A NEW SPECIES OF CARDICOLA SHORT, 1953 (DIGENEA: APOROCOTYLIDAE) FROM THE HEART AND BRANCHIAL VESSELS OF TWO SURFPERCHES (PERCIFORMES: EMBIOTOCIDAE) IN THE EASTERN PACIFIC OCEAN OFF CALIFORNIA

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ABSTRACT: Cardicola nonano n. sp. (Digenea: Aporocotylidae) infects the heart of white seaperch, Phanerodon furcatus Girard, 1854 (Perciformes: Embiotocidae) (type host), in Monterey Bay, California, and the branchial vessels of rubberlip seaperch, Rhacochilus toxotes Agassiz, 1854 (Eubranchipus: Embiotocidae). From Naples Reef, Santa Barbara Channel, off Santa Barbara, California. It is most easily distinguished from other species of Cardicola Short, 1953 by the combination of having (1) rows of minute tegumental spines distributing along the entire ventrolateral body margin; (2) an aspinous anterior sucker comprising a nearly indistinct spheroid length of the anterior ceca; (3) an esophagus 17–21% of the total body length; (4) convoluted posterior ceca 51–65% of the total body length and 9–18× length of the anterior ceca; (5) a rectangular, intercecal testis not extending posteriori beyond the anterior ceca; (6) a post-testicular and post-cecal ovary; (7) an oviduct emanating from the postrodistal margin of the ovary; (8) a post-ovarian uterus coiling twice just posterior to the ovary; and (9) male and female genital pores opening dorsosmedially and posterior to the uterus and ootype. The new species most closely resembles Cardicola ambrosioid Braicovich, Etchegeoin, Timi, and Sardella, 2006, which infects the blood vessels of the gill and liver of Brazilian flathead, Percahis brasiliensis Quoy and Gaimard, 1825 (Perciformes: Percophidae), in the southwestern Atlantic Ocean off Argentina; however, C. ambrosioid differs morphologically from the new species at least by lacking post-ovarian spine rows and by having posterior ceca that are 4× length of the anterior ceca. This is the first published record of an aporocotylid from a surfperch (Embiotocidae) as well as that of a species of Cardicola from the Pacific Ocean east of the Hawaiian Islands.

Cardicola Short, 1953 presently accommodates many of the nominal marine and estuarine fish blood flukes (Digenea: Aporocotylidae) that have a single testis and an “H-shaped” gut, i.e., an anterior and posterior pair of approximately equal-length ceca intersecting at the body midline. Cardicola spp. infect the blood vascular system of marine percomorphs (Percomorpha) (see Manter, 1947, 1954; Short, 1953; Lebedev and Mamaev, 1968; Yamaguti, 1970; Parukhin, 1976; Speare, 1995, 1999; Cribb et al., 2000; Bullard and Overstreet, 2004, 2006; Bullard et al., 2004; Braicovich et al., 2006; Nolan and Cribb, 2006; Holzer et al., 2008) and 2 euryhaline mullets (Mugil spp., Mugiliformes: Mugilidae) (Yamaguti, 1970; Knoff and Amato, 1992), with all of these host records deriving from fishes of superorder Acanthopterygii (see Nelson, 2006).

Much remains to be documented regarding the geographic distribution, host range, general biology, life history, and taxonomy of the collection of aporocotylids presently included within Cardicola. The ecological breadth and geographic range of definitive hosts used by Cardicola spp. comprises estuarine, coastal, and pelagic fishes occupying a wide band of latitude worldwide; however, noteworthy is that none have been reported previously from the eastern Pacific Ocean. Although generally regarded as a strictly marine group with species that mature in oceanic fishes (Smith, 2002), no life cycle has been published for any member of Cardicola, and those nominal species of Cardicola infecting euryhaline mullets, i.e., Cardicola mugilis Yamaguti, 1970 from flathead mullet, Mugil cephalus Linnaeus, 1758 in the Pacific Ocean and Cardicola brasiliensis Knoff and Amato, 1992 from the mullet, Mugil platys Günther, 1880 in the southwestern Atlantic Ocean, for example, could involve a brackish water or freshwater molluscan or polychaete intermediate host. Hence, it is indeterminate whether Cardicola can accurately be characterized as holding “strictly marine” aporocotylids.

Some adult aporocotylids seem specific to the heart (Smith, 1972, 1997a, 1997b, 2002; Bullard and Overstreet, 2002, 2004, 2006), but tissue and organ site specificities within the definitive fish host reportedly have not been studied for any species of Cardicola. Reported sites of infection for adults of Cardicola spp., in addition to heart, include “washings of gut” (Short, 1953), “gills and coelom, probably blood vessels” (Manter, 1954), “blood vessels and gills” (Lebedev and Mamaev, 1968), “intestine wall” (Lebedev and Mamaev, 1968), and “blood vessels of the heart, kidney, liver, and gill” (Knoff and Amato, 1992). Complicating the matter of site specificity in the definitive host is that at least some aporocotylids are motile and may relocate within the fish’s vascular system. This relocation could relate to potential seasonality of their life cycles (Avendaño de MacIntosh and Ostrowski de Núñez, 1998; Bullard and Overstreet, 2002, 2008) and/or to deposition of eggs nearest the gill or perhaps intestine to increase the likelihood that the miracidium can escape the host when the appropriate intermediate hosts are seasonally abundant in the system.

Monophyly of Cardicola has not been demonstrated by a phylogenetic analysis including morphological data or molecular data derived from the type species Cardicola cardiocolum (Manter, 1947) Short, 1953 (synonyms of this species are Psettarium cardiocolum of Manter [1947] and Short [1953]; and Cardicola cardiocolum of Short [1953], Smith [1997], and Cribb et al. [2000]) or the majority of aporocotylid species described before 2006. In fact, like many nominal species of the genus, reportedly no specimen of C. cardiocolum has been collected since its original description, which is based on specimens excised from the heart of jolthead poggy, Calamus bajonado (Bloch and Schneider, 1801) (Perciformes: Sparidae) captured off Tortugas, Florida. In addition, and like many deposited type and voucher specimens of species of Cardicola, the holotype of C. cardiocolum (United States National Parasite Collection [USNPC] 37035) is in generally poor condition, i.e., lightly stained and folded. Furthermore, Manter’s (1947) original description of the fluke was incomplete and overly stylized. That, coupled with the poor condition of the holotype and the lack of other deposited

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vouchers available for study, creates a situation wherein, quite simply, it is unclear what morphological features are present or absent in the type species. This has led to understandable confusion, with some authors assigning species to Cardicola that possess the diagnostic features of Elaphrobates Bullard and Overstreet, 2003, recognized herein as distinct from Cardicola (see Nolan and Cribb, 2006; Holzer et al., 2008). In addition to the type species, several species incertae sedis should be the focus of new collection efforts and subsequent descriptive work because their original descriptions are incomplete, and type materials are either lost, not available for loan, or in generally poor overall condition: Cardicola congruens Lebedev and Mamea, 1968; Cardicola grandis Lebedev and Mamea, 1968 (see Bullard and Overstreet, 2006); Cardicola ahí Yamaguti, 1970; Cardicola muglisis Yamaguti, 1970; and Cardicola kurochikini (Parukhin, 1976) Bullard and Overstreet, 2006.

Despite the need for taxonomic clarification, species discovery among related aporocotylids and within Cardicola will nevertheless contribute to an eventual systematic revision of the group. Herein, a new species of Aporocotylidae Odhner, 1912 is described based on 1 and 4 whole-mounted specimens collected during 1936 and 1980, respectively, from 2 species of surfperch (Perciformes: Embiotocidae) captured in the eastern Pacific Ocean off the coast of southern California. The new species is provisionally assigned to Cardicola, pending a revision of the genus that includes morphological and molecular data derived from C. cardicolum and related species.

**MATERIALS AND METHODS**

In 2000, the whole-mounted specimen designated as the holotype of the new species was given to SAB by Fuad Michael Nahhas (deceased, Department of Biological Sciences, University of the Pacific, Stockton, California), who probably obtained it directly from his departmental colleague Alden Earl Nobel (deceased, University of the Pacific), who either collected it himself or was given the specimen and subsequently informed that it was collected on 20 July 1936 from Monterey Bay, California. The 4 paratypes (on 1 slide, USNPC 82424.02, M1593-1) of the new species were collected by Mike Moser (University of California, Berkeley, California), who speared the host during summer 1980 on Naples Reef (Santa Barbara Channel) off Santa Barbara, California. Moser’s aporocotylid specimens were identified later as Cardicola sp. by John C. Holmes (University of Alberta, Edmonton, Alberta, Canada) and Cameron P. Goater (University of Lethbridge, Lethbridge, Alberta, Canada). That slide was borrowed from the USNPC by SAB in July 2009, with the newer specimens being regarded herein as conspecific with Nobel’s 1936 specimen. Illustrations were made with the aid of a Leica DM-2500 (Leica Microsystems, Inc., Deerfield, Illinois) equipped with differential interference contrast optical components and a drawing tube. Measurements were obtained by using a calibrated ocular micrometer and are herein reported in micrometers followed by the number of specimens measured in parentheses. Common and scientific names for fishes follow FishBase (Froese and Pauly, 2009). Higher-level fish classification and nomenclature follow Nelson (2006). Nomenclature for Aporocotylidae follows Bullard et al. (2009). Specimens of Cardicola spp. were borrowed from the USNPC; The South Australian Museum (SAM), Adelaide, South Australia; and the Parasite Collection of the H. W. Manter Laboratory of Parasitology (HWML), Lincoln, Nebraska.

**DESCRIPTION**

*Cardicola nonano n. sp.* (Figs. 1–4)

Diagnosis of adult (measurements and illustrations based on 5 whole-mounted adult specimens comprising the holotype and 4 paratypes): Body flat, ventrally concave, elongate oval, 3,750–5,100 (5) long, 640–760 (5) wide or 5.1–6.6× longer than wide, having posterior end slightly more broadly rounded than anterior end, lacking posterolateral body protuberances, margin crenulate, marginally or straightly. Esophagus length of body length from posterior body end, will never—

CARDICOLA

Elaphrobates Cardicola ahi

Yamaguti, 1970; and

Lebedev and Mamaev, 1968 (see Bullard and Overstreet, 2006). Specimens of C. cardiocolum Yamaguti, 1970; and C. cardiocolum

383

BULLARD—A NEW SPECIES OF *CARDICOLA*
*Cardicola nonamo* n. sp. (Digenea: Aporocotylidae) (holotype, USNPC 103042) from the heart of white seaperch, *Phanerodon furcatus* Girard, 1854 (Perciformes: Embiotocidae) in Monterey Bay, California, dorsal view. Note that the lateral tegumental spines, which are ventral only, are illustrated in these dorsal views to demonstrate their position relative to structures of the sensory, alimentary, and reproductive systems. (1) Body showing location of anterior sucker (as), dorsolateral nerve cord (dc), ventrolateral nerve cord (vc), esophagus (e), anterior cecum (ac), posterior velum (vt), tegumental sucker (tsr), oesophagus (o), ovary (oo), fertilization pore (fp).
Genitalia not extending lateral to ventrolateral nerve cords (Fig. 1). Testis approximately rectangular, 1,841–3,000 (5) long or 49–63% of body length, 300–400 (5) in maximum width or 42–54% of body width at level of midbody, intercecal, not extending laterad beyond posterior ceca, between cecal intersection and distal tips of posterior ceca, with border slightly irregular or occasionally slightly lobed, but never branching, enclosing refractive processes; processes 5–7 (5) in diameter; post-testicular space 980–1,400 (5) long or 22–27% of body length (Figs. 1, 3, 4). Vasa efferentia difficult to trace, an interconnecting meshwork of fine ducts entwining throughout testicular tissue, containing spermatozoa, approximately 10 in diameter, extending primarily along ventral surface of testis, uniting in posterior region of testis to form vas deferens; vas deferens 670–1,070 (5) long, 30–50 (5) wide, sinistral, extending posteriad from testis before curving slightly laterad and extending directly posteriad, containing sperm, ovary (o), primary vitelline duct (vt), oviduct’s connection (oc) with ovary, oviducal seminal receptacle (osr), ootype (oo), Mehl’s gland (mg), ascending uterus (au), seminal vesicle (sv), vas deferens (vd), descending uterus (du), metraterm (me), female genital pore (fp), and male genital pore (mp), dorsal view. Note that the lateral tegumental spines, which are ventral only, are illustrated in this dorsal view to demonstrate their position relative to reproductive structures, dorsal view. Bar = 250 μm. Posterior body end of a paratype (USNPC 82424.03) from the branchial vessels of rubberlip seaperch, *Rhacochilus toxotes* Agassiz, 1854 (Embiotocidae) from Naples Reef, Santa Barbara Channel, off Santa Barbara, California, showing comparable morphological features as in Figure 3, ventral view. Bar = 300 μm.

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cecum (pc), ventrolateral rows of tegumental spines (tsr), testis (t), vitellarium (vt), vasa efferentia (ve), ovary (o), ootype (oo), female genital pore (fp), and male genital pore (mp). Bar = 500 μm. (2) Anterior body end showing location of mouth (m), commissure of dorsolateral nerve cord (dnc), commissure of ventrolateral nerve cord (vnc), base of secondary branches of nerve cords (sb), vitellarium (vt), ventrolateral rows of tegumental spines (tsr), anterior portion of esophageal gland (aeg), posterior portion of esophageal gland (peg), cecal diverticula (cd), and esophageal intersection with ceca (ei). Bar = 200 μm.
narrowing distally before connecting with seminal vesicle. Seminal vesicle oblong, 154–230 (5) long, 50–80 (5) wide, medial, directing posterior and slightly upwards, containing sperm, with wall approximately 3 thick (Figs. 3, 4). Gland surrounding seminal vesicle indistinct. Everted cirrus small, nipple-like, unarmed, 37 (1) long or 24% of seminal vesicle length, 7 (1) wide, 5.3× longer than wide, everted dorsally between sinistral ventrolateral nerve cord and midline; cirrus sac indistinct (Figs. 3, 4).

Ovary medial, arcuate or ovoid, not branching, slightly lobed along margins and forming dorsal aspect. 250–350 (5) long or 6–7% of body length, 240–350 (5) wide or 35–47% of body width, 0.8–1.3× wider than long, medial, occupying space immediately posterior to testis, dorsal to vas deferens, not extending laterally beyond level of ventralateral nerve cords, containing refractive rod-like dorsoventral processes similar to those of testis; processes occurring singly or clustered. Post-ovarian space 732–1,100 (5) long or 16–22% of body length (Figs. 1, 3, 4). Oviduct 211–390 (5) in total length, 10 (4) wide in proximal portion immediately posterior to ovary, with proximal portion comprising a thin tube emanating from posteriorodextral margin of ovary and extending posteriorid before expanding laterally to form oviducal seminal receptacle; oviducal seminal receptacle comprising middle portion of oviduct, elongate oval in shape, having a conspicuous kink at distal (posterior) end, 75–155 (5) long, 12–28 (5) wide, slightly dextral, residing between level of ovary and seminal vesicle; distal portion of oviduct comprising a narrow tube recurving dorsolateral before extending posteriorid and connecting to ootype (Figs. 1, 3, 4). Vitellarium an extensive network of narrow interconnecting branching bands, primarily filling space both dorsal and ventral to alimentary tract and between level of alimentary tract and lateral body margin, extending laterally slightly beyond nerve cords, not extending posteriorid to ovary, with proximal level of distal tips of posterior ceca (Figs. 1–4); secondary collecting ducts indistinct; common collecting duct medioventral to testis, 427–550 (5) in length from level of testis to distal end, 15–35 (5) in maximum width at level of ovary. Ootype 40–50 (3) long, 15–40 (3) wide, elongate or nearly spherical in shape, dextral, located well anterior to junction of vas deferens and seminal vesicle (Figs. 1, 3, 4). Melhis’ gland approximately 124 in diameter, with individual cells approximately 3 in diameter (Figs. 3, 4). Uterus extending 240–390 (5) or 6–9% of body length posteriorid from ootype and approximately in parallel with dextral ventrolateral nerve cord before curving dorsally and anterid and forming ascending portion of uterus; ascending portion of uterus extending 390–650 (5) or 9–13% of body length anteriad before coiling 2 times medially and immediately posterior to level of ovary, occupying space between ootype and vas deferens, post-cecal, post-testicular, overlapping slightly ventral to posterior margin of ovary in holotype, but primarily post-ovarian, primarily anterior to level of seminal vesicle; descending portion of uterus an extremely thin-walled (approximately 1 thick) tube extending 292–450 (5) or 8–9% of body length posteriorid, 20–30 (5) in maximum width, crossing laterally to vas deferens lateral to first uterine coil, to ascending uterus, connecting with proximal portion of metraterm anterior to level of ootype (Figs. 3, 4); metraterm 110–280 (4) long, 25–50 (4) wide in proximal portion, having wall approximately 4 thick throughout, coursing primarily parallel to and between sinistral ventrolateral nerve cord and vas deferens. Uterine eggs 13–15 (4) long, 2–3 (4) wide, sub-spherical (Figs. 3, 4). Female genital pore dorsal, sinistral, post-ovarian, anteromedial to male genital pore (Figs. 3, 4). Excretory system indistinct.

Taxonomic summary

Type host: *Phanodon forruci* Girard, 1854 (Perciformes: Embiotocidae), white seaperch.

Other host: *Rhuacallis toxotes* Agassiz, 1854 (Embiotocidae), rubberlip seaperch.

Sites in host: Lumen of heart (holotype) and branchial vessels (paratypes).

Type locality: Eastern Pacific Ocean, Monterey Bay, California (geographic coordinates were not recorded for the exact collection site in the Bay).

Other localities: Eastern Pacific Ocean, Santa Barbara Channel, Naples Reef (approximately 1.4 km offshore), California 34°25.300 N, 119°57.137 W.

Specimens deposited: Holotype USNPC 103042; Paratypes USNPC 82424.03.

Specimens compared: Paratypes of *Cardicola larrei* Short, 1953 from the heart of sand weakfish, *Cynodon arenarius* Ginsburg, 1930 (Perciformes: Sciaenidae), in the Gulf of Mexico off Franklin and Wakulla Counties, Florida, USA (USNPC 37378 and 37379); paratype of *Cardiola cirriadiacis* Manter, 1954 from the branchial blood vessels of the coelom of greenbume, *Olapix pullus* (Forster, 1801) (Perciformes: Odaeidae), (as *Coridodax pullus*) in the southwest Pacific Ocean off Wellington, New Zealand (HWML 656); paratype of *Cardiola whittieri* Manter, 1954 from the branchial blood vessels of tarakiki, *Nemadactylus macropterus* (Forster, 1801) (Perciformes: Chelidactyidae), from off Wellington (HWML 657); holotype of *C. mugilis* from the heart or blood vessels of flathead mullet, *Mugil cephalus* (Mugilliformes: Mugilidae), in the central Pacific Ocean off the Hawaiian Islands (USNPC 63553); holotype of *Cardiola chaetodontis* Yamaguti, 1970 from the gill or heart of mullet butterflyfish, *Chaetodon miliaris* Quoy and Gaimard, 1825 (Perciformes: Chaetodontidae), or bluespotted butterflyfish, *Chaetodon frenbli* Bennett, 1828, from off the Hawaiian Islands (USNPC 63552); holotype of *C. ubi* from gill washings of yellowfin tuna, *Thunnus albacares* (Bonnaterre, 1788) (Perciformes: Scombridae), (as *Neothusmus macropterus*) from off the Hawaiian Islands (USNPC 63551); paratypes of *C. brasiliensis* from the heart or blood vessels of the kidney, liver, or gill of a mullet, *Mugil platanus*, from the southwestern Atlantic Ocean (Baia de Sepetiba, Estado do Rio de Janeiro) off Brazil (HWML 31717 and 31718); paratypes of *Cardiola forsteri* Cribb, Dainith, and Munday, 2000 from the heart of captive southern bluefin tuna, *Thunnus maccoyii* (Chapman, 1932), and the Taishan Sea (southwestern Pacific Ocean) off Rabbit Island, South Australia (SAM 28336 and 28337); and voucher specimens maintained in the collection of SAB from the heart of Gulf of Mexico fishes: *Elaphrosurus euzeti* Bullard and Overstreet, 2003 from red snapper, *Lutjanus campechanus* Poe, 1860 (Perciformes: Lutjanidae), *C. larrei* from the heart of *C. arenarius* and spotted weakfish, *Cynoscion nebulosus* (Cuvier, 1830), *Cardiola palmeri* Bullard and Overstreet, 2004 from black drum, *Pogonias clivosus* Linnaeus, 1766 (Perciformes: Sciaenidae), and *Cardiola curranii* Bullard and Overstreet, 2004 from red drum, *Sciaenops ocellatus* (Linnaeus, 1766) (Sciaenidae).

Etymology: The specific epithet *nonamo* incorporates, in chronological order, the first 2 letters of the last name of each worker who handled the holotype and paratypes, i.e., Nobel, Nahhas, and Moser, and it is a phonetic derivative of “no name;” which intends to underscore that the holotype and paratypes lacked a specific epithet for many years after they were collected in 1936 and 1980, respectively.

Remarks

*Cardiola nonamo* n. sp. differs from other species assigned to *Cardiola* by the combination of having (1) rows of minute tegumental spines distributing along the entire ventralateral body margin; (2) an aspinous anterior sucker comprising a nearly indistinct spherical structure centering on the mouth; (3) an esophagus 17–21% of the total body length; (4) convoluted posterior ceca 5–9% of the total body length and 9–18% length of the anterior ceca; (5) a rectangular, intercecal testis not extending posteriorid beyond the posterior ceca; (6) a post-testicular and post-cecal ovary; (7) an ovotestis emanating from the postroctodermal margin of the ovary; (8) a post-ovarian uterus coiling twice just posterior to the ovary; and (9) male and female genital pores opening dorsomedially and posterior to the uterus and ootype (Figs. 1–4). The new species most closely resembles *Cardiola ambrosioi* Braichovich, Ecchechin, Timi, and Sardella, 2006, which infects the blood vessels of the gill and liver of the Brazilian flathead, *Perophis brasiliensis* Quoy and Gaimard, 1825 (Perciformes: Perophididae) in the southwestern Atlantic Ocean off Argentina. Both aporocotylids have (1) relatively short anterior ceca; (2) ventralateral nerve cords coursing ventral to the posterior ceca; (3) a single vas deferens coursing ventral to the ovary and in parallel with the metraterm and descending uterus; (4) a more genital poral body margin posterior to the female genital pore; (5) an ovotestis emanating from the postroctodermal margin of the ovary; (6) a uterus coiling immediately posterior to the ovary; and (7) a seminal vesicle and metraterm adjacent to each other in the posterior body extremity. However, the new species can be most easily distinguished from *C. ambrosioi* by having rows of tegumental spines distributing along the entire body margin and by having posterior ceca that are 9–18× length of the anterior ceca. *Cardiola ambrosioi* reportedly lacks post-ovarian spine rows and has posterior ceca that are only 4× length of the anterior ceca. Although infrequently used as a source of taxonomic characters for species of *Cardiola*, the course of the uterus, specifically described in terms of its
ascending portion (that which extends anterior) and descending portion (that which extends posterior to connect with the metraterm), as well as the relative position of the ootype that hold promise for reliable taxonomic characteristics. For example, C. nonamo and C. ambrosioi each have a descending uterus that extends directly posterior in parallel with and between the vas deferens and body margin as well as an ootype that occupies the space at level of the middle region of the ascending uterus.

Cardicola nonamo and C. ambrosioi presently are known only from the Pacific and Atlantic Ocean basins, respectively. Moreover, these species presently are known only from the heart and gill vessels of 2 surfperches (Percoformes: Embiotocidae) and the gill and liver vessels of a duckbill (Perciformes: Perchocidae), respectively.

Cardicola nonamo can be most easily distinguished from the remaining species that previously have been assigned to Cardicola by considering features associated with the anterior sucker, relative lengths of the esophagus and ceca, position of the gonads relative to the ceca, the medial or lateral origin of the oviduct relative to the posterior margin of the ovary, relative location of the uterus and genital pores, and the course of the uterus (Figs. 1–4).

The absence of a spheroid anterior sucker bearing concentric spine rows distinguishes the new species from the species assigned to Cardicolu that infect the Australian siganids and lutjanid (Nolan and Cribb, 2006) and Cardicola aurata (Holzer, Montero, Repulle, Nolan, Sitj, Sotobaila, Alvarez-Pellitero, Zarza, and Raga, 2008 (see Holzer et al., 2008) as well as Elaphrobates euzeti Bullard and Overstreet, 2003 (see Bullard and Overstreet, 2003) (Figs. 1, 2). It is unclear whether C. cardiocolum, the type species, has a spheroid anterior sucker with concentric spine rows or not, and indeed some of the species presently assigned to Cardicola apparently lack the feature. Nolan and Cribb (2006) studied a digital photograph of the holotype and judged that the specimen possessed an anterior sucker; however, they could not discern whether spines were present or absent on the surface of the anterior sucker. Indeed, the holotype of C. cardiocolum is in poor condition, and it is likely that if spines were present that they probably became detached before fixation of the specimen. I have observed that the anterior sucker spines of E. euzeti detach within minutes of the specimen dying in physiologic saline and before it is placed in formalin. Moreover, if morphologically similar aporocotylids infect phylogenetically related definitive fish hosts, e.g., fishes in the same family, the fact that C. aurata and C. cardiocolum both mature in porgies (Sparidae) hints that their adults may have the same type of spiny anterior sucker. Moreover, a new species that matures in another sparid in the Gulf of Mexico has such an anterior sucker (A. Bullard, pers. obs.). Although Nolan and Cribb (2006) regarded Elaphrobates as a junior subjective synonym of Cardicola based on the fact that C. cardiocolum has an anterior sucker, the presence of an anterior sucker having spines was just one of several characters used by Bullard and Overstreet (2003) to justify their proposal of Elaphrobates Bullard and Overstreet, 2003 and differentiation of Cardicola from Cardicola. It is possible that species documented by Nolan and Cribb (2006) and Holzer et al. (2008) possibly should be allocated to Elaphrobates, i.e., congeneric with its type species E. euzeti, because they each possess a spiny anterior sucker as well as those additional features included in the diagnosis of Elaphrobates (see Bullard and Overstreet, 2003). Alternatively, and pending a redescription of Manter’s (1947) C. cardiocolum, perhaps E. euzeti should be regarded as congeneric with C. cardiocolum, thereby making Elaphrobates a junior subjective synonym of Cardicola, as proposed by Nolan and Cribb (2006). And, simultaneously, it may be that several species presently allocated to Cardicola should be reassigned to newly proposed genera that are based on the future collection of better quality specimens of Cardicola spp., it does differentiate several species. Cardicola cardiocolum, C. laruei, C. whitteni, C. congruenta, C. magillus, C. ahi, C. forsteri, C. palmeri, C. aurata, Nolan and Cribb’s (2006) species, and C. aurata each have an oviduct that can be most easily distinguished from the remaining Cardicola spp. studied Quoy et al. (1825–1851) and differentiate several species. Cardicola cardiocolum, C. laruei, C. whitteni, C. congruenta, C. magillus, C. ahi, C. forsteri, C. palmeri, C. aurata, Nolan and Cribb’s (2006) species, and C. aurata each have a relatively short posterior ceca (1–5× longer than the anterior ceca).

Cardicola nonamo has a testis that is rectangular and limited both laterally and posteriorly by the intestinal ceca, i.e., the testis does not extend laterally beyond the level of the posterior ceca nor posterior beyond the distal tips of the posterior ceca (Figs. 1, 3, 4), and a post-cecal ovary abutting the testis. This combination of characteristics differentiates the new species from C. laruei and C. palmeri, which both have posterior ceca extending posterior to the testis; from C. forsteri, which has a testis extending posterior beyond the tips of the posterior ceca; thereby forming a triangular-shaped posterior region; and from C. forsteri, which has a testis extending beyond the limits of the posterior ceca.

The new species has an oviduct that emanates from the posteroesophageal margin of the ovary (Figs. 3, 4). Although this character is indeterminate for some Cardicola spp., it does differentiate several species. Cardicola cardiocolum, C. laruei, C. whitteni, C. congruenta, C. magillus, C. ahi, C. forsteri, C. palmeri, C. aurata, Nolan and Cribb’s (2006) species all have an oviduct that emanates from the posteroesophageal margin of the ovary. In contrast and similar to the new species, C. cordiodacis, C. grandis, C. chaetodontis, and C. ambrosioi apparently have an oviduct that emanates from the posteroesophageal margin of the ovary. Cardicola aurata reportedly has an oviduct that can be dextral or medial (Holzer et al., 2008), but the oviducts of the type specimens of the Cardicola spp. studied herein (see Specimens compared) did not vary intraspecifically.

The new species has a post-ovarian uterus (Figs. 3, 4), whereas C. whitteni, C. congruenta, C. chaetodontis, and C. ahi have a uterus that to some degree courses slightly lateral to the ovary. In addition, C. nonamo has male and female genital pores that open dorsomedially and posterior to the uterus and ootype (Figs. 1, 3, 4), thereby differentiating it from other Cardicola spp., having 1 or both genital pores that open marginally, i.e., C. whitteni, C. brasiliensis, and C. magillus, or from species having a female genital pore that opens anterior to a portion of the uterus, i.e., C. laruei, C. whitteni, C. forsteri, C. palmeri, and C. chaetodontis. The presence of 2 uterine coils immediately posterior to the ovary comprise a seemingly reliable species-level character further differentiating the new species from C. laruei, C. cordiodacis, C. congruenta, C. grandis, C. aurata, and C. aurata.

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