

PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

FRESHWATER TRICLADS (TURBELLARIA) OF
NORTH AMERICA. X. THREE NEW SPECIES OF
PHAGOCATA FROM THE EASTERN UNITED STATES

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The genus *Phagocata* is well represented in North America. The latest revision of the North American planarian fauna (Kenk, 1972) lists 12 species of the genus. In the meantime, the following changes have been made in this list: *Phagocata monopharyngea* Hyman proved to be identical with *P. velata* (Stringer) and *P. vernalis* Kenk turned out to be the male phase of the protandrous *Hymanella retenuova* Castle (Kenk et al., in preparation). One new species has been added, the western *P. fawcetti* Ball & Gourbault (1975), a species similar to *P. velata*.

The writer wishes to express his deep appreciation to the various colleagues who have furnished the materials described in this paper: Dr. David C. Culver of Northwestern University, Dr. John R. Holsinger of Old Dominion University, Mr. Sam L. H. Fuller of the Academy of Natural Sciences in Philadelphia, and Mr. Arnold Norden, graduate student of Towson State College.

The types of the new species have been deposited in the National Museum of Natural History, Smithsonian Institution.

***Phagocata angusta* new species**

Figures 1A, 2

Type-material: Holotype, set of sagittal sections on 3 slides (USNM 53620); paratypes, sagittal sections of 5 specimens on 6 slides (USNM 53621-53625).

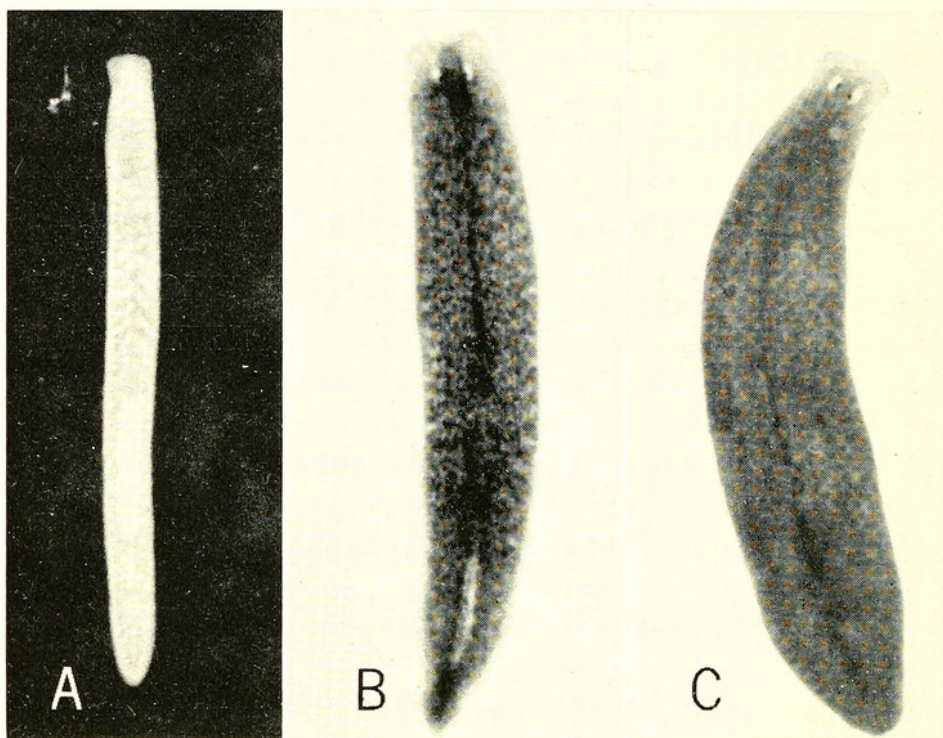


FIG. 1. Photographs of living specimens. A, *Phagocata angusta* n. sp. $\times 8$; B, *P. virilis* n. sp., $\times 7$; C, *P. nordeni* n. sp., $\times 6$.

External features (Fig. 1A): This is a white species, externally very similar to *Phagocata morgani* (Stevens and Boring) but of more slender shape, measuring up to 10 mm in length and 0.7 mm in width. The anterior end is truncate, with a straight or slightly convex frontal margin and rounded lateral edges which protrude laterally when the worm is in gliding locomotion. Eyes are 2, very small, situated at a mutual distance of about $\frac{1}{4}$ the width of the head at eye level and far removed from the frontal margin. The intestinal area begins posterior to the level of the eyes. The pharynx is rather long, located behind the middle of the body, occupying the fourth fifth of the body length. The copulatory apparatus is seen as a transparent area behind the pharynx.

Anatomy: The eyes are very small, the diameter of the pigment cup being only 15–22 μm . They are situated close to the dorsal side of the cerebral ganglion.

The reproductive system of 7 specimens was examined in sagittal serial sections. The testes are subventral, some of them very large and extending through the entire dorsoventral space of the body. They are arranged, on either side, in a longitudinal band reaching posteriorly to the level of the pharynx. The 2 ovaries, each provided with a large lobed parovarium, are situated behind the second lateral branches of the anterior intestinal ramus. In the copulatory complex (Fig. 2), the penis has a muscular bulb (*bp*) of moderate size and a rather short, generally plug-shaped

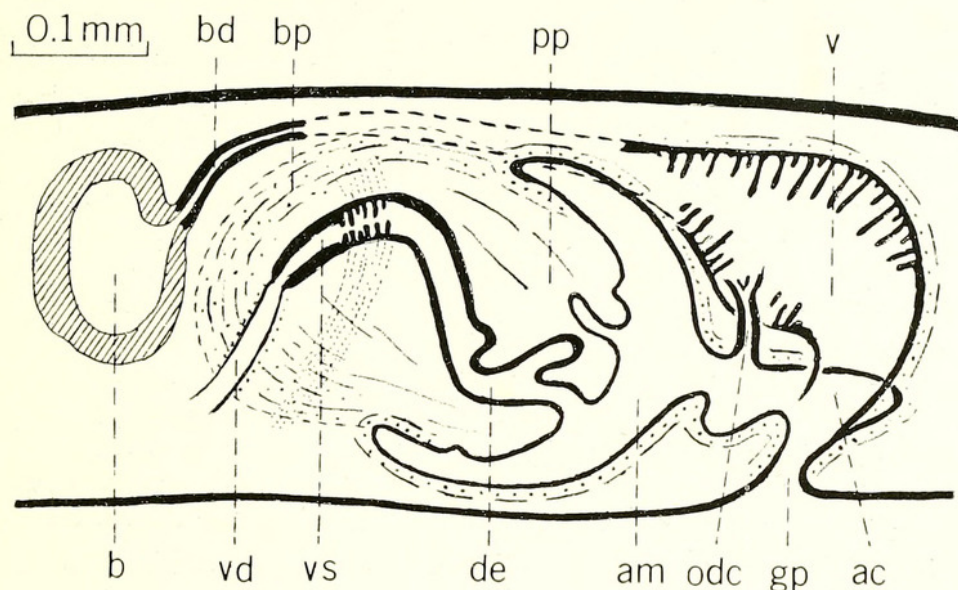


FIG. 2. *Phagocata angusta*, semidiagrammatic view of copulatory apparatus in sagittal section. Abbreviations used in Fig. 2-4: *ac*, common atrium; *am*, male atrium; *b*, copulatory bursa; *bd*, bursal canal or duct; *bp*, penis bulb; *de*, ejaculatory duct; *gp*, gonopore; *m*, mouth; *odc*, common oviduct; *pp*, penis papilla; *v*, vagina; *vd*, vas deferense or sperm duct; *vs*, seminal vesicle.

papilla (*pp*) with somewhat irregular outline. The papilla lacks the muscular wart which is characteristic of the related *P. morgani*. The penis lumen begins in the bulb as an elongated cavity (*vs*) extending first posterodorsally, then arching posteroventrally to open into a variously shaped papillar cavity (*de*) which often shows lateral extensions and sinuses and empties into the atrial cavity near the rounded tip of the papilla. The anterior part of the bulbar lumen is lined with tall epithelial cells of a secretory nature. Then follows a section in which the cells project club-like into the lumen and numerous eosinophilic glands enter the cavity. In the papilla, the lumen is lined with a flattened infranucleate epithelium. Muscle fibers seem to be absent or, at least, are not conspicuous around the penial lumen, which may account for the variability of its shape. The papilla itself is covered with a flattened epithelium, nucleate at the base and infranucleate in the more distal parts of the papilla. Apparently the bulbar lumen corresponds to a seminal vesicle and the cavity in the papilla to a modified ejaculatory duct. The vasa deferentia (*vd*) approach the penis bulb as tortuous spermi-ductal vesicles, enter it anterolaterally or anteroventrally, and open into the bulbar part of the penis lumen.

The cavity surrounding the papilla, the male atrium (*am*), narrows posteriorly and receives the outlet of the common oviduct (*odc*) from the

dorsal side. It connects with a small posterior compartment, the common atrium (*ac*).

The copulatory bursa (*b*) is a rounded sac situated anterior to the penis bulb. Its outlet, the bursal duct (*bd*), begins as a rather narrow canal proceeding posteriorly above the penis or somewhat laterally to it. The lining of this anterior part is generally a smooth epithelium. Behind the male atrium, the duct widens considerably and the epithelial lining projects villus-like into the lumen. This part, which is histologically different from the anterior section, may be called a vagina (*v*).

Distribution and ecology: The species is known so far from only one locality, Harper Cave in Tucker County, West Virginia. It was collected first by John R. Holsinger and David C. Culver in a small pool with muddy bottom near the entrance of the cave, on 19 May 1973 (14 specimens); and again by Arnold Norden and Beth Ball on 2 January 1974 (4 specimens). The cave also contained two species of kenkiids, *Macrocotyla hoffmasteri* (Hyman) and *Sphalloplana culveri* Kenk (in press). It is the "*Phagocata* sp." mentioned in 2 of my papers (Kenk, 1975: 336 and 1976 [in press]).

Taxonomic position: *Phagocata angusta* is externally very similar to several North American white planariids. From the sympatric *Planaria occulta* Kenk it differs by the lack of the median extension of the anterior gut trunk between the eyes and, anatomically, by the lack of an adeno-dactyl in the copulatory complex; from the Alaskan *Phagocata nivea* Kenk, by the restriction of the testes to the prepharyngeal region and by the anatomy of the penis; from *Phagocata oregonensis* Hyman, chiefly by the penial anatomy; and from the sympatric *Phagocata morgani* (Stevens and Boring), to which it seems to be most closely related, by several characteristics: a more slender shape, lack of the wart-like structure on the penis papilla, and a different configuration of the penial lumen. The covering of the penis papilla and the lining of the papillar lumen are infranucleate, while in *P. morgani* they are normal nucleate epithelia. The villus-like projections of the cells lining the vagina are also a good distinguishing character. The name of the species, *angusta* (Latin, narrow), refers to its slender shape.

***Phagocata virilis* new species**

Figures 1B, 3

Type-material: Holotype, set of sagittal sections on 4 slides (USNM 53626); paratypes, 3 sets of sagittal sections on 11 slides (USNM 53627-53629), set of transverse sections on 4 slides (USNM 53630), and set of horizontal sections on 2 slides (USNM 53631).

External features (Fig. 1B): A pigmented species, measuring in life up to 10 mm in length and 1.3 mm in width. The head is truncate, with a straight frontal margin and rounded lateral edges. There is no constriction or neck behind the anterior end. The lateral margins run parallel in the greater part of the body and the posterior end is rather pointed. The distance of the 2 eyes from each other is about $\frac{1}{4}$ to $\frac{1}{3}$ the width of the

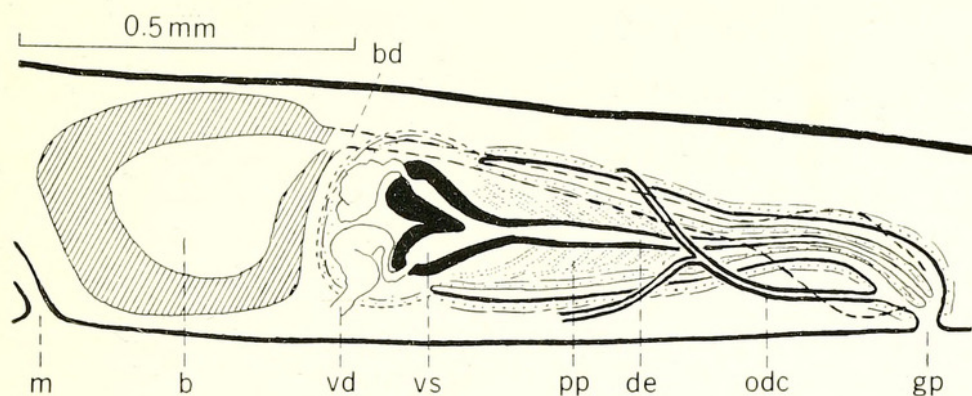


FIG. 3. *Phagocata virilis*, copulatory apparatus. For abbreviations see Fig. 2.

head, their distance from the lateral margin slightly smaller than that from the frontal margin. The pigmentation is dark brown both dorsally and ventrally, appearing somewhat mottled under the dissecting microscope.

Anatomy: The 2 ovaries, each with a large lobed parovarium, are located below or behind the first pair of branches of the anterior intestinal trunk. The testes are predominantly ventral, situated on either side of the midline in a zone beginning immediately behind the ovaries and reaching posteriorly to the level of the copulatory complex. They are developed in only a moderate number, not as closely packed as in most other species of the genus. The copulatory apparatus (Fig. 3) is characterized by a pronounced asymmetry of its components. The penis is situated in the midline and has a rounded bulb of moderate size, with muscle fibers developed only at its periphery. The penis papilla (*pp*) is exceedingly long and conical. The penial lumen consists of a bulbar cavity or seminal vesicle (*vs*) divided into 2 anterolateral lobes, the lobe of the right side being somewhat more dorsal than that of the left side. Toward the papilla, the cavity extends into a canal, the ejaculatory duct (*de*), which runs through the center of the papilla and opens at its tip. This duct is rather wide in its anterior half and tapers to a very narrow canal posteriorly. The seminal vesicle is lined with a tall epithelium of secretory cells. The lining of the widened part of the ejaculatory duct consists of a cuboidal epithelium pierced by many gland ducts with a granular eosinophilic secretion. The narrow distal part of the duct has a flattened epithelium without gland openings. The covering of the penis papilla is a very flattened nucleate epithelium. Below it is a layer of fine circular muscle fibers, followed by a sheet of longitudinal muscles. The 2 vasa deferentia approach the penis bulb as enlarged spermiductal vesicles and enter the bulb anterolaterally. In the bulb, each vas deference, filled with sperm, retains its expanded shape and, after some contortions, enters the lobe of the seminal vesicle of its side. The right oviduct, in the region of the male atrium, ascends to the dorsal side, pro-

ceeds in an arch across the atrium to the left side, and unites with the left oviduct to form the common oviduct (*odc*) which runs posteriorly on the left side of the midline and empties into the posterior part of the atrium close to the gonopore (*gp*). The copulatory bursa (*b*) is a large rounded sac. Its outlet, the bursal duct (*bd*), originates in the midline but gradually turns to the left and continues posteriorly to join the male atrium near the genital aperture. There is no common atrium. In the posterior part, the lumen of the bursal duct is somewhat widened, representing a vagina.

Asymmetry of the copulatory apparatus is frequently observed in planarians, usually caused by irregular contractions and twistings of the organs at the time of fixation. In our specimens, however, which had been killed by the application of a hot corrosive sublimate solution, distortions were minimal and were confined principally to a slight bending of the body producing an arched shape. Nevertheless, the asymmetrical arrangement of the bursal duct and the oviducts was evident in all 6 individuals examined and must be considered to be a normal characteristic of the species.

Distribution and ecology: *Phagocata virilis* was obtained in a seep on the bank of the Patuxent River, Prince Georges County, Maryland, located at McGruder Landing, about 5 miles northeast of the town of Poplar Hill. Seven specimens were collected by Sam L. H. Fuller on 4 February 1976, together with *Procotyla fluviatilis* Leidy, and sent to me alive. When placed in a culture kept at 14° C, some specimens laid five cocoons by 21 March. The cocoons were oblong-ovoid, measuring 0.7–0.8 × 1.4–1.7 mm. The young animals that hatched in early April varied in length from 1.5 to 3 mm.

Taxonomic position: By its external appearance, *Phagocata virilis* is very similar to other North American pigmented planarian species with truncated head, from which it cannot be distinguished in life with certainty: *Phagocata velata* (Stringer), *P. bulbosa* Kenk, the western *P. crenophila* Carpenter, and the sympatric *Planaria dactyligera* Kenk. *P. velata*, when kept in a culture, shows asexual reproduction by fragmentation and encystment, which has not been observed in *P. virilis*. From *Planaria dactyligera*, our species differs by the lack of an adenodactyl and from *P. bulbosa* and *P. crenophila*, by the anatomy of its copulatory apparatus. The name of the species, *virilis* (Latin, masculine), refers to the highly developed male copulatory organ.

***Phagocata nordeni*, new species**

Figures 1C, 4

Type-material: Holotype, set of sagittal sections on 4 slides (USNM 53632); paratypes, set of sagittal sections on 3 slides (USNM 53633) and set of transverse sections of posterior part on 3 slides (USNM 53634).

External features (Fig. 1C): A pigmented polypharyngeal species, externally not distinguishable from the southern form of *Phagocata gracilis* (Haldeman) or from *P. woodworthi* Hyman. Mature specimens

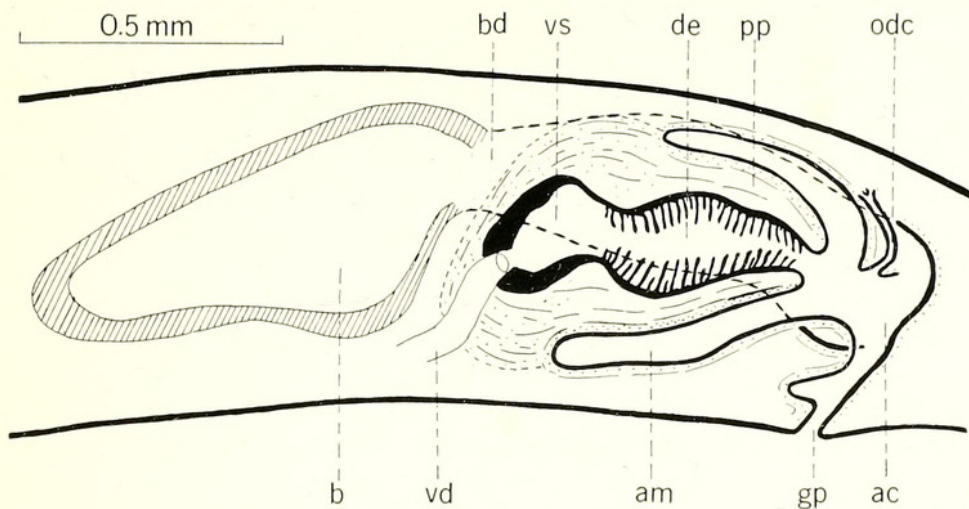


FIG. 4. *Phagocata nordeni*, copulatory apparatus. For abbreviations see Fig. 2.

are up to 15 mm long and 2.5 mm wide. Head truncate, with slightly convex frontal margin which may show a light central protuberance when the animal is gliding. The lateral edges of the head are rounded. Behind the head, a shallow narrowing may appear, but no conspicuous constriction. The lateral body margins gradually diverge, run parallel in the greater part of the body length, then converge again and meet in a rather pointed tail end. The distance between the 2 eyes is about $\frac{1}{3}$ the width of the head, their distance from the lateral margins slightly smaller than that from the frontal margin. The pigmentation is dark brown, almost black, on the dorsal side, with a darker median line in the posterior $\frac{2}{3}$ of the body. The ventral side is also pigmented, but somewhat lighter. The gonopore is visible as a white dot in the middle of the postpharyngeal section.

Anatomy: The species shares its polypharyngy with 2 other species of the genus *Phagocata*, *P. gracilis* (including *P. subterranea* Hyman) and *P. woodworthi*. As in those species, the mouth opening is not at the posterior end of the pharyngeal pouch, but somewhat more anterior.

The numerous testes are predominantly ventral, although a few individual follicles may be found in intermediate and even dorsal positions. The testicular zone reaches posteriorly almost to the tail end. The ovaries, equipped with parovaria, are situated below or behind the first or second lateral branches of the anterior intestine. In the copulatory apparatus (Fig. 4), the penis has a muscular bulb (*bp*) and a large, conical papilla (*pp*). The bulb contains a large cavity, the seminal vesicle (*vs*), lined with a tall secretory epithelium. Posteriorly, the cavity continues into a wide canal (*de*) which opens at the tip of the papilla. The lining of this canal is histologically quite different from that of the seminal vesicle. It consists of an epithelium of club-shaped cells which protrude villus-like into the lumen. The canal corresponds to a considerably expanded

ejaculatory duct. The outer covering of the penis papilla is a cuboidal epithelium underlaid by a thick sheet of fine circular muscles followed by a layer of longitudinal muscle fibers. The vasa deferentia (*vd*) enter the penis bulb anteroventrally, proceed medially and empty into the seminal vesicle separately. The male atrium (*am*) duplicates the shape of the penis papilla, narrows posteriorly, and connects with the small common atrium (*ac*). The common oviduct (*odc*) opens from the dorsal side at the transition between the 2 atria. The copulatory bursa (*b*) is a large sac in the usual position anterior to the penis bulb. It has a very wide outlet, the bursal canal (*bd*), which runs posteriorly on the right side of the penis and connects with the common genital atrium. It is histologically uniform throughout its length, not showing any terminal sphincter such as is seen in *P. woodworthi*. All epithelia of the copulatory apparatus are nucleate.

Distribution and ecology: *P. nordeni* was taken among vegetation in the outflow of Lake Harris, in a ditch along the west side of U.S. Road 27, 0.5 mile south of Leesburg, Lake County, Florida. Seven specimens were collected on 7 January 1976 by Arnold and Beth Norden and D. Franz and brought to me alive. The water temperature was 11° C. *Procotyla fluviatilis* Leidy also occurred in the locality.

Taxonomic position: *P. nordeni* is the third polypharyngeal species of the genus *Phagocata*. In life it cannot be distinguished from the other 2 species, *P. gracilis* and *P. woodworthi*. Anatomically it differs from *P. gracilis* by the structure of the penial lumen (see Kenk, 1970), in particular by the lack of a second seminal vesicle and by the shape and histology of the ejaculatory duct. From *P. woodworthi* it is differentiated by the lack of a sphincter on the bursal duct, the lack of a layer of interlaced circular and longitudinal muscle fibers in the penis papilla, and the configuration of the penial cavities. The species is named in honor of one of its collectors, Mr. Arnold Norden.

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