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Descriptions of two new acanthocephalans (Rhadinorhynchidae) from marine fish off the Pacific coast of Vietnam

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Abstract Two rhadinorhynchid acanthocephalans are described from marine fishes off the Pacific coast of Vietnam. *Sclerocollum neorubrimaris* n. sp. (Gorgorhynchinae Van Cleave & Lincicome, 1940) is described from the spine-foot rabbitfish *Siganus guttatus* (Bloch) (Siganidae) off Nha Trang. The new species is similar to the type-species, *Sclerocollum rubrimaris* Schmidt & Paperna, 1978 in most measurements and counts but has a posterior cephalic ganglion, a sub-ventral female gonopore, and one dorsal paravaginal filament bundle. In *S. rubrimaris*, the cephalic ganglion is near the middle of the receptacle, the female gonopore is terminal with two paravaginal filament bundles. The new species is distinguished from three other species of *Sclerocollum* Schmidt & Paperna, 1978 in proboscis hook formulas and the position of the female gonopore and cephalic ganglion. The issue of the importance of the position of the cephalic ganglion at the generic and sub-generic levels in the Acanthocephala is discussed. Females of *Australorhynchus multispinosus* n. sp. (Gorgorhynchinae) are described from the red cornetfish *Fistularia petimba* Lacépède off Nha Trang in the Pacific south. It is distinguished from the only other species of the genus, *Australorhynchus tetramorphacanthus* Lebedev, 1967, by having more trunk spines extending beyond the level of the proboscis receptacle and a smaller proboscis with considerably fewer hooks.

This article is part of the Topical Collection Acanthocephala.

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Introduction

Most of the recent taxonomic work on the acanthocephalans from Vietnam was reported by the Amin-Heckmann-Ha team since 2000. A number of acanthocephalan species from freshwater fishes, amphibians, reptiles, birds and mammals were previously described in Vietnam by Amin & Ha (2008) and Amin et al. (2000, 2004, 2008a, b, c). Additionally, 11 species of acanthocephalans were collected from marine fishes off the eastern seaboard of Vietnam in Halong Bay in 2008 and 2009. Of these, six new species of *Neoechinorhynchus* Stiles & Hassall, 1905, one new species of *Heterosentis* Van Cleave, 1931, and two new species of *Rhadinorhynchus* Lühe, 1911 were described (Amin et al. 2011a, b, c). Four other species of echinorhynchid acanthocephalans from

marine fishes in Halong Bay were described by Amin & Ha (2011) and five other new species from fishes and amphibians of eight collected host species were described by Amin et al. (2014). Three other species of *Rhadinorhynchus* and one species of *Gorgorhynchus* were otherwise previously reported from marine fishes in Vietnam by Arthur & Te (2006).

Fifteen species of acanthocephalans in five families were more recently collected from fishes in the Pacific and amphibians in central Vietnam in 2016 and 2017. In the present report, we describe females of a new species of *Sclerocollum* Schmidt & Paperna, 1978 and a new species of *Australorhynchus* Lebedev, 1967.

Materials and methods

Freshly collected rhadinorhynchid acanthocephalans from marine fishes off the coast of Vietnam were extended in water until proboscides were everted and fixed in 70% ethanol for transport to the Institute of Parasitic Diseases (IPD) in Arizona, USA, for processing and further studies. Worms were punctured with a fine needle and subsequently stained in Mayer's acid carmine, destained in 4% hydrochloric acid in 70% ethanol, dehydrated in ascending concentrations of ethanol reaching 100% (24 h each), and cleared in 100% xylene then in 50% Canada balsam and 50% xylene (24 h each). Whole worms were then mounted in Canada balsam. Measurements are in micrometres, unless otherwise noted; the range is followed by the mean in parentheses. Width measurements represent maximum width. Trunk length does not include proboscis, neck or bursa. No DNA or metal analysis, or SEM studies were possible because of the limitations of the sample size of specimens available in these collections.

Line drawings were created by using a Ken-A-Vision micro-projector (Ward's Biological Supply Co., Rochester, New York, USA) which uses cool quartz iodine 150W illumination with 10×, 20×, and 43× objective lenses. Images of stained whole mounted specimens were projected vertically on 300 series Bristol draft paper (Starthmore, Westfield, Massachusetts, USA), then traced and inked with India ink. Projected images were identical to the actual specimens being projected.

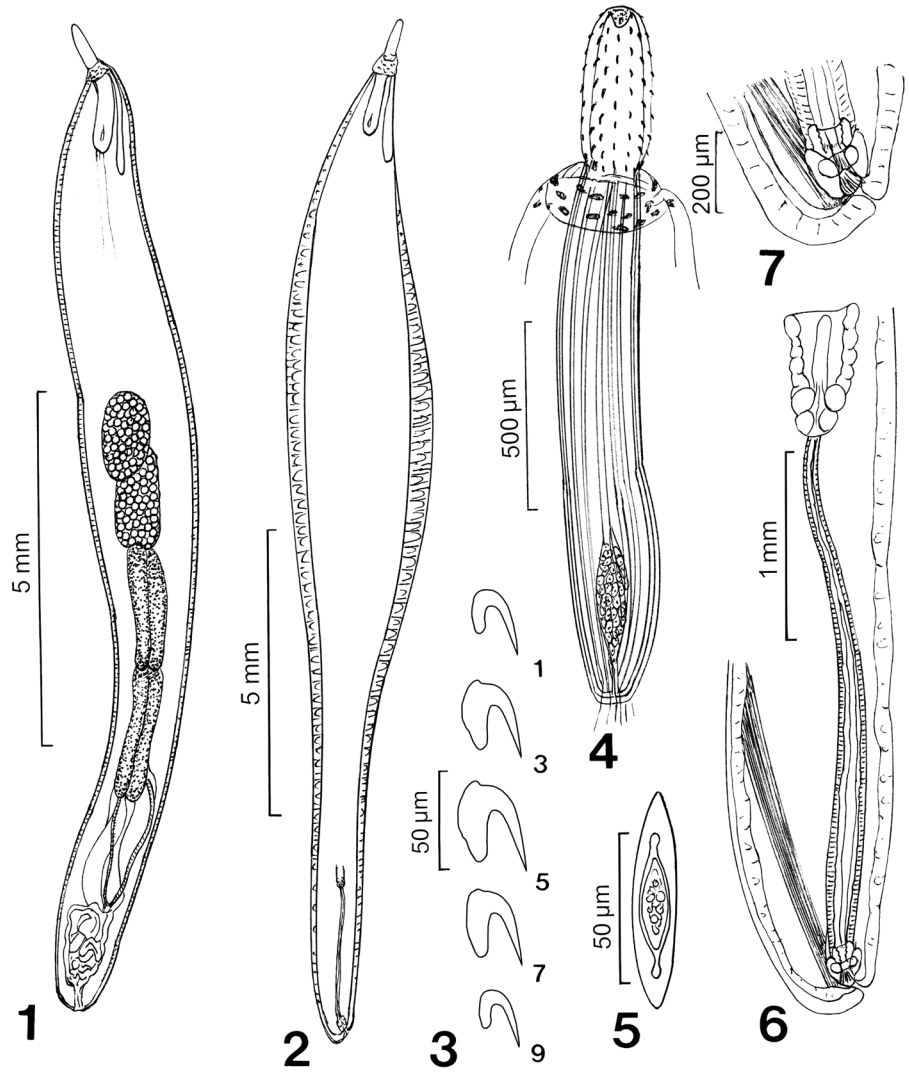
The type-material was deposited in the University of Nebraska's State Museum's Harold W. Manter Laboratory (HWML) collection in Lincoln, Nebraska, USA.

Additional type- and voucher specimens of species of *Sclerocollum* were obtained from various museums for further study. The following are the abbreviations of museum/collection names from which specimens were loaned: USNPC (US National Parasite Collection, The Smithsonian Institution, Maryland, USA), HWML (Harold W. Manter Laboratory, University of Nebraska State Museum, Lincoln, USA), SAM (South Australian Museum, Adelaide, Australia), NHM (Natural History Museum, London, UK), AM (Australian Museum, Sydney, Australia). The holotype male and the allotype female of *Sclerocollum robustum* (Edmonds, 1964) Schmidt & Paperna, 1978 preserved in 80% ethanol were obtained from Dr Stephen Keable, Collection Manager, Marine Invertebrates, with permission to process and mount specimens from Branch Head Dr Cameron Slatyer (AM). The loan was made available through Dr Gabor Racz, Collection Manager (HWML; Institution no. US 066). Whole mounts allowed the microscopical examination of the *S. robustum* material.

Family Rhadinorhynchidae Luhe, 1912
Subfamily Gorgorhynchinae Van Cleave & Lincicome, 1940
Genus *Sclerocollum* Schmidt & Paperna, 1978

Sclerocollum neorubrimaris n. sp.

Type-host: *Siganus guttatus* (Bloch) (Perciformes: Siganidae), spine-foot rabbitfish.
Type-locality: Pacific Ocean off Nha Trang (12°15′N, 109°11′E), Vietnam.
Type-material: HWML collection no. 139409 (holotype male, allotype female and paratypes on 1 slide); all specimens collected on 10.ii.2016.
Site in host: Intestine.
Prevalence: In 6 out of 9 fish.

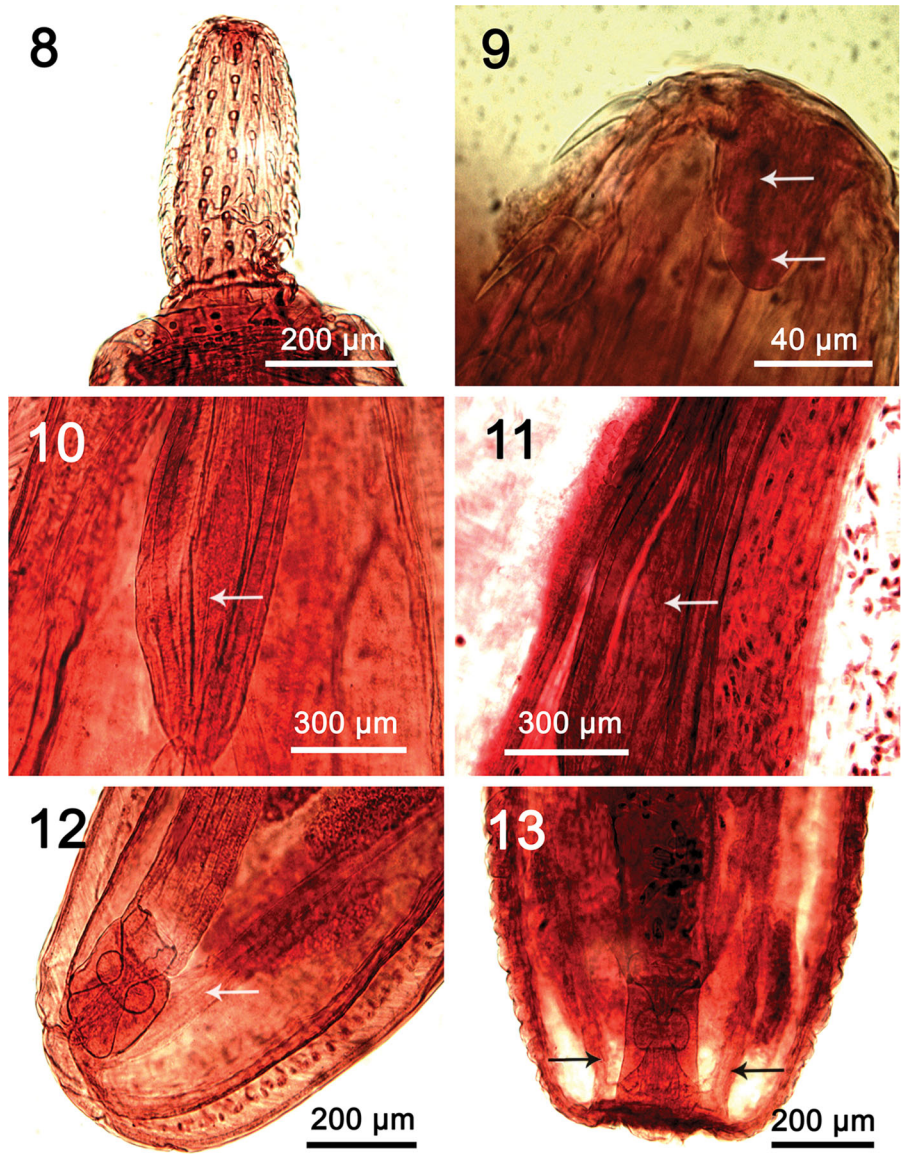


Figs. 1–7 Line drawings of *Sclerocollum neorubrimaris* n. sp. ex *Siganus guttatus* off Vietnam. 1, Holotype male; 2. Allotype female (not showing eggs and ovarian balls); 3, Proboscis hooks and hook roots in 1 longitudinal row; 4, Anterior part of a male specimen showing the apical organ, numerous dermal plaques, and the posterior position of the cephalic ganglion; 5, A ripe egg (note the pointed polar ends); 6, Posterior part of a female specimen (note the subterminal gonopore and the single dorsal band of paravaginal ligaments); 7, Posterior extremity of a female at a higher magnification showing the subterminal position of the gonopore and the insertion of the paravaginal ligaments

Etymology: The name of the new species depicts its similarities to *S. rubrimaris* and the fact that it has new distinguishing features from it.

Description (Figs. 1–13)

General. Rhadinorhynchidae, Gorgorhynchinae, with characters of the genus *Sclerocollum* Schmidt & Paperna 1978. Trunk of medium size, elongate, with thick walls, swollen anteriorly, especially in females. Proboscis cylindroid, somewhat constricted posteriorly, with apical organ appearing bifold and 14 rows of 9 or 10 hooks with similar roots. Hooks small anteriorly, increase in length to middle then progressively decrease to smallest size basally. Hook roots simple, slightly shorter than blades, directed posteriorly. Neck unremarkable. Anterior trunk with many



Figs. 8–13 Light microscopy photomicrographs of *Sclerocollum neorubrimaris* n. sp. (Figs. 8–10, 12) and *S. rubrimaris* [Figs. 11, 13 from the Schmidt collection (USNPC 73897)]; 8, Proboscis of a specimen of *S. neorubrimaris* showing the apical organ and the anterior trunk dermal plaques; 9, Anterior tip of the proboscis shown in Fig. 8 showing a magnification of the double apical organ (2 arrows); 10, Posterior part of the receptacle of a specimen of *S. neorubrimaris* showing posterior position of the cephalic ganglion (arrow); 11, Middle section of the receptacle of a specimen of *S. rubrimaris* showing the middle position of the cephalic ganglion (arrow); 12. Posterior extremity of a female specimen of *S. neorubrimaris* showing the subterminal position of the gonopore and the single dorsal band of paravaginal ligaments (arrow); 13, A comparable presentation of the posterior extremity of a female specimen of *S. rubrimaris* from Schmidt's material (USNPC 73898) showing the terminal position of the gonopore and the two paravaginal ligament bands (2 arrows)

prominent plaques. Proboscis receptacle bi-walled, with drop-shaped cephalic ganglion at its base. Lemnisci digitiform, relatively longer than proboscis receptacle, distant from anterior testis.

Male [Based on 5 mature adults; metrical data in Tables 1, 2.] Trunk 12.25–20.00 (16.75) mm long, 1.25–1.80 (1.42) mm wide anteriorly. Proboscis 480–551 (517) long, 150–147 (161) wide at middle. Proboscis receptacle 1.09–1.14 (1.07) mm long,

0.21–0.47 (0.34) mm wide. Lemnisci 1.56–1.98 (1.77) mm long, 0.10–0.18 (0.14) mm wide posteriorly. Testes ovoid, contiguous with each other and with cement glands, pre-equatorial. Anterior testis 750–1,040 (888) long, 520–625 (565) wide, slightly shorter than posterior testis 710–1,250 (1,000) long, 420–575 (515) wide. Cement glands 4, in 2 successive pairs: glands in anterior pair 1.62–2.87 (2.29) mm long, 0.32–0.42 (0.37) mm wide; glands in posterior pair 1.25–2.62 (1.96) mm long, 0.32–0.42 (0.37) mm wide. Cement reservoir 625–1,270 (950) long, 300–375 (340) wide; Saefftigen'a pouch 936–1,570 (1,340) long, 250–400 (340) wide, immediately posterior to and partially overlapping posterior cement glands.

Female [Based on 5 partially gravid adults; metrical data in Tables 1, 2.] Trunk 15.00–23.25 (18.77) mm long, 1.17–2.25 (1.57) mm wide at middle to anterior. Proboscis 416–562 (504) long, 182–208 (192) wide at middle. Proboscis receptacle 1.09–1.46 (1.23) mm long, 0.22–0.38 (0.29) mm wide. Lemnisci 1.74–1,77 (1.75) mm long, 0.16–0.24 (0.20) mm wide posteriorly. Reproductive system 2.55–4.16 (3.52) mm long, with subterminal gonopore, well defined vagina, long uterus, beady uterine bell without uterine bell glands, and single band of dorsal paravaginal ligaments. Eggs fusiform, slender, with extended slim opposite ends and polar prolongation of fertilization membrane, 62–75 × 12–17 (68 × 15).

Remarks

Siganus guttatus is found in the Eastern Indian Ocean and Western Pacific and inhabits turbid inshore reefs among mangroves, prefers low salinities and feeds on benthic algae, zooplankton, and invertebrates (Woodland, 1990). A morphometric comparison among the five species of *Sclerocollum* known so far is shown in Table 1. Additionally, type and voucher specimens of all five species were obtained from various museums, studied, and reported in Table 2. While most characters depicted in both tables appear to agree, certain characters such as position of the cephalic ganglion, the female gonopore, position of testes and presence of the apical organ do not often agree. Our comparison will give first priority to the observations of the museum specimens. The inception of the genus *Sclerocollum* by Schmidt & Paperna (1978) conceived of a genus comparable to *Neorhadinorhynchus* Yamaguti, 1939, but distinguished from it by (i) having prominent sclerotised plates on the anterior wall of the trunk considered homologous to spines hence the inclusion in Rhadinorhynchidae; and (ii) having alternating basal proboscis hooks not forming a ring. The distribution of the dermal plaques appears to be variable within individuals of the same species. Schmidt & Paperna (1978) examined the type-specimens of *N. aspinosus* and confirmed the absence of sclerotised plaques in that species but established their presence in *Neorhadinorhynchus robustus* (Edmonds, 1964) Golvan, 1969 [syn. of *Sclerocollum robustus* (Edmonds, 1964) Schmidt & Paperna, 1978] from the Pacific Ocean off Australia and New Caledonia. On the other hand, Pichelin & Cribb (2001) observed variations in the number of plaques in type-specimens of *Sclerocollum* but reported their presence on Yamaguti's (1939) specimens of *N. aspinosus*, contrary to the findings by Schmidt & Paperna (1978) who examined the type-specimens of the same species. Pichelin & Cribb (2001) claimed "no basis to consider these two genera different" based on variations in the sclerotised plaques and synonymised them. We rejected this argument and retained *Sclerocollum* as an independent genus (Amin, 2013) as did Hassanine (2006).

Since the original description of the first member of *Sclerocollum*, *S. rubrimaris*, from the Gulf of Elat, the Red Sea, by Schmidt & Paperna (1978), three other species of the same genus have been recognised: *S. saudii* Al-Jahadli, 2010 in the Red Sea off Saudi Arabia (Al-Jahdali, 2010) and *S. robustum* Edmonds, 1964 and *S. australis* Pichelin, Smales, & Cribb, 2016 in the Pacific Ocean off Australia (Edmonds, 1964; Pichelin et al., 2016) mostly from fishes of the genus *Siganus* Forsskål. We herein additionally describe a fifth species of *Sclerocollum*, *S. neorubrimaris* n. sp., from a new host species in the Pacific off the coast of Vietnam. All species are known to have restricted distribution except *S. subrimaris* which appears to occur in a wide range in siganids from the Red Sea to Australia and New Caledonia (Pichelin et al., 2016). However, those restricted ranges stand to be revised with more collections of specimens from other host populations in new geographical areas.

A comparison of published reports on all species of *Sclerocollum* (Table 1) shows that *S. neorubrimaris* is most similar to *S. rubrimaris* except for four distinct

Table 1 Reported morphometric characteristics of species of *Sclerocollum* compared to *Sclerocollum neorubrimaris* n. sp. from Vietnam. Characters distinguishing from *S. rubrimaris* (Schmidt & Paperna, 1978) are in boldface

Character	*S. rubrimaris* Schmidt & Paperna, 1978		*S. robustum* Edmonds, 1964	*S. saudii* Al-Jahdali, 2010	*S. australis* Pichelin, Smales & Cribb, 2016	*S. neorubrimaris* n. sp.
Host	*Siganus rivulatus*; *S. argentatus*	*Siganus oramin*	*Siganus lineatus*	*Siganus rivulatus*	*Siganus corallines*; *S. doliatus*; *Zebrasoma velifer*	*Siganus* sp.
Locality	Red Sea, Indo-Pacific, off Australia	Arabian Gulf	Off Queensland, Australia	Red Sea	Western Pacific off Queensland, Australia, New Caledonia	Vietnam
Source	Schmidt & Paperna (1978)	Amin et al. (1984)[a]	Edmonds (1964)	Al-Jahdali (2010)	Pichelin et al. (2016)	Present study
General						
Cephalic ganglion	At mid-receptacle	At mid-receptacle		At mid-receptacle	**At posterior receptacle**	**At posterior receptacle**
Hook length	Ant. 34–44, 34–44, 34–44, 44–50, 44–50, 44–50, 30–38, 30–38, 30–38	Ant. 26–38, 29–42, 29–42, 32–42, 32–42, 32–42, 26–35, 26–35 (males)[b]		Ant. **34–38, 34–38, 34–38, 36–40, 36–40, 36–40, 24–30, 24–30, 24–30**	Ant. **32–38, 32–40, 37–41, 35–42, 32–43, 35–41,** 35–40, 32–40, 32–37, **27–34, 19–30**	Ant. 32–37, 37–42, 40–45, 42–50, 45–55, 45–50, 37–42, 33–40, 32–42, 25–27
Apical organ						**Yes**
Male						
Trunk (mm)	9.5–17.0 × 1.0–2.1	5.72–13.12 × 0.60–1.08	15.0 × 2.0	**5.6–11.3 × 0.9–1.4**	4.5–14.0 × 0.54–1.50	12.25–20.0 × 1.25–1.80
Proboscis	415–480 × 100–170	332–490 × 98–154	**750 × 250**	**323–387 × 95–140**	355–459 × 121–134	480–551 × 150–177
Hook rows/ row	13–15 × 8–10	12–15 × 7–10	**14 × 12–13**	14 × 8–9	**14–16 × 10–12**	14 × 9–10
Hook roots *vs* blades	Little shorter	Little shorter			Nos. 1, 4, 6, 9, 11 tiny	Little shorter
Receptacle (mm)	1.2–1.5 × 0.21–0.25	0.81–1.19 × 0.11–0.21	**2.2 × 0.3**	**0.65–1.11 × 0.12–0.18**	**0.60–1.27 × 0.13–0.20**	1.09–1.14 × 0.21–0.47
Lemnisci (mm)	1.3–1.5 × –	0.46–0.98 × 0.10–0.18	Short	0.92–1.74 × 0.11–0.18	**0.80–1.21 × –**	1.56–1.98 × 0.10–0.18
Testes	Pre-equatorial (Fig. 3)	Pre-/ post-equatorial	Equatorial (Fig. 6)	Pre-equatorial	**Posterior**	Pre-equatorial
Anterior testis (mm)	0.87–1.0 × 0.44–0.64	0.46–1.57 × 0.29–0.50	**1.2–1.5 × –**	**0.51–0.87 × 0.24–0.40**	**0.28–0.88 × 0.17–0.59**	0.75–1.04 × 0.52–0.62
Posterior testis (mm)	0.87–1.6 × 0.40–0.73	0.41–1.68 × 0.32–0.49	1.2–1.5 × –	**0.52–1.05 × 0.21–0.42**	**0.29–0.85 × 0.15–0.61**	0.71–1.25 × 0.42–0.57
Anterior cement gland (mm)		0.59–2.03 × 0.17–0.56		0.69–1.96 × 0.08–0.20	long: 0.99–1.18 × –	1.25–2.62 × 0.32–0.42

Table 1 continued

Character	*S. rubrimaris* Schmidt & Paperna, 1978		*S. robustum* Edmonds, 1964	*S. saudii* Al-Jahdali, 2010	*S. australis* Pichelin, Smales & Cribb, 2016	*S. neorubrimaris* n. sp.
Host	*Siganus rivulatus*; *S. argentatus*	*Siganus oramin*	*Siganus lineatus*	*Siganus rivulatus*	*Siganus corallines*; *S. doliatus*; *Zebrasoma velifer*	*Siganus* sp.
Locality	Red Sea, Indo-Pacific, off Australia	Arabian Gulf	Off Queensland, Australia	Red Sea	Western Pacific off Queensland, Australia, New Caledonia	Vietnam
Source	Schmidt & Paperna (1978)	Amin et al. (1984)[a]	Edmonds (1964)	Al-Jahdali (2010)	Pichelin et al. (2016)	Present study
Posterior cement gland (mm)		0.56–2.17 × 0.11–0.34		0.69–1.96 × 0.08–0.20	long: 0.99–1.18 × –	1.25–2.62 × 0.32–0.42
Saeffligen's pouch (mm)					0.33–1.31 × –	0.94–1.57 × 0.25–0.40
Female						
Trunk (mm)	11.3–21.5 × 1.0–2.2	6.60–18.40 × 0.64–1.12	**28.0–37.0 × 35**	**6.59–15.41 × 0.69–1.42**	**8.0–16.0 × 0.57–1.70**	15.00–23.25 × 1.17–2.25
Proboscis	370–495 × 120–170	336–448 × 112–168	**900–1,000 × 300**	**335–391 × 90–138**	355–582 × 114–147	416–562 × 177–200
Hook rows/row	13–15 × 8–10	13–16 × 7–10	**14–16 × 12–14**	14 × 8–9	**14–16 × 10–12**	14 × 9–10
Receptacle (mm)	1.20–1.60 × 0.20–0.22	0.87–1.26 × 0.11–0.21	**2.4–2.8 × 0.35**	**0.57–0.98 × 0.12–0.18**	**0.83–1.34 × –**	1.09–1.46 × 0.22–0.38
Lemnisci (mm)	1.3–2.05 × –	0.60–1.22 × 0.08–0.15	As long as receptacle	0.77–1.55 × 0.09–0.16	0.99–1.70 × –	1.74–1.77 × 0.16–0.24
Reproductive system (mm)	2.41–4.6	2.60–3.40	**4.5**	**1.48–3.08**	**1.31–2.46**	2.55–4.16
Paravaginal ligaments						**1 dorsal bundle**
Conopore	Terminal	Terminal	**Subterminal**	Terminal	**Subterminal**	**Subterminal**
Eggs	58–72 × 14–16	51–70 × 13–19	**100–115 × 22–29**	**20–28 × 6–10**	**72–93 × 13–30**	62–75 × 12–17
Egg poles	Rounded, blunt		Rounded, blunt	Rounded, blunt	Rounded, blunt	Ellipsoidal

[a]Results of this report are comparable to those of Hassanine (2006) from *Siganus luridus* Ruppell in the Red Sea off Sharm El-Sheikh, South Sinai, and Egypt; [b]Hook length in females: 22–38; 32–42; 32–42; 35–45; 35–45; 35–45; 35–45; 19–35

Table 2 Observations of type- and voucher specimens of *Sclerocollum* for key diagnostics structures

Characters	*S. rubrimaris* Schmidt & Paperna, 1978		*S. robustum* Edmonds, 1964	*S. saudii* Al-Jahadli, 2010	S. *australis* Pichelin, Smales & Cribb, 2016	*S. neorubrimaris* n. sp.
Host	*Siganus rostratus*; *S. rivulatus*	*Siganus oramin*; *S. rivulatus*	*Siganus lineatus*	*Siganus rivulatus*	*Siganus corallinus*; *S. doliatus*; *Zebrasoma veliferum*	*Siganus guttatus*
Locality	Red Sea at Arabian Gulf, off Aqaba	Arabian Gulf off Kuwait	Off Heron Island, Queensland, Australia	Red Sea off Saudi Arabia	Off Lizard Island, Queensland, Australia	Off Nha Trang, Vietnam
Source	Schmidt & Paperna (1978)	Amin et al. (1984)	Edmonds (1964)	Al-Jahadli (2010)	Pichelin et al. (2016)	Present study
Museum collection numbers[a]	USNPC 73897 (*S.ro.*); USNPC 73898 (*S.ri.*)	USNPC 77421 (*S.o.*)	AMW 3796	NHM: BMNH 2009.11.13.8-10	SAM: (*S.c.*) AHC 36128, AHC 36208, AHC 36128, AHC 36207; (*S.d.*) AHC 36125; (*Z.v.*) AHC 36123	Author's collection & HWML 139409
Collected by	Paperna, 1975	Amin et al., 1979	Pearson, 1956	Al-Jahadi, 2009	Cribb et al., 1997, 1998	N.V. Ha, 2016
Collection manager	Anna Phillips	Anna Phillips	Stephen Keable	Eileen Harris	Leslie Chisholm	Gabor Racz
Specimens examined	12♂♂, 14♀♀	8♂♂, 10♀♀	1♂, 1 much larger ♀[b]	1♂, 1♀	3♂♂, 5♀♀	5♂♂, 5♀♀
Apical organ	+	+	+	+	+	+
Cephalic ganglion	At mid-receptacle	At mid-receptacle	At mid-receptacle	At mid-receptacle	At mid-receptacle	At posterior receptacle
Plaques	Many in all	Usually few in all	Few	Many	0-many	Many
Female gonopore	Terminal	Terminal	Sub-terminal	Terminal	Sub-terminal	Sub-terminal
Paravaginal ligaments	Paired	Paired	?	Paired	Yes, reduced	Yes, single
Eggs	Rounded poles	Rounded poles	?	Rounded poles	Rounded poles	Pointed
Hooks/row	9–10 (rarely 8)	8 (rarely 7, 9, 10)	12–13	8	10–12	9–10
Hook roots	As long as blades	As long as blades	As long as blades	As long as blades	As long as blades	As long as blades
Testes	Pre-equatorial	Pre-equatorial (rarely equatorial)	Near equatorial	Equatorial	Posterior	Pre-equatorial

[a]Abbreviated host names in parentheses; [b]The holotype and the allotype specimens (preserved in ethanol) that we processed with permission and examined microscopically

characteristics. *Sclerocollum neorubrimaris* n. sp. has a cephalic ganglion at the base of the receptacle, a subventral female gonopore, one dorsal bundle of paravaginal ligaments, and an elongate elliptoidal egg, slender and extending at the poles. *Sclerocollum rubrimaris* has a cephalic ganglion near the middle of the receptacle or just posterior to the middle, a terminal gonopore, two bundles of paravaginal ligaments, and more rounded and blunt eggs at the poles (Table 1). *Sclerocollum neorubrimaris* n. sp. is further distinguished from the other species of *Sclerocollum* by the following features. In *S. saudii*, the trunk, proboscis, proboscis hooks, receptacle, and reproductive structures are smaller, the cephalic ganglion is at the middle of the receptacle, and the female gonopore is terminal. In *S. robustum*, the female trunk, the proboscis (with more hooks), the receptacle, the reproductive structures, and eggs are considerably larger and with rounded blunt poles. Additionally, sexual dimorphism in trunk size is extreme, the trunk of the holotype male and allotype female processed and whole mounted by us measured 7.50 × 1.35 mm and 23.00 × 3.45 mm, respectively. In *S. australis*, the trunk and the proboscis are smaller but with smaller hooks, the cephalic ganglion just posterior to middle (Table 2), the testes are posterior (pre-equatorial in *S. neorubrimaris*), and the reproductive structures are smaller but the eggs are somewhat longer with rounded blunt polar ends. It appears from these comparisons that the position of the cephalic ganglion, the testes, and the female gonopore, the size of trunk and other structures, the number of hooks on the proboscis and their size, and the shape of eggs assume special importance in the differential diagnosis of species of *Sclerocollum*.

Upon the examination of type- and voucher specimens from museum collections of all species (Table 2), we find additional distinguishing features not reported in the original descriptions: (i) extreme sexual dimorphism in trunk size was found only in *S. robustum*; (ii) the apical organ is present in all species but cephalic ganglion is at the posterior end of the receptacle only in *S. neorubrimaris* n. sp.; (iii) the dermal plaques are numerous in all specimens of *S. neorubrimaris* n. sp. but vary in other species; (iv) the paravaginal ligaments are single in species with subterminal gonopore such as *S. neorubrimaris* but paired in species with terminal gonopore such as *S. subrimaris* and *S. saudii*; (v) the eggs are somewhat pointed at the poles but more rounded in all other species; (vi) the roots of proboscis hooks are about as long as blades in all species but the number of proboscis hooks per row vary from 7–10 in *S. rubrimaris*, 8 in *S. saudii*, 9–10 in *S. neorubrimaris* n. sp., 10–12 in *S. australis*, and 12–13 in *S. robustum*; (vii) the testes are near equatorial or pre-quatorial in all species expect for being posterior in *S. australis*. Host and geographical distribution vary but usually associated with species of *Siganus* in the Pacific Ocean and the Red Sea.

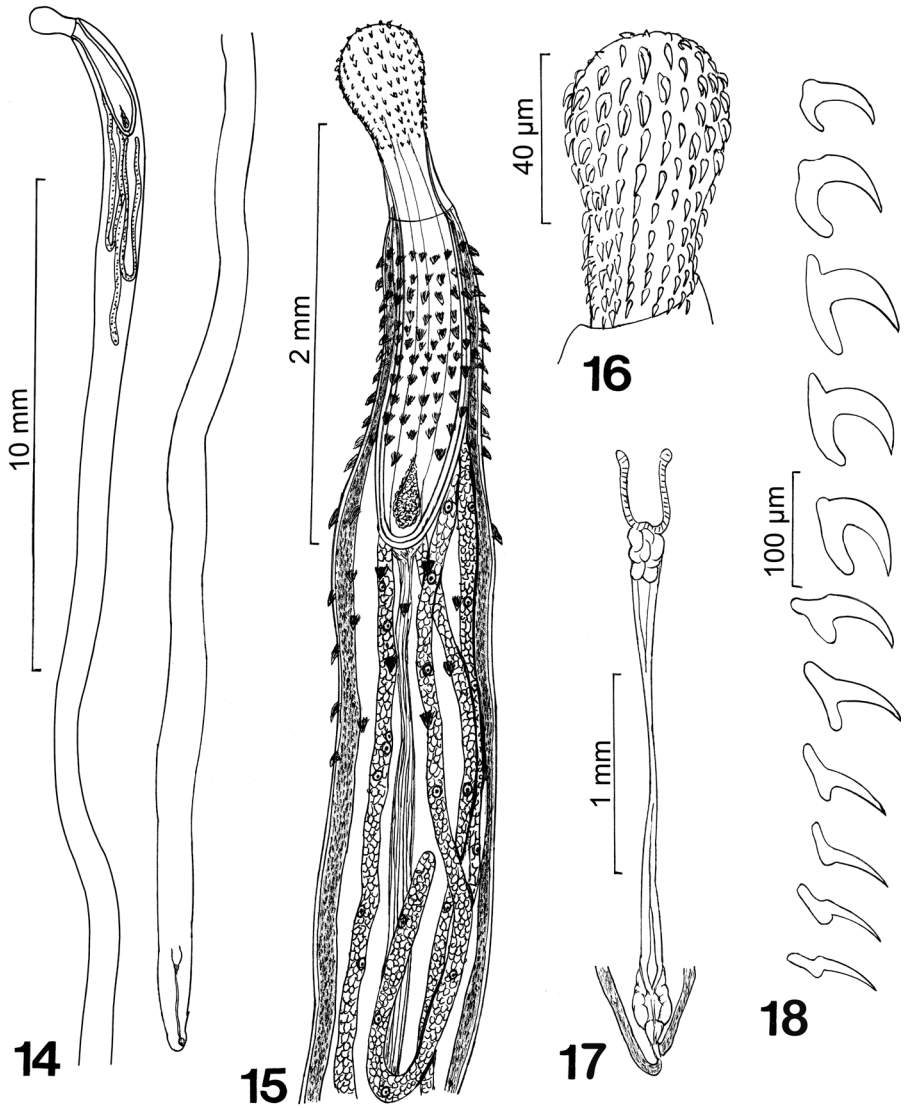
Genus *Australorhynchus* Lebedev, 1967

Australorhynchus multispinosus n. sp.

Type-host: *Fistularia petimba* Lacépède (Syngnathiformes: Fistilariidae), red cornetfish.
Type-locality: The Pacific Ocean off Nha Trang (12°15′N, 109°11′E).
Type-material: HWML 139407 and 139408 (holotype and paratype females).
Site in host: Intestine.
Prevalence and intensity: Three female specimens collected from 3 of 4 fish (9.x.2016).
Etymology: The name of the new species describes its multiple trunk spines that extend beyond the receptacle compared to nominal species that has fewer spines with limited distribution.

Description (Figs. 14–18)

Female [Based on 3 specimens with ovarian balls; see also Table 3.] Trunk long, thick-walled, uniformly cylindrical, spinose anteriorly, slightly tapering anteriorly and posteriorly, 41.25–115.00 (76.75) mm long, 0.72–1.37 (0.97) mm wide. Anterior trunk with 1 zone of broad, deeply embedded cuticular spines 2.50–2.65 mm long, extending posterior to receptacle for 0.50–1.00 mm. Spines in 7–14 dorsal, 10–15 lateral, and 11–16 ventral circles of about 20 spines each anteriorly. Posterior spines larger than anterior spines and ventral spines larger than dorsal spines. Length and width at base of dorsal spines 42–62 (50) and 20–30 (26) anteriorly and 32–62 (50) and 20–55 (42) posteriorly. Corresponding measurements for ventral spines 45–62 (53) and 22–50 (38) anteriorly and 55–62 (57) and 42–80 (61) posteriorly. Ventro-lateral hooks reaching 100 in length. Proboscis spheroid anteriorly



Figs. 14–18 Line drawings of female specimens of *Australorhynchus multispinosus* n. sp. ex *Fistularia petimba* off Vietnam. 14, Holotype female; 15, Anterior part of a paratype female (note the posterior position of the cephalic ganglion, the extension of trunk spines well posterior to the receptacle, and the multinucleated lemnisci); 16, Proboscis of holotype female; 17, Reproductive system of a paratype female (note the subterminal position of the gonopore and the long slender uterus); 18, One row of simple proboscis hooks showing the progression of decreasing curvature of the hooks, decreasing size of the roots, and increasing development of anterior root manubria in more posterior locations

and cylindroid posteriorly, 780–790 (785) long, 416–478 (442) wide anteriorly, with 20 rows of 11 rooted hooks each. Hooks sickle-shaped anteriorly, gradually becoming less curved posteriorly, smallest anteriorly and basally, and largest near middle. Hook roots uniformly simple, directed posteriorly, with anterior manubria. Roots small anteriorly, increase to maximum at posterior end of spheroid anterior proboscis, gradually decreasing to near vestigial basally as manubria proportionally increase in size and angulate (Table 3). Neck prominent, 416 × 416. Proboscis receptacle 1.97–2.01 (1.99) mm long, 0.38–0.50 (0.44) mm wide, double-walled, with drop-shaped cephalic ganglion at its base. Lemnisci 4, multinucleated, 6.24–8.59 (6.92) mm long, 0.16–0.21 (0.18) mm wide. Eggs not available but

Table 3 Measurements of proboscis hooks and hook roots of *Australorhynchus multispinosus* from *Fistulatia petimba* in Vietnam

Hook no. from anterior	Hooks		Hook roots	
	Length	Thickness at base	Length	Thickness at base
1	60–62 (61)	13–16 (15)	40–50 (45)	13–15 (14)
2	67–90 (82)	20	80–83 (81)	20–27 (23)
3	85–87 (86)	27–35 (30)	83–100 (92)	30–35 (33)
4	82–112 (95)	27–37 (31)	80–100 (90)	82–112 (95)
5	70–85 (79)	30–32 (31)	70–75 (72)	27–28 (27)
6	62–80 (71)	20–25 (22)	50–75 (63)	16–27 (21)
7	65–82 (72)	15–20 (18)	40–72 (45)	10–12 (11)
8	62–80 (69)	12–17 (15)	37	10–12 (11)
9	55–67 (61)	12–15 (13)	30–32 (31)	10–12 (11)
10	55–62 (59)	12–14 (13)	22–25 (23)	10
11	55–62 (58)	12	22–25 (23)	10–12 (11)

ovarian balls with 3–9 nuclear clusters, 200–420 (346) long, 100–225 (162) wide. Reproductive system simple, 2.83–3.07 (0.87) mm long, with developed vagina, subventral gonopore, long uterus, and few uterine bell glands.

Remarks

One other species of the same genus, *Australorhynchus tetramorphacanthus* Lebedev, 1967 was described from 64 males, 49 females, and 101 juveniles collected from the intestines of 4 species of fish in 3 families, Carangidae, Triglidae, and Sparidae, in the Tasmanian Grand Bay, Australia in May and June, 1963. The red cornetfish are found along soft bottom coastal areas in the tropical waters of the Atlantic and Indo-Pacific and feeds mainly on small fishes and shrimps (Fritzsche, 1976; Allen & Swianston, 1998). Considering the distribution of *F. petimba* in the world's tropical oceans, it would not be surprising to find *A. multispinosus* in the same host in other locations within its distributional range.

In the description of *A. tetramorphacanthus*, Lebedev (1967) measured only the holotype male and the allotype female and listed variations in a short separate paragraph that included variations in the dimensions of trunk, receptacle and lemnisci. In this paragraph, he noted no variations in proboscis hooks' size or position, but basal hooks varied. Females of *A. multispinosus* n. sp. are readily distinguishable from those of the type-species using the following characteristics. Females of *A. tetramorphacanthus* are about the same size (87.5–117.3 mm long) compared to 41.25–115.00 mm in our specimens but the gonopore is terminal (compared to subterminal in our specimens). The proboscis is larger (1.10 × 0.67 *vs* 0.78–0.79 × 0.42–0.47 mm). Proboscis hooks in 28 rows with 22 hooks each but figure 1C in Lebedev (1967) shows 30–32 hook rows, each with 16–18 hooks. The smaller proboscis in our specimens had 20 rows each with only 11 hooks. Hook roots in our specimens were uniform and simple with lengthening of the anterior manubria posteriorly, radically different from the four types of roots reported in the description of *A. tetramorphacantha* (figure 2 in Lebedev, 1967). Most distinctly, the anterior trunk spines were limited to the pre-receptacle field and were randomly distributed (figure 1C in Lebedev, 1967) despite their depiction in regular circles by Golvan (1969). In our specimens, these spines extended well posterior to the receptacle in regular circles. In *A. tetramorphacanthus*, the lemnisci were considerably longer (24.2 mm long) compared to 6.25–7.59 mm long in our specimens, and the immature females were 12.5–14.7 mm long.

Concluding remarks

The status of the genus *Sclerocollum* is examined especially in light of new insights from museum material that refined and, in some cases corrected

information in published descriptions. New information was added especially regarding the apical organ and paravaginal ligament bundles. The position of such structures as the cephalic ganglion and the testes were refined and adjusted in some cases. A comparison between Table 1 and Table 2 highlight the discrepancies between published descriptions and observations of characters of actual specimens used to provide these descriptions. Of all the species of *Sclerocollum* known do date, *S. rubrimaris* appears to be the most widely distributed species from the Arabian Gulf across the Indian Ocean to Australia. Intraspecific diversity within these populations needs a thorough examination which is beyond the scope of the present publication. The finding of another species of *Australorhynchus* from a cosmopolitan fish species in the Vietnamese Pacific is of a special interest considering extreme differences in hook root morphology and in the distribution of trunk spines, among other differences.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All applicable institutional, national and international guidelines for the care and use of animals were followed.

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