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A NEW DEROPRISTIID SPECIES (TREMATODA: DEROPRISTIIDAE) FROM THE LAKE STURGEON *ACIPENSER FULVESCENS* IN WISCONSIN, AND ITS BIOGEOGRAPHICAL IMPLICATIONS

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ABSTRACT: *Pristicola bruchi* n. sp. (Trematoda: Deropristiidae) is described from the spiral-valved intestine of the lake sturgeon, *Acipenser fulvescens*, from the Wolf River in Wisconsin, United States. It differs from the only other species of the genus, *Pristicola sturionis*, a parasite of the European Atlantic sturgeon *Acipenser sturio*, in being smaller and in possessing the following characters: a single row of conspicuous peg-like oral spines instead of 2 rows; vitelline follicles that are dorsally confluent over only a small region and that barely overlap the testes instead of extending beyond the posterior testes; and a shorter hermaphroditic duct. Comparisons are hindered by the fact that the type material of *P. sturionis* is no longer available. This is the first report of the genus in North America and is, apparently, the first time the genus has been reported in sturgeon anywhere since the description of *P. sturionis* in 1930. The presence of a species of *Pristicola* in North America means that all 3 genera of deropristiids, *Deropristis*, *Pristicola*, and *Skrjabinopsolus*, now have 2 described species, 1 in North America and another in Europe, reinforcing the amphi-Atlantic biogeography of the family. This, in turn, supports the contention that the deropristiids had diversified into the 3 generic lineages before the establishment of the North Atlantic, and that the present day distribution was likely effected by historical vicariance processes. The association of species of *Pristicola* and *Skrjabinopsolus* with the exclusively freshwater lake sturgeon in the interior of the continent also indicates their considerable geological age.

Pristicola Cable, 1952 is thus far known by its type and its only species, *P. sturionis* (Little, 1930), in the anadromous European Atlantic sturgeon *Acipenser sturio* L. from the Belgian coast (Van Beneden, 1870) and from British waters (Little, 1930), from where it was originally described. This is in contrast to the 2 other deropristiid genera, *Skrjabinopsolus* Ivanov in Ivanov and Murygin, 1937 and *Deropristis* Cable and Hunninen, 1942, which are more widely distributed (Leidy, 1889; Skrjabina, 1974; Appy and Dadswell, 1978). The record of *P. sturionis* from the shovelnose sturgeon (*Scaphirhynchus platorynchus* [Rafinesque, 1820]) in North America, attributed to Cable (1952, 1955) by Hoffman (1967, repeated in Hoffman, 1999) and Skrjabina (1974), and the record of *P. sturionis* from the lake sturgeon (*Acipenser fulvescens* Rafinesque, 1817) also attributed to Cable (1952) by Yamaguti (1971), are both incorrect (see Choudhury and Dick, 1998a). Cable's (1952, 1955) studies, which described *Skrjabinopsolus manteri* (Cable, 1952) and established *Pristicola* for *P. sturionis* in Europe, made no report of the species in North America. During a study of lake sturgeon from the Wolf River and Lake Winnebago, Wisconsin, United States, individuals of a previously undescribed species of *Pristicola* were recovered from the spiral-valved intestine of a single sturgeon from each of the locations. The species is described here, and its implications for hypotheses of the historical biogeography of deropristiid-sturgeon associations are discussed.

MATERIALS AND METHODS

Lake sturgeon, *Acipenser fulvescens*, were collected from the Wolf River in Wisconsin, United States, by trawling on 13 April 2004, and from Lake Winnebago by spear fishing on 19 February 2007. The gastrointestinal tracts of 1 fish from each location were kept on ice and examined within 3–4 hr of capture. In total, 8 specimens of this new species of *Pristicola* were collected from the Wolf River sturgeon, of which 5 were collected live and 3 were dying or dead. Five intact worms were collected from the Lake Winnebago fish; 1 of these, a non-gravid specimen, was used to study the details of the female reproductive complex, unobstructed by eggs, but was not used for measurements; the others were fixed for molecular studies. The parasites were briefly washed in 0.6% saline and killed and fixed simultaneously in steaming hot 5% buffered formalin (VanCleave and Mueller, 1934), accompanied by brief, vigorous shaking (see also Platt [2000] and Platt and Brooks [2001] for method). The digeneans were stained with acetocarmine, dehydrated, and mounted in balsam on slides or between 2 cover slips. The double cover-slip preparations were mounted in aluminum Cobb slides. Specimens were examined using bright-field and Nomarski differential interference contrast optics on an Olympus BX 41 microscope (Olympus, Tokyo, Japan). Illustrations were made with a drawing tube attached to the microscope. A single specimen used for scanning electron microscope (SEM) studies was post-fixed in phosphate-buffered osmium tetroxide, dehydrated through a graded ethanol series, and infiltrated with Peldri (Ted Pella Inc., Redding, California). The Peldri was allowed to evaporate off the specimen, which was then mounted on a stub, sputter-coated with gold, and scanned using a Hitachi S-2500 SEM (Hitachi, Tokyo, Japan). Unfortunately, the specimen prepared for SEM collapsed, and the photographs were not suitable for publication; the preparation was thus used to confirm details of the external morphology.

The type material of *P. sturionis* could not be located at the Museum of Natural History in London (Bray, 2005; David Gibson, pers. comm.). Little's (1930) paper makes no mention of museum deposits. Attempts by Dr. David Gibson, Museum of Natural History, London, U.K. to locate the material by contacting Little's son were also unsuccessful. It appears that the type material is no longer available. Fortunately, the considerably detailed original description by Little (1930) allowed some valid comparisons. The only other specimens that were examined for this study were those of *S. manteri*, a more common parasite of lake sturgeon in the Lake Winnebago system (Choudhury et al., 1996; Choudhury and Dick, 1998a). The *Pristicola* sp. is unique enough that no other species of trematode was needed for comparison. Type and paratype specimens (n = 3) are being deposited in the United States National Parasite Collection (USNPC), Beltsville, Maryland.

Measurements are given in micrometers (μm) and are expressed as range, followed by the measurement of the holotype, in parentheses. Whereas the description is based on 5 whole adults and 1 non-gravid worm, measurements are from 4 gravid worms, unless otherwise mentioned (indicated by 'n =' following values for range).

DESCRIPTION

Pristicola bruchi n. sp.

(Figs. 1–11)

Diagnosis: Body 1,660–2,110 (2,110) long; anterior end broadly rounded, 260–325 (325) wide; body narrowing behind oral sucker region, then widening gradually to maximum hind body width of 235–280 (280) at

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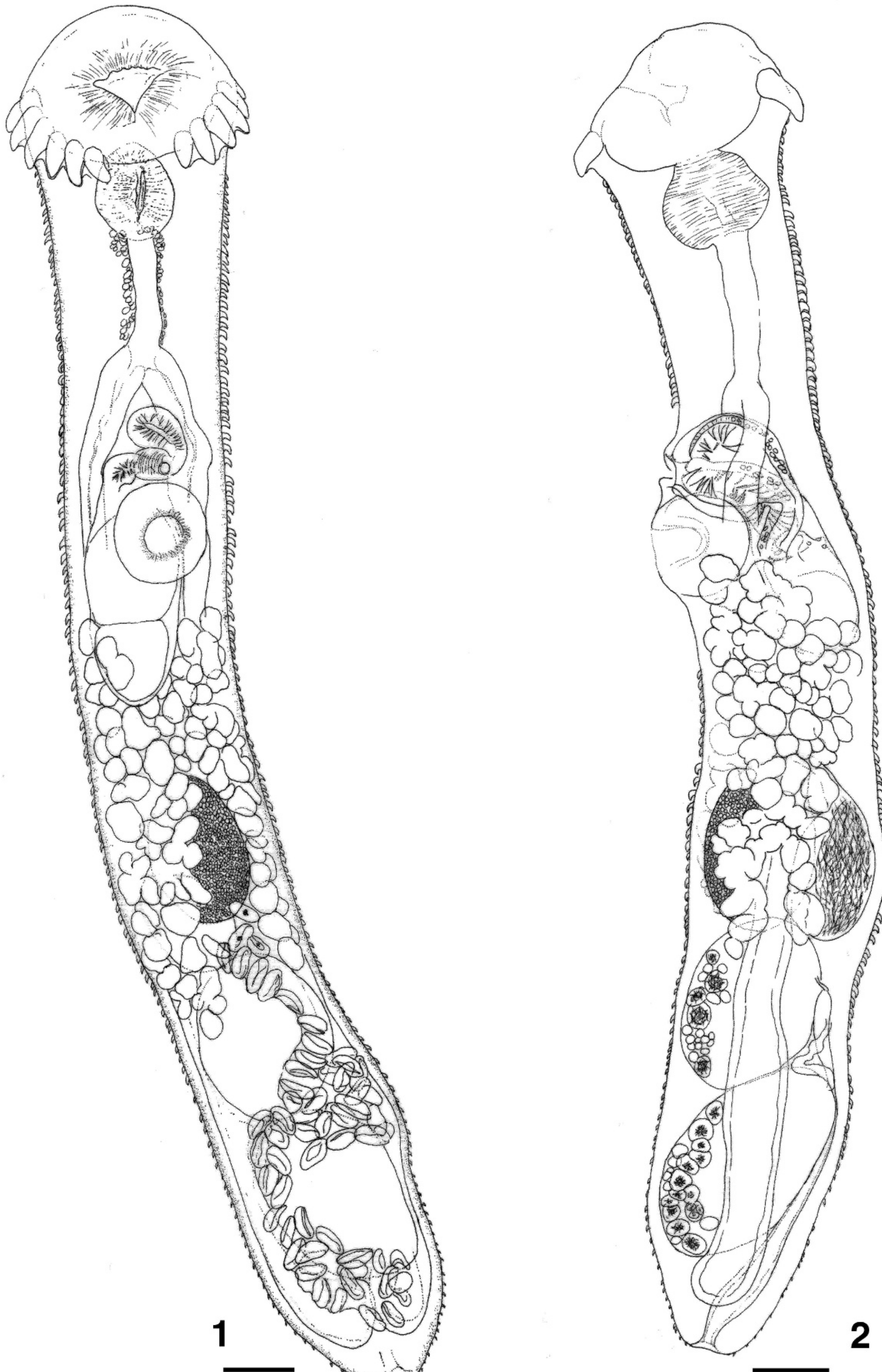
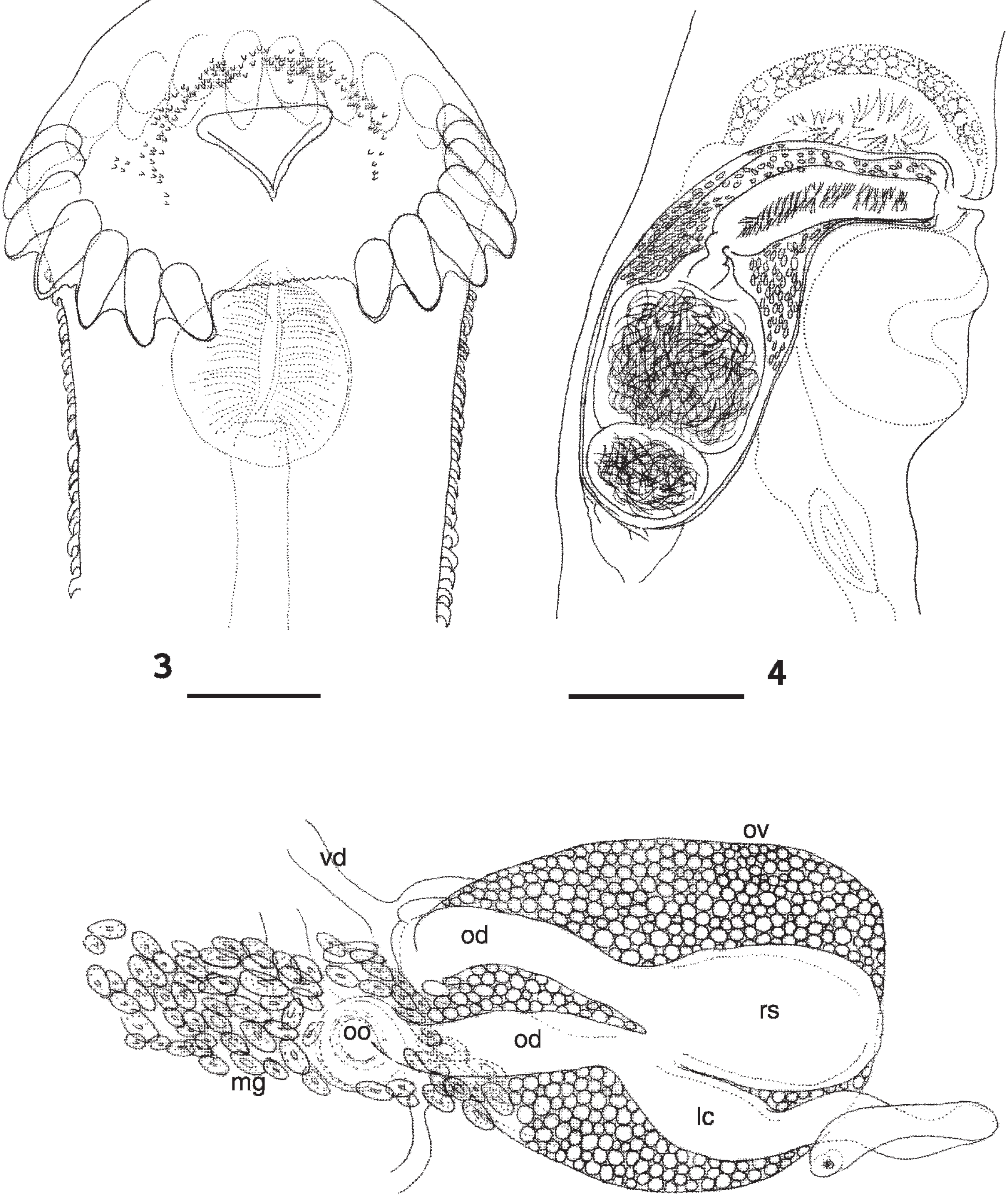
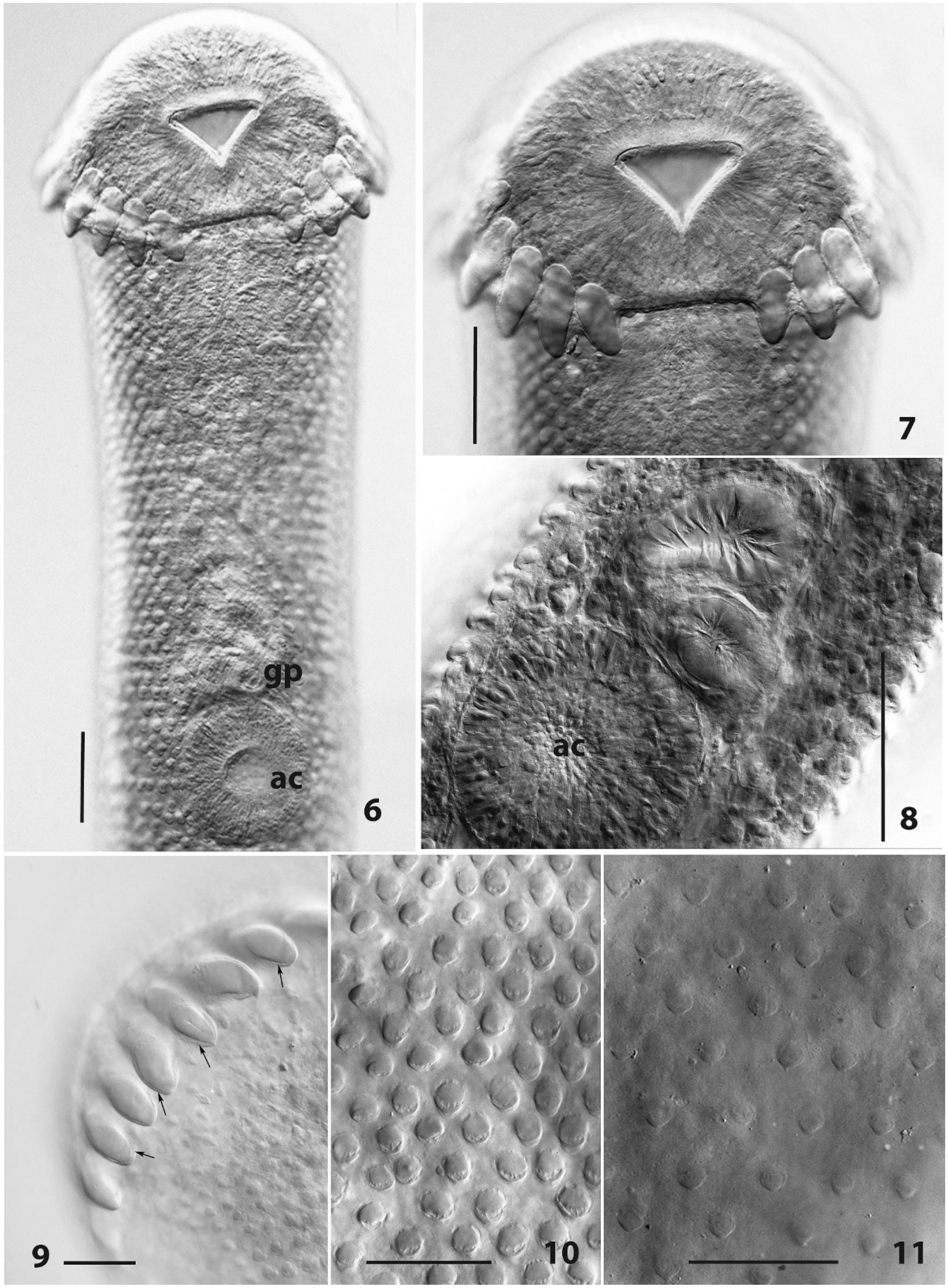


FIGURES 1–2. (**1**) *Pristicola bruchi* n. sp. Ventral view. (**2**) *Pristicola bruchi.* Lateral view (only one ventral and dorsal peg-like oral spine drawn for reference, uterus omitted). Bars = 100 μm.



FIGURES 3–5. *Pristicola bruchi* n. sp. (**3**) Oral sucker region of worm showing interrupted row of large, peg-like spines and field of small spines bordering oral opening. (**4**) Terminal genitalia, with details of cirrus sac; lateral view. (**5**) Female reproductive complex. Labels: ov, ovary; od, oviduct; lc, Laurer's canal; sr, seminal receptacle; ut, uterus, left is anterior. Bars = 50 μm.



FIGURES 6–11. *Pristicola bruchi* n. sp. DIC images of worm. (**6**) Forebody. (**7**) Oral sucker region, showing peg-like spines. (**8**) Internal view showing spines in cirrus and metraterm. (**9**) Dorsal view of peg-like spines showing tegumental covering (arrows). (**10**) Preacetabluar dorsal spination. (**11**) Dorsal spination at the level of posterior testis. Bars = 50 μm.

level of ovary or testes, terminating in bluntly rounded end. Forebody 590–710 (710) long; forebody: total body length 0.3–0.4 (0.3):1. Tegument spinose; spines curved, bases embedded; anterior spines larger, denser, most conspicuous laterally in region between esophageal bifurcation and ovary; spines becoming smaller, sparse, in hind body, especially in post-testicular region. Anterior end surrounded by sub-terminal row of 22 circumoral peg-like spines, discontinuous (interrupted) mid-ventrally; spines completely enclosed by thin tegument, largest ventral spines 65–70 long. Oral sucker 150–230 (230) long, 220–270 (270) wide; oral opening anteroventrally directed, posteriorly notched, edges with 2 conspicuous lateral surface papillae; anterior edge with field of minute spines. Acetabulum 125–150 (150) long, 125–145 (145) wide, opening rounded, ventrally directed, edges with field of minute spines. Ratio of oral sucker:acetabulum length 1.1–.5 (1.5):1, oral sucker width:acetabular width 1.6–1.9 (1.9):1. Prepharynx not discernible. Pharynx muscular, 110–140 (140) long, 100–125 (125) wide. Esophagus short, broadening posteriorly, 145–190 (190) long. Ceca dorsolateral, terminating blindly posterior to testes, left cecum 65–70 (70), right cecum 60–75 (65) from posterior end (distance measured from end of cecum). Cecal bifurcation anterior to gonopore. Testes 2, tandem, contiguous or overlapping, ellipsoidal, margins smooth, anterior testis medial, 175–250 (250) long, 155–180 (180) wide, contiguous with or overlapping ovary anterior to it (in 4 individuals) or slightly separated from ovary (in 1 individual); posterior testis medial, 210–285 (285) long, 140–195 (195) wide, 100–190 (155) from posterior end of body. Cirrus sac elongate, medial, or slightly displaced laterally, dorsal, maximum width 95–145 (145), containing unequally bipartite (anterior chamber larger) internal seminal vesicle occupying posterior half of cirrus sac, short tubular to vesicular pars prostatica, and muscular spined ejaculatory duct opening to short hermaphroditic duct; cirrus sac reaching 80–165 (165) beyond posterior acetabular margin. Gonopore median, immediately preacteabular, postbifurcal. Ovary ellipsoidal to pyriform, margin smooth, entire, 160–210 (210) long, 125–145 (145) wide, ventral, medial, occasionally obliquely oriented, post-acetabular, anterior margin 350–530 (530) posterior to posterior margin of acetabulum. Seminal receptacle 170–210 (210) long, 110–60 (160) wide, dorsal to ovary, overlapping it; Laurer's canal opening dorsally (visible in one gravid specimen and the single non-gravid specimen) in the region of seminal receptacle. Uterus descending posteriorly and ventrally, over and alongside testes but not obscuring them, looping back on itself, ascending ventrally also; descending and ascending uterine ducts not in clearly separated fields; coiled uterus filling small post-testicular region in more gravid individuals; distal arm of uterus traversing pre-testicular region medially or slightly laterally, forming rounded, muscular, spined ventral metraterm leading to short hermaphroditic duct. Vitellarium follicular, in 2 ventrolateral–dorsolateral fields, anteriorly follicles overlapping acetabular region or not reaching it; anterior extent of vitelline fields on either side occasionally asymmetrical; posteriorly follicles overlapping ovary or anterior region of anterior testis; follicles confluent ventrally in limited region immediately posterior to level of cirrus sac, also confluent dorsally in approximately same region; overlying ceca ventrally, also dorsally; vitelline reservoir medial, immediately anterior to ovary. Mehlis' gland inconspicuous. Eggs operculated, immature untanned eggs usually ovoid, mature tanned eggs collapsed and boat-shaped 53.0 $\pm$ 1.4 (52.5–55.0) long, 24.2 $\pm$ 1.5 (22.5–27.5) wide ($n = 15$), containing developing embryo. Excretory vesicle dorsal, tubular, slightly expanded terminally, reaching mid-level of anterior testis, giving off 2 narrow collecting ducts; excretory pore dorsoterminal.

Taxonomic summary

Type host: Acipenser fulvescens (Rafinesque, 1817).

Site of infection: Posterior part of spiral-valved intestine.

Type locality: Wolf River near Shawano, Wisconsin (44°47′03.25″N, 88°37′16.25″W).

Additional localities: Lake Winnebago, Wisconsin (44°03′09.33″N, 88°24′02.12″W).

Holotype: USNPC 101949.

Paratypes: USNPC 101950 (3 slides).

Etymology: The species is named after Dr. Ronald Bruch, Senior Fisheries Biologist, Wisconsin Department of Natural Resources, Oshkosh, Wisconsin, for his deep and long-standing commitment to understanding, preserving, and managing our state's most ancient natural heritage fish species, the lake sturgeon.

Remarks

Pristicola bruchi n. sp. differs from *P. sturionis* in being smaller (1,660–2,110 µm vs. 3,500–6,200 µm) and in possessing the following characters: a single row of conspicuous, peg-like oral spines instead of 2 rows, vitelline follicles that are dorsally confluent over only a small region and that barely overlap the testes instead of overlapping them extensively, and a shorter hermaphroditic duct (not overlapping the acetabulum vs. reaching the posterior margin of the acetabulum). This is the first report of the genus in North America, and apparently the first time a species of the genus has been reported in sturgeon anywhere since the description of *P. sturionis* in 1930. Whereas the type locality is the Wolf River, it is not surprising that the species also occurs in lake sturgeon from Lake Winnebago, as the Wolf River drains into that lake.

DISCUSSION

In a previous study, Choudhury and Dick (1998a) returned Deropristiidae to its original status (Cable and Hunninen, 1942; Cable 1952), an arrangement also followed by Bray (2005). The morphology of *P. bruchi* reinforces the putative adult synapomorphies suggested for the family by Choudhury and Dick (1998a), i.e., vitellarium in lateral fields between seminal vesicle and testes, metraterm and cirrus identically spined, and an unequally bipartite septate seminal vesicle. A cladistic analysis of Deropristiidae (Choudhury and Dick, 1998a) indicated that *Deropristis* and *Pristicola* form a monophyletic group with *Skrjabinopsolus* as a sister taxon. However, those conclusions need to be re-evaluated; the synapomorphy for *Deropristis* and *Pristicola*, a long hermaphroditic duct, is no longer valid because *P. bruchi* has a short hermaphroditic duct, as in *Skrjabinopsolus*. Given the small number of characters used by Choudhury and Dick (1998a), a revised analysis is not attempted here.

The discovery of *P. bruchi* also has implications for the historical biogeography of the deropristiids. All 3 genera of deropristiids, i.e., *Deropristis*, *Skrjabinopsolus*, and *Pristicola*, now contain 2 species each, 1 of which is found in Eurasia (mainly Europe) and the other in North America (but *D. hispida* is found in both the coastal Atlantic sturgeons, the North American *A. oxirhynchus* Mitchill, and the European *A. sturio*). Furthermore, all 3 genera have thus far been reported from the central or eastern part of North America and from Europe, but not from Siberia or the Pacific drainages of North America and Eurasia (Skrjabina, 1974; Margolis and McDonald, 1986; Bykovskaya and Kulakova, 1987; Choudhury et al., 1996; Choudhury and Dick, 2001). The distribution of the deropristiids in drainages of the Atlantic basin, or immediately adjacent to it, indicates an amphi-Atlantic vicariance pattern that dates the separation between the North American and European species as far back as the Cretaceous (Choudhury and Dick, 2001). According to this model of historical biogeography, all 3 genera originated before the final separation of North America from Europe in the Eocene and, perhaps, long before that. Speciation within the 3 genera in North America and Europe was likely a gradual process of genetic drift following "the progressive opening and widening of the North Atlantic in late Cretaceous and through the early Tertiary" (Choudhury and Dick, 1998b). The fossil record of sturgeons is consistent with such hypotheses (Choudhury and Dick, 1998b, 2001).

The historical biogeography of *Pristicola bruchi* can be expected to parallel that of *S. manteri*, the other deropristiid found in lake sturgeon in Wisconsin, because both species are truly freshwater representatives of their genera and are associated with an exclusively freshwater sturgeon. Based on the biogeography, biology, and host-associations of the deropristiids and related trematodes, Choudhury and Dick (1998a) proposed that the deropristiids were marine in origin and that the freshwater biology of *S. manteri* was derived. We can make the same argument for the freshwater *P. bruchi*, whose only nearest relative, *P. sturionis*, is found in an anadromous host, *A. sturio*, in European coastal waters and an associated river (Thames) (Van Beneden, 1870; possibly Cobbold, 1879 after Bray, 2005; Little, 1930).

Based on our updated information, we should also not be surprised if a species of *Pristicola* were to be found in the American Atlantic sturgeon, *A. oxirhynchus*, or its subspecies, the Gulf of Mexico sturgeon, *A. o. desotoi*. Finally, we may also predict that the biology of *P. bruchi* involves oligochaete second intermediate hosts, as in the life cycle of *S. manteri*. Both trematodes apparently occur in sympatry in the Lake Winnebago drainage system, and oligochaetes are common dietary items of lake sturgeon there (A. Choudhury and R. Bruch, unpubl. obs.).

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