugesia*.

ECOLOGY.—*Procotyla fluviatilis* is not confined to any particular kind of habitat. It has been found in lakes, ponds, rivers, and springs. It commonly rests on the lower surfaces of stones or on water plants. The season of sexual reproduction seems to be in late autumn and winter. Individuals with sexual structures may be found at other times of the year, but the genital system is not fully developed, being either in the process of differentiation, or already degenerating. The animal never undergoes agamic reproduction by fission.

DISTRIBUTION.—*Procotyla fluviatilis* is by no means common in Michigan.

1. Round Lake, Charlevoix County (Woodworth, 1896b: 95; 1896c: 241).

2. Big Stone Creek (Pl. III, Fig. 1), in Wilderness State Park, northwest of Carp Lake, Emmet County. Water clear, current mostly sluggish, in some places rapid; bottom, mud and stones. July 3, 1940: about twenty-five specimens of *P. fluviatilis* of different sizes (3–15 mm.), two of them with sex organs; also many specimens of *Curtisia foremani*.

3. Lancaster Lake (north of Douglas Lake), Cheboygan County. Along the sandy east shore of the lake (Pl. IV, Fig. 2) are numerous cold seepage springs. July 25 and 27, 1940, 14° to 18° C., measured in the sand at different depths: under stones, thirty-three specimens of *P. fluviatilis*, fourteen with genital organs; also *Dugesia tigrina* and *Phagocata velata*.

*Procotyla fluviatilis* occurs from New England west to Wisconsin and Illinois. It has so far been recorded from Connecticut, Illinois, Indiana, Massachusetts, Michigan, New Hampshire, New Jersey, Pennsylvania, Rhode Island, Washington (?), Wisconsin, and from Ontario, Canada. It is doubtful whether Scheffer's (1933: 29) "*Dendrocoelum lacteum*" from Echo Lake, King County, Washington, is *Procotyla fluviatilis* or some other species.

#### "*Planaria simplex*" Woodworth, 1896b

This species was established by Woodworth (1896b: 94; 1896c: 239–40) from one preserved immature specimen collected by the Michigan State Fish Commission "off N. Y. Point, Lake Michigan." The animal had no outstanding characteristics by which the species could be recognized if collected again. It must be left to further investigations of the fauna of Lake Michigan to suggest the identity of Woodworth's animal.



## ECOLOGY AND DISTRIBUTION

Several environmental factors influence the distribution of planarians in the waters of a given area. The more important factors are the water movement (current), the temperature conditions, the chemical properties of the water, and the nature of the substratum.

The two great series of fresh-water environments, the lotic or running-water series (spring, brook, creek, river) and the lentic or standing-water series (lake, pond, pool), differ considerably in the composition of their planarian faunas. Several species, including the Michigan planarians *Curtisia foremani*, *Dugesia dorotocephala*, *Phagocata velata*, and *P. morgani*, show a marked preference for running water (rheophilic forms). *Phagocata vernalis*, is decidedly limnadophilic, or restricted to lentic habitats. The remaining two species, *Dugesia tigrina* and *Procotyla fluviatilis*, may be present in either standing or running water.

As to the limitations given by the temperature of the water, the planarians living in stagnant-water habitats are exposed to a wide range of temperatures during the different seasons of the year. *Dugesia tigrina* and *Procotyla fluviatilis* are examples of such eurythermic forms. In running water, the yearly temperature amplitudes are generally narrower, very small at the source and gradually increasing in the course of a stream. Frequently, rheophilic planarians are at the same time stenothermic, that is sensitive to sudden changes of temperature, particularly to a warming-up of the environment. This relation may be observed easily in *Phagocata velata* and *P. morgani*, which do not keep well in laboratory cultures at indoor temperature, but may be maintained for long periods in aquaria placed in a refrigerator. These two species mainly inhabit springs, brooks, and the upper parts of creeks. Generally speaking, the temperature amplitudes decide the succession of the planarian species in the different parts of a stream. The springs and upper reaches may be inhabited by *Phagocata velata* and *P. morgani*. Farther down *Curtisia foremani* appears, and, finally, when the stream becomes sluggish, or after it has passed through a lake, *Curtisia* is supplanted by *Dugesia tigrina*. Such a complete succession has not been actually observed in Michigan in one single stream. This is probably due to the physiographic conditions of the country, to the absence of high mountains and, therefore, of typical mountain streams that gradually change to rivers in the valleys. The numerous lakes through which the rivers flow, or which drain into rivers, likewise greatly interfere with the normal gradation of the biological conditions in the course of the rivers. Nevertheless, the associations of the different species with each other are typical: *Phagocata velata* is often associated with *P. morgani*, *P. morgani* with either *P. velata* or *Curtisia foremani*, and *Curtisia* with *P. morgani* or

*Dugesia tigrina*. *D. tigrina* never occurs simultaneously with *P. velata* or *P. morgani* in the same section of a stream.

Stenothermy is generally a characteristic of planarians living in running water. It also occurs, however, in *Phagocata vernalis*, which inhabits temporary ponds. This species leads an active life only during the colder seasons, in winter and spring, and reacts to the rise of temperature in late spring by fragmentation and encystment. The cysts are capable of enduring higher water temperatures and also survive the drying out of the habitat. The animals hatch again when the ponds fill in winter or early spring.

Generally, the chemical composition of the water has little effect on the distribution of planarians. Waters with a low pH, such as obtains frequently in marshes and bog lakes, are decidedly unfavorable for planarians. The same is true for heavily polluted creeks and rivers.

The nature of the substratum is of only secondary importance. Planarians may thrive on almost any kind of bottom, on mud, sand, stones and rocks, or organic material. The only limiting factor seems to be the scarcity or absence of suitable resting places. Planarians spend the greater part of the day in a "resting" condition and are probably more active during the night. On account of their negative phototaxis, they come to rest in places where they are not exposed to open daylight: on the undersurfaces of stones, of pieces of wood, among dead leaves, and between the leaves of aquatic plants, particularly on their bases. These are the places where planarians are usually collected. Since the resting periods are of great physiological importance to the animals, bodies of water devoid of resting places are only sparingly or not at all populated by planarians, though otherwise such waters may, by their physicochemical and biological (food) properties, be suitable to the animals. Such conditions can be observed in creeks running over sandy ground, for example, in the northern part of the Lower Peninsula. Planarians may be found in them in places where the bottom has at least a few stones or other objects, such as leaves, beneath which they may retire. Where these are lacking, planarians are rare or absent.

#### KEY TO THE FRESH-WATER TRICLADS OF MICHIGAN

(The characters in parentheses require study of sectioned material.)

I. Animals pigmented. The pigment extends into the head and the lateral margins. White circumocular spaces distinct.

A. Head triangular<sup>9</sup> (Pl. I, Figs. 1-4).

a. Anterior end blunt, auricles rounded, each with an oblique white dash (Pl. I, Fig. 1), pharynx unpigmented. (Testes few, dorsal. No copulatory bursa.)

*Curtisia foremani*

<sup>9</sup> The normal shape of the head is seen only in quietly gliding, uninjured animals in good physiological condition.

- b. Anterior end pointed, greater part of pharynx pigmented. (Testes many, ventral.)
1. Auricles short (Pl. I, Figs. 2, 3) ..... *Dugesia tigrina*
  2. Auricles long (Pl. I, Fig. 4) ..... *Dugesia dorotocephala*
- B. Head truncated<sup>10</sup> (Pl. I, Figs. 5, 6).
- a. In temporary pools. (Testes ventral, fused. Bursa U-shaped. Ejaculatory duct without diverticulum) ..... *Phagocata vernalis*<sup>11</sup>
  - b. In springs and spring-fed waters. (Testes numerous, dorsal. Bursa sac-shaped. Ejaculatory duct with diverticulum) ..... *Phagocata velata*<sup>11</sup>
- II. Animals unpigmented. The color of the intestine may show through, but the head and the lateral margins are always white.
- A. Eyes usually two, close together, removed from the anterior end (Pl. I, Fig. 7). No subterminal grasping organ. (Inner muscle zone of the pharynx with two separate layers) ..... *Phagocata morgani*<sup>11</sup>
  - B. Eyes in two groups of 1 to 8 each, the groups far apart (Pl. I, Fig. 8). Ventral side of head with grasping organ. (Inner muscle zone of the pharynx with intermingled longitudinal and circular fibers) ..... *Procotyla fluviatilis*

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<sup>10</sup> See footnote 9.

<sup>11</sup> Newly hatched specimens of *Phagocata vernalis* and *P. velata* are devoid of pigment for several days. Precystic individuals of the same species may have lost their pigment almost completely. Complete depigmentation, however, is very rare and would not likely occur simultaneously in several individuals of one lot. Unpigmented specimens of the two species lead in the key to *P. morgani*.

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PLATES

PLATE I

Sketches of living animals, all  $\times 7.5$ .

- FIG. 1. *Curtisia foremani*.  
FIG. 2. *Dugesia tigrina*, asexual specimen from the shore of Douglas Lake.  
FIG. 3. *Dugesia tigrina*, sexual specimen from the bottom of Douglas Lake, at a depth of 4-5 m.  
FIG. 4. *Dugesia dorotocephala*.  
FIG. 5. *Phagocata vernalis*.  
FIG. 6. *Phagocata velata*.  
FIG. 7. *Phagocata morgani*.  
FIG. 8. *Procotyla fluviatilis*.



PLATE I

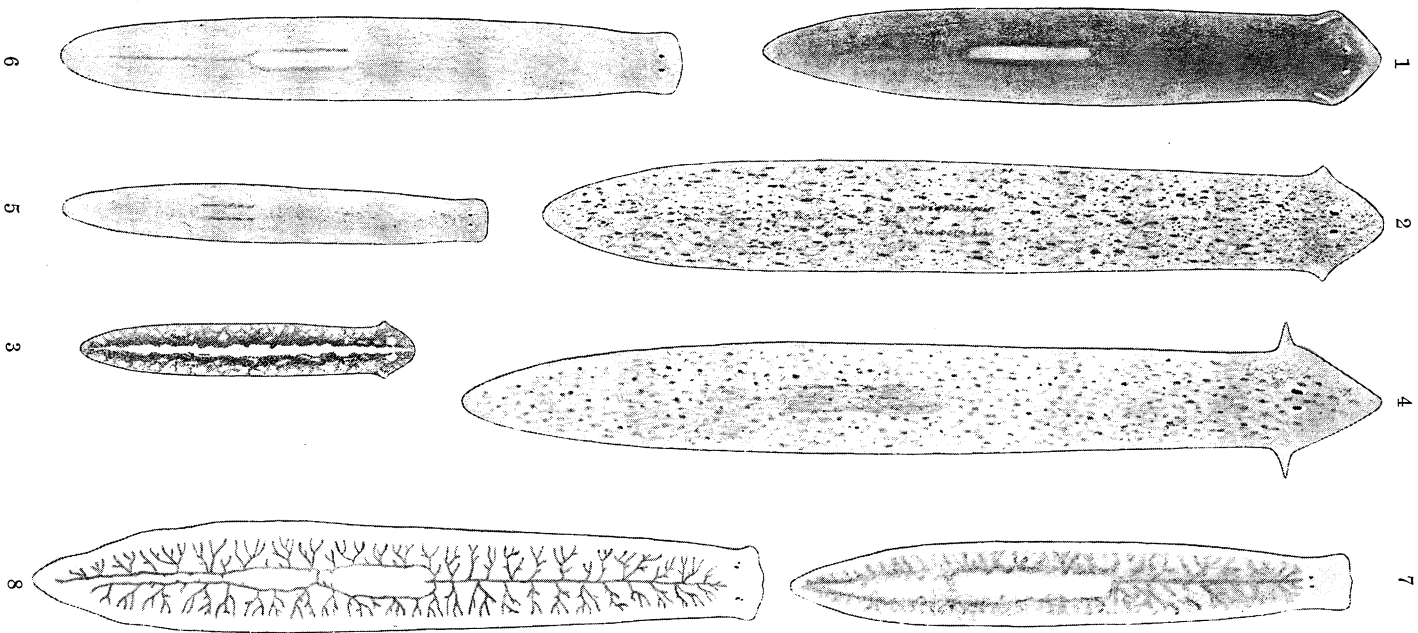


PLATE II

FIG. 1. Jackson's Creek, about four miles northeast of Wakefield, Gogebic County, above the bridge of Michigan Highway 28. Rapid current. Water clear, highly colored. *Curtisia foremani* on the undersides of stones.

FIG. 2. Milliken Creek (tributary of Black River), at the bridge of U. S. Highway 23, Cheboygan County. Swift current. *Curtisia foremani* under stones.

PLATE II



FIG. 1



FIG. 2

PLATE III

FIG. 1. Big Stone Creek, in Wilderness State Park, northwest of Carp Lake, Emmet County. Water clear, current mostly sluggish, in some places rapid. Bottom, mud and stones. *Curtisia foremani* and *Procotyla fluviatilis* under stones.

FIG. 2. East Branch of Maple River, northeast of Pellston, Emmet County. Water clear, current swift. Bottom, sand and stones. *Curtisia foremani* and *Dugesia tigrina* under stones.

PLATE III



FIG. 1

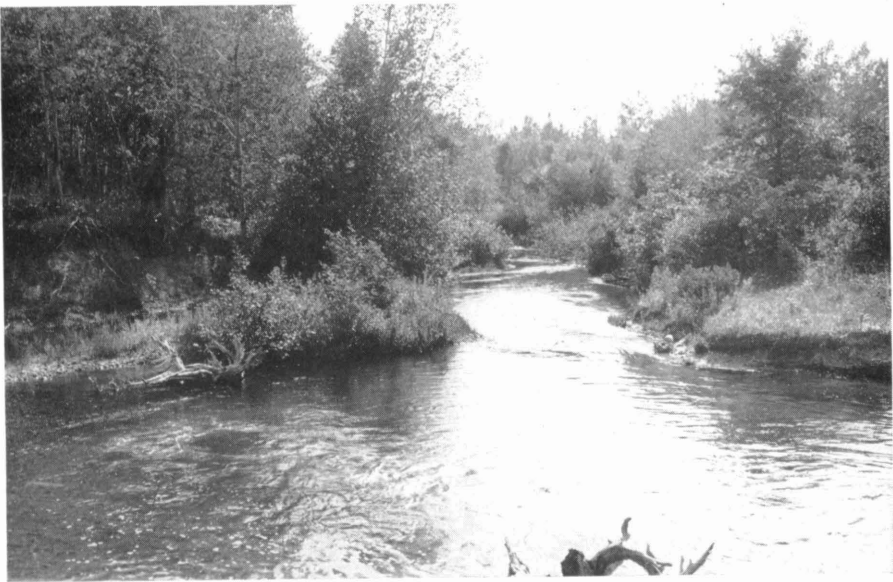


FIG. 2

PLATE IV

FIG. 1. Douglas Lake, Cheboygan County, on the west side of South Fishtail Bay. Numerous *Dugesia tigrina* under stones along the bank.

FIG. 2. Eastern bank of Lancaster Lake, north of Douglas Lake, Cheboygan County. Cold springs seep through the sand in several places. *Phagocata velata*, *Procotyla fluviatilis*, and *Dugesia tigrina* are in these springs and in the lake.

PLATE IV



FIG. 1



FIG. 2

ROMAN KENK

PLATE V

Roadside fountain on the north side of U. S. Highway 31, near the eastern village limit of Oden, Emmet County. The fountain is fed by several artesian wells the overflow of which forms a small brook running along the highway. Numerous specimens of *Phagocata velata* under stones in the brook.



PLATE V



PLATE VI

FIG. 1. Temporary pond on the west side of U. S. Highway 23, about five and one-half miles southeast of Ann Arbor, Washtenaw County. The pond fills up in autumn and is dry during the summer months. *Phagocata vernalis* inhabits the muddy bottom and the water plants.

FIG. 2. Mill Creek, about four miles southeast of Mackinaw City, on U. S. Highway 23, Cheboygan County. Swift current; bottom, rocks, stones, and mud. Under stones are *Phagocata morgani* and *P. velata*.

PLATE VI



FIG. 1

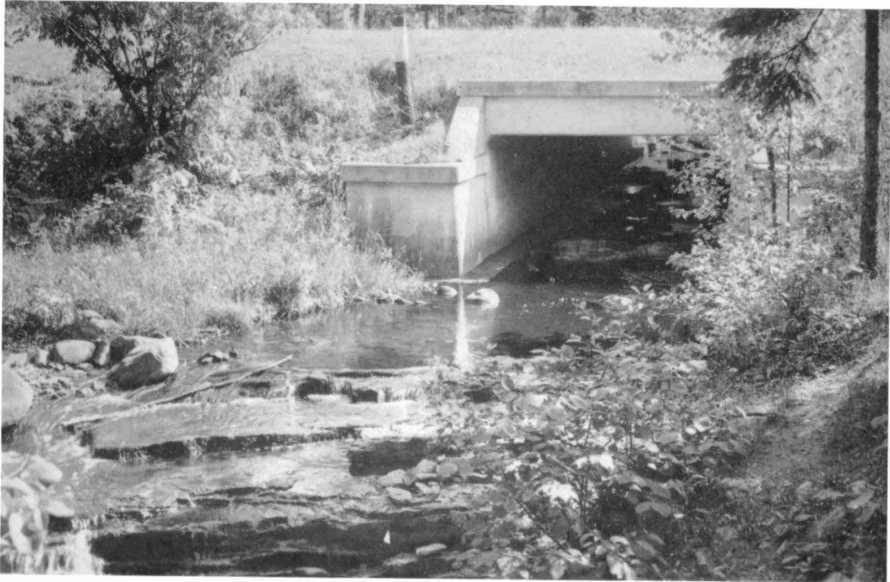


FIG. 2

PLATE VII

FIG. 1. Fish hatchery west of Oden, Emmet County. The hatchery draws water from numerous artesian wells, which discharge into two large ponds. *Phagocata velata* and *P. morgani* are under stones in the outlet of these ponds.

FIG. 2. Creek northwest of Harbor Springs, Emmet County. In the background, Lake Michigan. Water clear and cold; current rapid. Bottom, sand and stones. *Phagocata morgani* lives under stones above the mouth of the creek.

PLATE VII



FIG. 1



FIG. 2



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