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A revision of the genus *Radicipes* Stearns, 1883 (Anthozoa: Octocorallia: Chrysogorgiidae)

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Abstract

Radicipes is an octocoral genus composed of whip-like chrysogorgiids. Representatives of this group, also called ‘pig-tails’, occur in almost all continental margins around the globe. Since its description in the 19th century, no comprehensive revision of this genus has been made. Thus, we present herein a revision of *Radicipes*, with descriptions of previously known species and one new species, *Radicipes stonei*. Type specimens from several museums were examined and seven species are considered valid. A distribution map of the genus and illustrations for all species are provided and a brief discussion is given on the possibility of additional undescribed species.

Key words: Alcyonacea, new species, deep-sea, pigtails

Introduction

Since it was proposed in the 19th century, the family Chrysogorgiidae Verrill, 1883 is purported to encompass at least 15 genera (Bayer, 1981; Bayer & Stefani, 1988; Cairns & Cordeiro, 2017). These so-called ‘golden corals’ were known to inhabit diverse marine environments, from shallow reefs to abyssal depths. Nonetheless, with the increasing use of molecular techniques this situation is changing; current interpretation of data indicates that the family has a polyphyletic origin, based on sequencing of three genes and the extinction pattern revealed when sclerites are exposed to polarized light (Pante *et al.*, 2012). The family is currently considered to be composed of a strongly supported monophyletic clade of only six genera, called the “Monophyletic Chrysogorgiidae Clade” by Pante *et al.* (2012), consisting of: *Chrysogorgia* Duchassaing & Michelotti, 1864, *Iridogorgia* Verrill, 1883, *Rhodaniridogorgia* Watling, 2007, *Pseudochrysogorgia* Pante & France, 2010, *Metallogorgia* Versluys, 1902 and *Radicipes* Stearns, 1883. This clade is equivalent to Chrysogorgiidae *sensu stricto*, as it includes the type genus *Chrysogorgia*. Pante *et al.* (2012) imply that the other eight remaining genera may fall into as many as four other families. Nonetheless, the same authors present *Radicipes* as a monophyletic subclade with the Chrysogorgiidae consisting of typical cold- and deep-water octocoral genera (Watling *et al.*, 2011).

Representatives of *Radicipes*, sometimes called “pig-tails”, form coral meadows in soft bottoms of continental slopes and seamounts of all oceans (Stone, 2005; Buhl-Mortensen *et al.*, 2010; Watling *et al.*, 2011), in densities of 2.34–2.39 colonies/m² and most of the records being in temperate zones between 241 to more than 3500 m depth (Althaus *et al.*, 2009; Gonzalez-Mirelis & Buhl-Mortensen, 2015). Along with *Chrysogorgia*, they have a very broad bathymetric distribution (Watling *et al.*, 2011) and seven of the deepest octocoral records belong to members of these genera (Cairns, 2015). Regions around the globe without records of the genus correspond to poorly-explored sites; enhancement of collections in these areas will probably add new species to the group.

Most of the revisions of *Radicipes* were performed within a few decades after the species were described in the late 19th century (Kükenthal, 1919; Verrill, 1922; Kükenthal, 1924). Two final accounts of the group were made by

Madsen (1944) and Cordeiro *et al.* (2015). These two studies list eight species in the genus. Until now, none of the revisions made were based on the examination of all the types (excluding those that were likely lost). Thus, in this study, we present a complete revision of *Radicipes*, including the description of a new species.

Materials and methods

Although ubiquitous in all oceans, the slender nature of the usually firmly attached colonies of *Radicipes* makes collection of specimens a rare event. Thus, most species of the genus were described based on few samples. For example, there are taxa represented by one or two specimens that have been sampled only once in more than a century. Despite the paucity of specimens, we still consider it appropriate to describe species based on a few specimens herein, rather than wait for new collections, not likely to occur any time soon. All type specimens were re-examined and a list of all records used herein is provided (Supplementary file).

The terminology used herein follows Bayer *et al.* (1983). The distribution map was prepared using QGIS (2015).

Abbreviations. Institutions: BMNH: The Natural History Museum, London; MCZ: Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts; NIWA: National Institute of Water and Atmospheric Research, Wellington; OBIS: Ocean Biogeographic Information System; USNM: United States National Museum (National Museum of Natural History—NMNH), Washington, DC; YPM: Yale Peabody Museum of Natural History, New Haven, Connecticut; MNRJ: Museu Nacional, Rio de Janeiro; ZMB: Zoologisches Museum, Berlin. Research vessel/ Cruises: Alb: USFWS Albatross; Chall: Challenger Expedition; Del: Delaware II R/V, NOAA Climate; Ger: Gerda R/V; J or JD corresponds to stations of the Jason II ROV, aboard of the R/V Roger Revelle; Or: R/V Oregon; Pill: R/V Pillsbury; R/V Thal: Thalassa, REVIZEE Bahia II cruise.

Taxonomy

Subclass Octocorallia Haeckel, 1866

Order Alcyonacea Lamouroux, 1812

Suborder Calcaxonnia Grasshoff, 1999

Family Chrysogorgiidae Verrill, 1883

Genus *Radicipes* Stearns, 1883

Radicipes Stearns, 1883: 97.—Kinoshita, 1913: 5.—Jungersen, 1915: 1183.—Kükenthal, 1919: 540 (in part: not *R. squamiferus*).—Verrill, 1922: 41.—Kükenthal, 1924: 410.—Deichmann, 1936: 236.—Madsen, 1944: 44.—Bayer, 1956: F216, text-fig. 3.—Bayer & Muzik, 1976: 68 (key to genus).—Bayer & Stefani, 1988: 258 (key to genus).—Williams, 1992: 252.—Pante & France, 2010: 600 (key to genus, molecular phylogeny).—Cordeiro *et al.*, 2015: 94.

Lepidogorgia Verrill, 1884: 220 (type species: *L. gracilis* Verrill, 1884, by monotypy); 1885: 512.—Versluys, 1902: 5.—Thomson & Henderson, 1906: 26–27 (tabular key to species).—Nutting, 1908: 587–588 (in part: not *L. gibbosa*).—Thomson, 1927: 20.

Strophogorgia Wright, 1885: 691 (*nom. nud.*).

Strophogorgia Studer, 1887: 41 (*nom. nud.*).

Strophogorgia Wright & Studer, 1889: 2 (type species: *Strophogorgia challengeri* Wright & Studer, 1889, subsequent designation).

Type species. *Radicipes pleurocristatus* Stearns, 1883, by monotypy.

Diagnosis. Unbranched (flagelliform) chrysogorgiids, brittle, sometimes elongate (up to 1 m long), and often loosely coiled, arising from a root-like calcareous holdfast. Polyps arranged uniserially along one side of axis, delimiting a polypar and an abpolypar face, the former usually facing inner part of colony spiral. Coenenchyme usually quite thin. Axis slightly quadrangular to round in cross-section. Sclerites composed of irregularly shaped scales and rods.

Discussion. Three genera were proposed almost simultaneously: *Radicipes* Stearns (1883), *Lepidogorgia* Verrill (1884) and *Strophogorgia* Wright (1885). Kinoshita (1913) was the first author to establish the synonymy among these three genera. The first publication in which the name *Strophogorgia* appears (Wright, 1885) has no descriptions or specimen designations. Along with the creation of the subfamily Strophogorginae, Studer (1887) provided the first description of *Strophogorgia* (by monotypy), but did not list any species. Descriptions associated with species were given only subsequently, by Wright & Studer (1889). Thus, *Strophogorgia* Wright, 1885 and *Strophogorgia* Studer, 1887 are considered herein as *nomen nudum*, and the next available publication date is *Strophogorgia* Wright & Studer, 1889. Its type-species is *Strophogorgia challengerii* Wright & Studer, 1889, in accordance with recommendation 69A of the International Code of Zoological Nomenclature (ICZN, 1999).

Among the 15 genera previously assigned to Chrysogorgiidae, only five have unbranched colonies: *Radicipes*, *Helicogorgia* Verrill, 1883, *Chalcogorgia* Bayer, 1949, *Distichogorgia* Bayer, 1979 and *Flagelligorgia* Cairns & Cordeiro, 2017. *Radicipes* can be distinguished as being the only unbranched chrysogorgiid genus to have uniserially arranged polyps, the other three unbranched genera having bi- or multiserially arranged polyps. The monophyly of *Radicipes* implied by this morphological distinction is reinforced by molecular sequencing of both mitochondrial and nuclear genes (Pante *et al.*, 2012), its sister group suggested to be *Chrysogorgia* (Pante & France, 2010; Pante *et al.*, 2012).

The low number of morphological characters, as well as the low number of samples for some species makes the systematics of this genus difficult. Intracolony variation is also a challenge. For instance, in a single colony, the basal coenenchymal sclerites may be quite different from those in the median region. Similarly, some species have the coenenchyme between polyps filled with the same sclerites as those seen in the body wall (Table 1). Sclerite densities in polyps may also vary according to age and position in a colony. Also, size, arrangement and shape of the sclerites from the polyp base can be drastically modified within a specimen, when it is fully developed or sexually mature (Figs. 1E, 2H-1'). In the same way, mature polyps usually show an enlargement at the base and at the oral portion.

The unbranched and usually coiled nature of the *Radicipes* colony (Figs. 1A,D) make it similar to other deep-water unbranched Cnidaria, such as some species of octocorals of the genera listed as follows: *Ainigmaptilon*, *Bathygorgia*, *Callozostron*, *Calyptrophora*, *Ellisella*, *Helicoprimnoa*, *Lepidisis*, *Narella*, *Narelloides*, *Onogorgia*, *Ophidiogorgia*, *Perissogorgia*, *Viminella* and the antipatharian genera *Cirripathes* and *Stichopathes*. Thus *in situ* observations based on photographs must be made with care.

Distribution. The genus *Radicipes* shows a broad distribution, latitudinal and bathymetric (Fig. 3 and Table 1: 241–3580 m), with most of the records (about 80%) for the genus belonging to two species, *Radicipes gracilis* (Verrill, 1884) and *R. pleurocristatus*. The least reported species is *Radicipes spiralis* (Nutting, 1908), recorded only at the occasion of its description. The records incorporated herein were given by Watling *et al.* (2011) and Pante *et al.* (2012). Another source of biogeographic information is the “Ocean Biogeographic Information System” (OBIS), which also provides environmental conditions to better understand the requirements for the occurrence of *Radicipes* populations (see: <http://iobis.org/explore/#/taxon/502435>).

As most of the records of the genus given by Watling *et al.* (2011) were based on expedition and collections data (see Watling *et al.*, 2011: p.70, fig. 2.5), it is likely that their Antarctic record was based on one previously misidentified specimen (USNM 1019007—a clavulariid attached to a *Primnoella* sp. stem). Indo-Pacific specimens recorded by Pante *et al.* (2012) and Alderslade *et al.* (2014) and South African specimens noted by Williams (1992) were identified only to genus level. Buhl-Mortensen *et al.* (2010: 43, fig. 42) show *Radicipes* sp. at around 700 m in Norwegian waters. Other records include the mid-Atlantic Ridge (Mortensen *et al.*, 2008), off Norway (Gonzalez-Mirelis & Buhl-Mortensen, 2015), the Gulf of Vizcaya (France) (Altuna, 2010), and the Gulf of Cádiz (Spain) (Rueda *et al.*, 2012) (Fig. 3).

Key to species of *Radicipes* Stearns, 1883

1. Sclerites virtually absent or rare in polyp body wall. *R. spiralis*
- 1a. Sclerites always present in polyp body wall 2
2. Body wall sclerites predominantly long scales with irregular margins. *R. aureus* (Fig. 14A,B)
- 2a. Body wall sclerites predominantly rods, flattened rods or scale-like rods with regular margins 3
3. Body wall sclerites predominantly flattened to slightly rounded rods 4

- 3a. Body wall sclerites predominantly rounded rods, sometimes with one flattened tip 5
4. Fully developed polyps with body wall filled by sclerites longitudinally arranged in eight regular rows (adaxials less developed) and usually able to keep its shape when dry; rounded to slightly flattened rods as body wall sclerites; completely flattened rods rare in body wall *R. gracilis* (Fig. 2E–F)
- 4a. Fully developed polyps rarely with eight regular longitudinal sclerite rows and usually unable to keep its shape when dry; flattened rods as body wall sclerites; rounded rods rare in body wall *R. challengerii* (Fig. 2A,B, 11, 12)
5. Coenenchymal sclerites 8-shaped scales; polyps usually unable to keep its shape when dry *R. kopeulos* (Fig. 2D)
- 5a. Coenenchymal sclerites longitudinally curved rods; polyps usually able to keep its shape when dry 6
6. Body wall sclerites long rounded rods, reaching 2.0 mm or more in length; coenenchymal sclerites strongly sculptured (woody in appearance) *R. pleurocristatus* (Fig. 2H–I', 4, 5)
- 6a. Body wall sclerites long rounded rods, up to 0.8 mm long; coenenchymal sclerites weakly sculptured... *R. stonei* (Fig. 2C, 6)

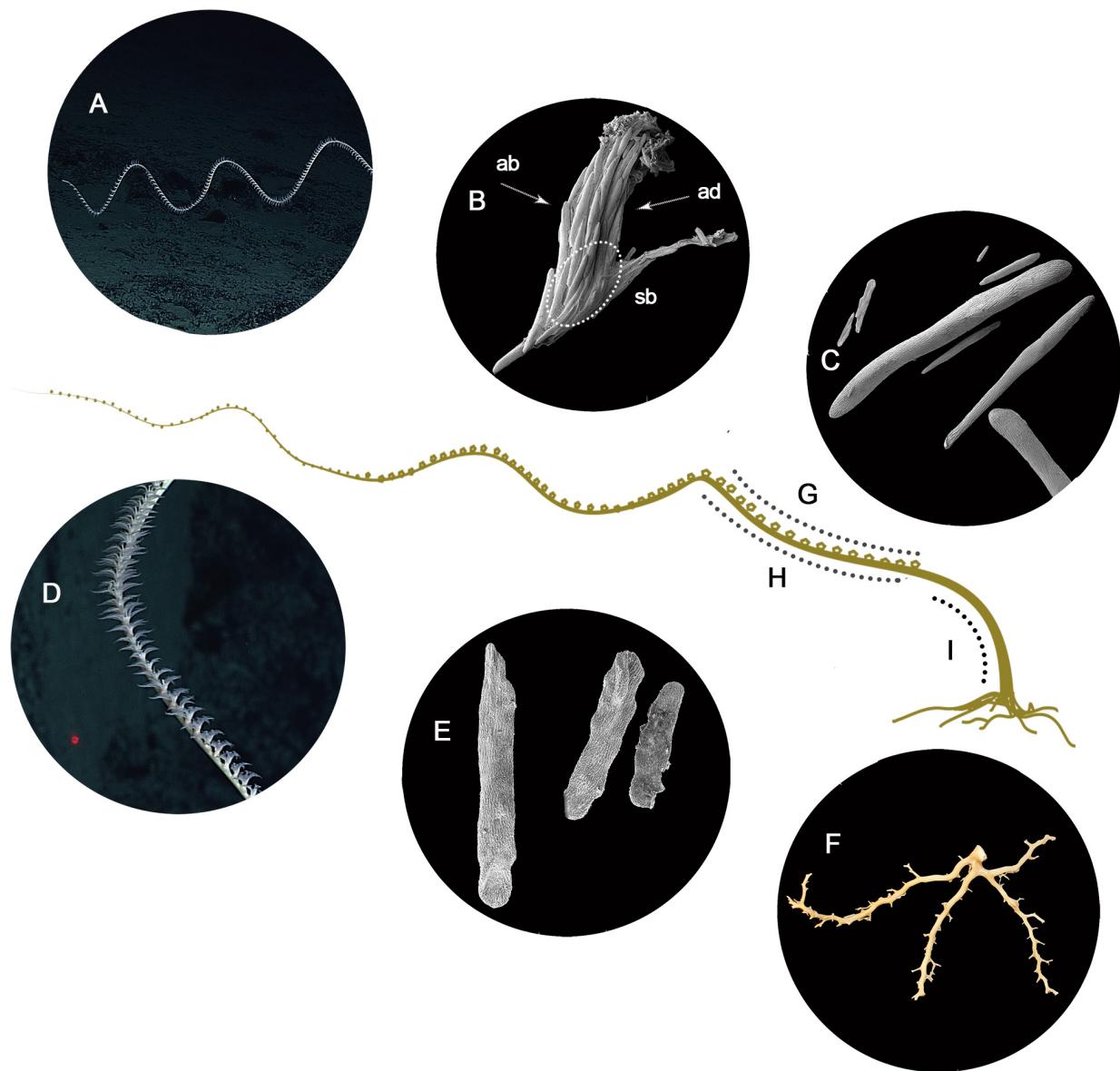


FIGURE 1. Schematic representation of a colony of *Radicipes*. A: gross morphology of a gorgonian *Radicipes spiralis* in their natural environment (Nutting, 1908) (NOAA-Okeanos Explorer, Expedition 1504, leg 2); B: common sclerite arrangement on polyps; C: relative proportion between different sclerite classes in *Radicipes pleurocristatus* Stearns, 1883 (rods from body wall, tentacular and pinnular rods and coenenchymal scales); D: close-up view of polyp arrangement in the latter colony; E: coenenchymal deformed scales from the base of the colony; F: calcified holdfast; G: polypar face in polypar portion; H: abpolypar face in polypar portion; I: sterile portion (basal) of the colony (usually first one third of the colony without polyps). ab: abaxial side; ad: adaxial side; sb: saddle bag portion (infrabasal).



FIGURE 2. Polyps of *Radicipes* spp. A, B: polyps of *Radicipes challengereri* (Wright & Studer, 1889) (BMNH1889.5.27.3, holotype, and USNM 57314, respectively); C: polyp of *Radicipes stonei* sp. nov. (USNM 1418007, holotype); D: polyp of *Radicipes kopelatos* Cordeiro, Pérez & Castro, 2015 (MNRJ 8566, holotype); E–F: polyps of *Radicipes gracilis* (Verrill, 1884) (BMNH 1889.5.27.4, holotype, including detail of the oral portion (E'), of *Radicipes fragilis* (Wright & Studer, 1889) and, USNM 8877, syntype of *Radicipes gracilis* (Verrill, 1884)), respectively; G: polyp of *Radicipes aureus* Kükenthal, 1919 (ZMB 8565, holotype); H, H': polyp of *Radicipes pleurocristatus* Stearns, 1883 (BMNH1889.5.27.2, holotype of *Radicipes verrilli* (Wright & Studer, 1889)) and detail of the oral portion, respectively; I, I': polyps of *Radicipes pleurocristatus* Stearns, 1883 (USNM 49464), full-sized polyps, normal and fertile, respectively. Scale bars: A, H': 0.2 mm; B: 0.6 mm; C: 0.5 mm; D, E, G, H, I': 1 mm; D', E': 0.5 mm.

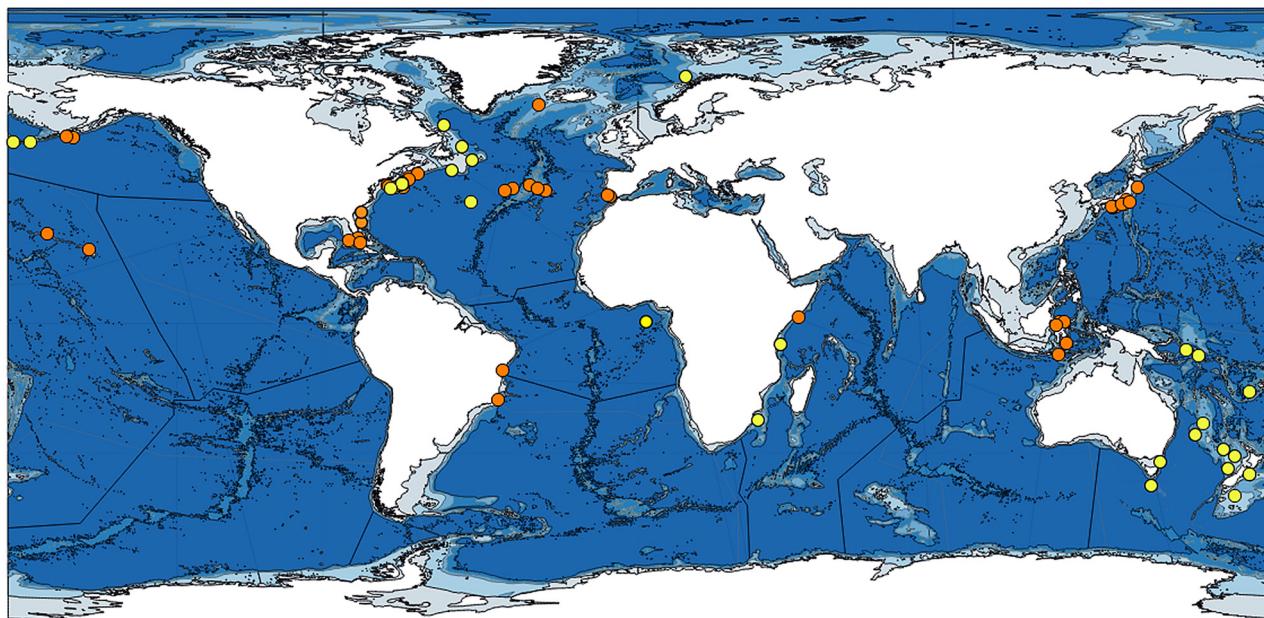


FIGURE 3. Distributional range of *Radicipes* records based on localities of the specimens herein examined (orange circles) as well as geo-referenced data compiled from literature (Williams, 1992; Mortensen *et al.*, 2007; Altuna, 2010; Watling *et al.*, 2011; Rueda *et al.*, 2012; Alderslade *et al.*, 2014; Gonzalez-Mirelis & Buhl-Mortensen, 2015) and the Ocean Biogeographic Information System—OBIS (yellow circles).

Radicipes pleurocristatus Stearns, 1883

Figs. 1B,C,E, 2H–I', 4, 5

Radicipes pleurocristatus Stearns, 1883: 97–98, pl. 7, figs. 1–2.—Kinoshita, 1913: 5–8, pl. 3, figs. 1–2, text-figs. 1–3.—Kükenthal, 1919: 542–543; 1924: 410–411 (key to species).—Bayer, 1961: F218, text-fig. 156, 3a–d; 1979: 882, fig. 2b.—?Fujita & Ohta, 1988: 2019–2042, figs. 1–6, in part (brittle star commensals).—?Fujita, 2001: 267, fig. 3a–c, in part (brittle star commensal).—Matsumoto *et al.*, 2007: 241 (listed).—Cordeiro, *et al.*, 2015: 95 (tabular key to species).

Strophogorgia verrilli Wright, 1885: 691 (*nom. nud.*).

Strophogorgia verrilli Wright & Studer, 1889: 3, pl. 1, fig. 2, pl. 5a, fig. 3.

Strophogorgia petersi Wright & Studer, 1889: 2–3, pl. 2, fig. 1, pl. 5a, fig. 1.

Lepidogorgia petersi.—Versluys, 1902: 7–12, text-figs. 4–14.—Thomson & Henderson, 1906: 27 (tabular key to species).—Nutting, 1912: 53.

Lepidogorgia verrilli.—Versluys, 1902: 12–14, text figs. 15–17.—Thomson & Henderson, 1906: 26–27, pl. 3, fig. 5 (tabular key to species).—Not Thomson, 1927: 20–21 (=*R. gracilis*).

Radicipes verrilli.—Kükenthal, 1919: 543; 1924: 411 (key to species).—Fujita, 2001: 267–272, figs. 3, 5, 6 (brittle star commensal).—Matsumoto *et al.*, 2007 (listed).—?Stone & Shotwell, 2007: 107 (listed, Alaska).—Cairns *et al.*, 2009 (listed for New Zealand).—Cordeiro *et al.*, 2015: 95 (tabular key to species).

Types and type localities. *Radicipes pleurocristatus*: USNM 5685 (syntype, eight dry fragments), Japan, depth unknown (specimens purchased from a fisherman in Enoshima (=Sagami Bay)).

Strophogorgia verrilli: BM 1889.5.27.2. Type Locality: *Chall*-235, 34°07'N, 138°00'E, 1033 m (off Japan, syntypes); and *Chall*-237, 34°37'N, 140°32'E, 3429 m (not found).

Lepidogorgia petersi: Types were not found at the BMNH and are presumed to be lost. Type Locality: *Chall*-232, 35°11'N, 139°28'E, 631 m (off Chiba Peninsula, Japan).

Material examined. Alb-4969, 33°23'40"N, 135°33'E, 1073 m (USNM 49464 and USNM 50095); Alb-4971, 33°23'40"N, 135°34'E, 1187 m (USNM 49465); Alb-4976, 33°02'50"N, 135°38'30"E, 994–997 m (USNM 30070); Alb-4958, 32°36'20"N, 132°24'30"E, 741 m (USNM 57487); Alb-5605, 00°21'33"N, 121°13'10"E, 1183 (USNM 49899); Alb-5648, 5°35'03"N, 122°20'E, 1022 m (USNM 49966).

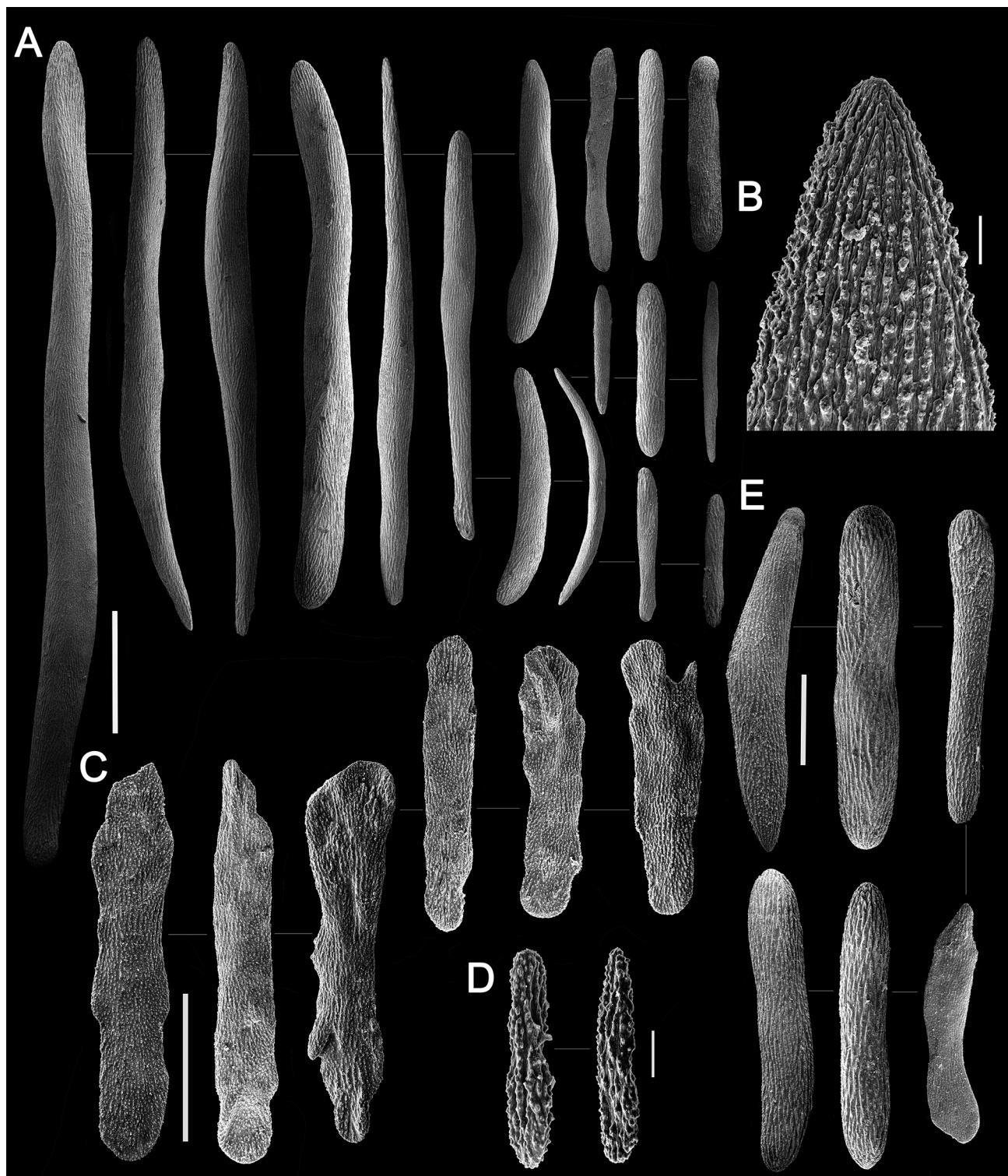


FIGURE 4. Sclerites of *Radicipes pleurocristatus* Stearns, 1883 (USNM 49464) A: rods from the body wall; B: detail of a rod from the body wall; C: coenenchymal scales; D: pinnular scales; E: tentacular rods. Scale bars: A: 0.5 mm, B,D-E: 0.02 mm, C: 0.2 mm.

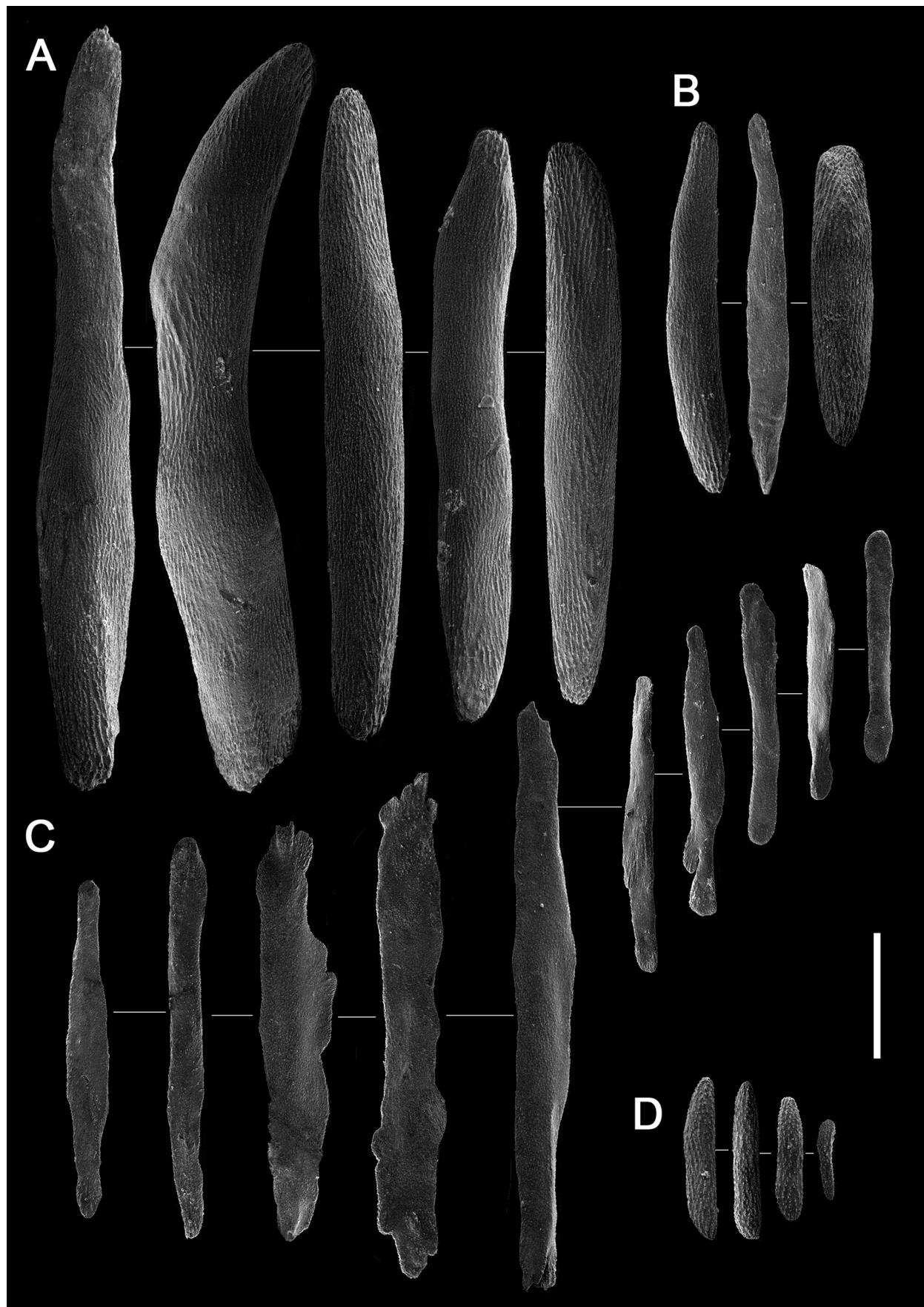


FIGURE 5. Sclerites of *Radicipes pleurocristatus* Stearns, 1883 (BMNH1889.5.27.2, holotype of *Radicipes verrilli* (Nutting, 1908)). A: rods from the body wall; B: tentacular rods; C: coenenchymal scales; D: pinnular flattened rods. Scale bar: 0.2 mm.

Description. Colonies fragile and brittle, light brown in color or completely white, with an iridescent aspect. Minimum axis diameter of 0.4 mm in most of the specimens examined; maximum of 4.3 mm. Axis stiff, clockwise helicoidal in basis-apex direction, slightly elliptical in cross-section. Axial diameter decreasing in basis-apex direction. Calcareous holdfasts with root-like projections, usually thicker than axis. Polyps arranged in a single longitudinal line (polypar side), corresponding to the external face of axis. Polyps cylindrical or trumpet shaped, vertically or obliquely oriented, 2.8 to 5.1 mm long in those fully developed (Fig. 2H–I'). Wider saddle bags and oral portions in fertile polyps (Fig. 2I'). Polyps closely placed, in number four per centimeter in proximal portions, separated by about 1.4 mm, and well spaced in distal parts with one polyp per centimeter and up to 6.0 mm between. Usually three polyps per centimeter. Some specimens (e.g., USNM 30070) with perpendicularly-oriented polyps. In distal portion, both polyps and sclerites thinner and smaller. Abaxial portion of fully developed polyp filled with longitudinally-oriented rods as long as entire body wall, 0.6 to 2.3 mm in length, and from 0.04 mm to 0.16 mm in width (Fig. 4A, 5A). Rods cylindrical to slightly flattened or with flattened tips (rare) (Fig. 4B). Adaxial portion of polyps with fewer developed sclerites, fewer in number. Fully developed polyps with flattened sclerites in a structure resembling a saddle bag and usually curved rods transversely or irregularly arranged, forming a bulb-like base (Fig. 2I'); infertile or not completely developed polyps lack saddle bag and transversely arranged sclerites (Fig. 2H). Coenenchymal scales long, longitudinally curved and usually disposed in a single layer, along entire colony on polypar and abpolypar faces, 0.15 to 1.0 mm long, and 0.04 mm to 0.12 mm wide, rarely reaching the length of the rods from the body wall (Fig. 4C, 5C). Coenenchymal scales smaller in abpolypar side and absent on polypar line, where body wall rods cover the spaces between fully developed polyps. Tentacular rods one quarter to one-fifth the length of those in body wall, 0.2–0.46 mm long and 0.02–0.1 mm wide (Figs. 4E, 5B). Flattened pinnular rods 0.09–0.26 mm long and 0.01–0.05 mm wide (Figs. 4D, 5D).

Remarks. The syntypes consist of eight fragments, including four holdfasts, indicating at least four specimens, with the largest fragment 32 cm long and 4.3 mm in diameter but with only 14 polyps remaining. One of the specimens examined (USNM 57487) is very slender, with well spaced polyps, lacking transverse infrabasal sclerites, irregular rods, also lacking curved sclerites in coenenchyme.

Kükenthal (1919) mistakenly described *R. pleurocristatus* as having naked lateral walls and Cordeiro *et al.* (2015) compiled this information in their table of valid species of *Radicipes*. In fact, there are no naked polyp parts in *R. pleurocristatus*. As did Cordeiro *et al.* (2015), we also provide a tabular key of valid species, but mainly based on the examination of types (Table 1).

We did not examine the type of *Strophogorgia petersi* Wright & Studer, 1889, but the illustrations of the type given by Versluys (1902) and the distribution pattern match *R. pleurocristatus* (e.g., Versluys, 1906, p. 8–11, figs. 4–13). We also accept *Radicipes verrilli* (Wright & Studer, 1889) as a junior synonym of *R. pleurocristatus*, as previously implied by Versluys (1902) and Kükenthal (1919). Additionally, these species have the same distribution patterns. The basic difference between the types of *R. pleurocristatus* and *R. verrilli* was based on a more slender shape of the polyps in *R. verrilli* and a body wall filled only with longitudinally arranged rods (Fig. 2H,H'), whereas *R. pleurocristatus* has longer body wall rods and a basal bulb (saddlebag) in most of the polyps, giving it a more robust appearance (Fig. 2I,I'). It is likely that the development of the bulb-like portion is directly related to the sexual maturation of the polyp, as well the enlargement of the oral portion, as most of the studied species showed eggs in the basal portion of their robust polyps. There is no information in the literature to indicate the reproductive features in species of *Radicipes* or any other chrysogorgiid. Thus we cannot discard the possibility of sexual dimorphism among colonies or even within polyps of a single colony. Finally, it is worth mentioning the common association of this species with white brittle stars of the genus *Asteronyx* (Fujita & Ohta, 1988).

Distribution. Eastern Pacific (Japan) to Indo-Pacific (Indonesia), 629 to 1301 m.

Radicipes stonei sp. nov.

Figs. 2C, 6

Radicipes verrilli.—Stone & Shotwell, 2007: p. 107, Appendix 2.1 (table).

Radicipes sp.—Watling *et al.*, 2011: p. 47, fig. 2.2G–H, p. 70, fig. 2.5.

Types. Holotype: J2105-4-1 (USNM 1418007). Paratypes: J2096-6-1, 52°23'34.2"N, 174°53'3.24"W, 2153 m (USNM 1418006, one specimen); JD-092, 53°27'12"N 163°23'22"W, 3580 m (Derickson Seamount, Aleutian

Islands) (USNM 1081191, one specimen); JD-093 53°00'53"N 161°14'35"W, 3179 m (Derickson Seamount, Aleutian Islands) (USNM 1081144, one specimen).

Type Locality. 51°53'12.18"N, 178°21'27.18"W (northwest of Tanaga Island, Aleutian Islands), 2107 m.

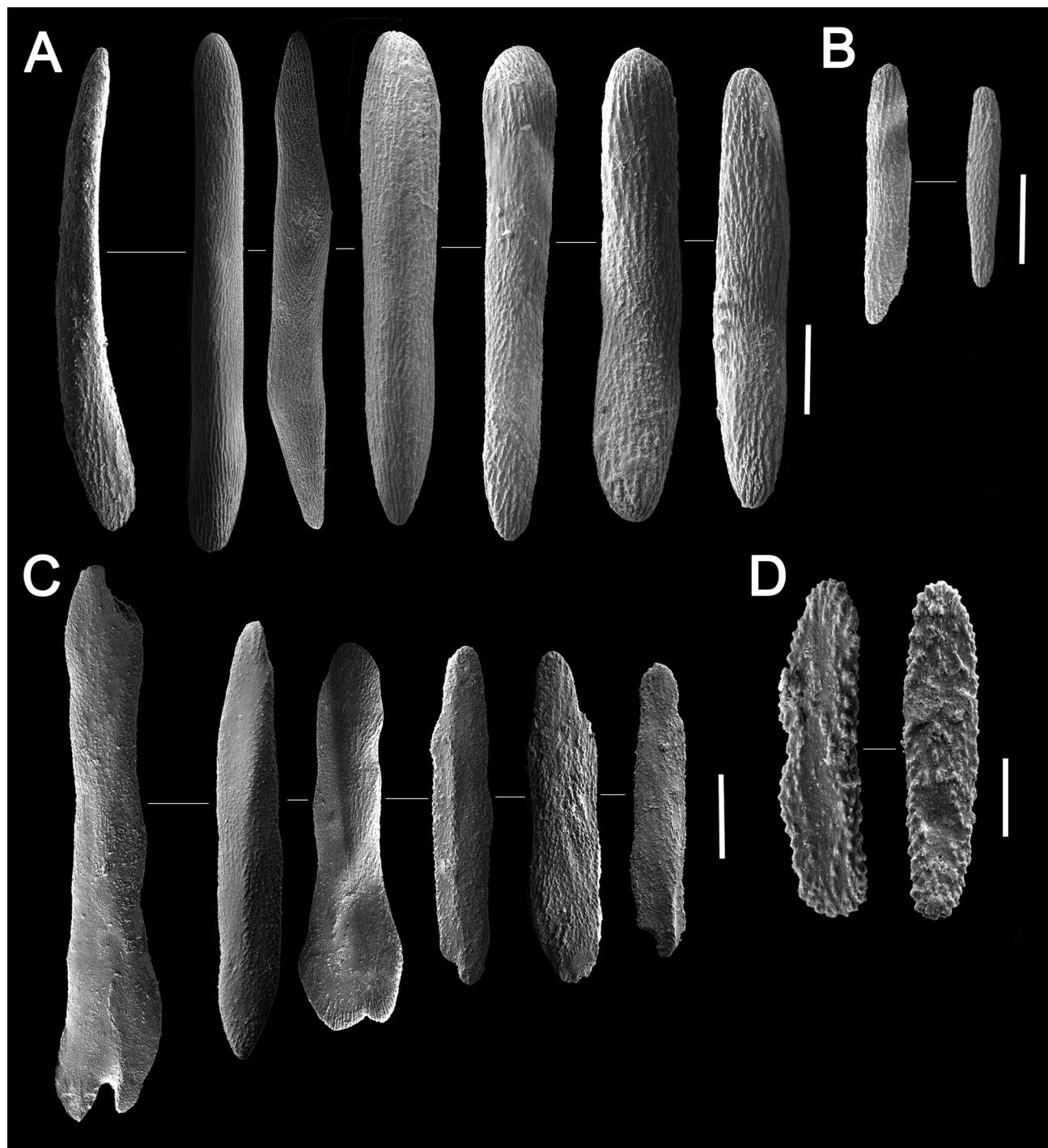


FIGURE 6. Sclerites of *Radicipes stonei* sp. nov. A: rods from body wall; B: tentacular rods; C: coenenchymal scales; D: flattened pinnular rods. Scale bars: A: 0.2 mm; B: 0.05 mm; C: 0.1 mm; D: 0.02 mm.

Description. Colonies white, delicate, golden-iridescent aspect and coiled both clockwise or counterclockwise in ascendant direction. Axis 2.9 mm maximum diameter. First one-third of colonies (up to 12 cm) usually without polyps. Polyps 1.0–3.0 mm long, inclined 45° to 90° in relation to axis, linearly disposed on only one side of colony, in a frequency of about three polyps per centimeter, spaced 2.0–5.0 mm from each other, but ranging from one to five polyps per centimeter. Density of polyps decreasing toward branch tip and distance between polyps increasing in the same direction. Body wall of polyps with rods, longitudinally arranged, some with a flat end and

(rarely) completely flattened (scale-like), 0.13–0.86 mm long and 0.03–0.10 mm wide (Figs. 2C, 6A). Adaxial side with large supporting curved rods, with slightly flattened and rounded tips. Outer lateral side with flattened rods, half the length of abaxial supporting rods. Size of rods decreasing toward the oral portion of tentacles. Inner lateral and adaxial side with sparse flattened scales with almost blunt tips, sometimes naked. Coenenchymal scales longitudinally grooved and with at least one flattened tip, longitudinally arranged, uniformly surrounding axis from base to polypar portion (except in juvenile colonies), gradually changing in length and form in the same direction. Basal coenenchymal scales larger, more deformed and more tuberculate than those from polypar portion, 0.15–0.68 mm long and 0.05–0.12 mm wide (Fig. 6C). Juvenile specimens with four to eight longitudinal sclerite rows along the coenenchyme. In basal sterile portion, short scales and rods present, oval or waisted (8-shaped) in shape. In polypar portion scales are as long as the rods from the body wall. In polypar line, rods from the body wall frequently connect coenenchyme between two adjacent polyps. Tentacular rods smaller with slightly flattened ends, 0.14–0.3 mm long and 0.02–0.06 mm in width (Fig. 6B). Pinnular rods completely flat, with ridges and serrate margins, 0.06–0.14 mm long and 0.01–0.04 mm wide (Fig. 6D).

Comparisons. Along with *R. pleurocristatus* and *R. aureus*, this species shares the longest polyps and body wall sclerites in the genus. Colonies of *R. stonei* sp. nov. are quite delicate, but their polyps are similar to those of *R. pleurocristatus* in general aspect (especially in comparison with the holotype of *R. verrilli*). The ratio between the maximum length of the polypar and coenenchymal sclerites is another distinctive feature. In *R. pleurocristatus*, the length of the coenenchymal sclerites never reaches more than half that of those from the body wall, whereas in *R. stonei* sp. nov. they are nearly the same size. *Radicipes pleurocristatus* can also have slightly flattened short rods close to the base, transversely or irregularly arranged, whereas *R. stonei* sp. nov. has only scales longitudinally disposed. The latter has less sculptured coenenchymal scales with more regular margins and with at least one much flattened tip. Furthermore, the two species colonize different bathymetric ranges (Table 1).

Etymology. Named in honor of Robert P. Stone, coral and sponge authority of the Alaskan region.

Remarks. This species was probably photographed during NOAA cruises in the Aleutian Ridge, forming dense meadows in muddy bottoms, and this record is already mapped and available in the literature (see Watling *et al.*, 2011, p. 47, fig. 2.2G and p. 70, fig. 2.5). The species was first recorded at the location as *R. verrilli* by Stone & Shotwell (2007).

DNA sequences obtained from the holotype (USNM 1418007) for *COI+igr+msh1* are similar to the specimen sequenced by McFadden *et al.* (2011) and Pante *et al.* (2012) from station J209661 (Alaska: uncorrected *p*-distance = 0.07%) (see GenBank accessions KY748360 and KY748361, unpublished data). Analyses made by the authors mentioned above show an isolation of the Alaskan lineage, supporting the establishment of the new species. Genetic distances (uncorrected-*p*) of *R. stonei* sp. nov. to other non-Alaskan *Radicipes* sequences range from 0.21% to 0.92% (unpublished data).

The morphological similarity as well as the closeness with the geographical range of *R. pleurocristatus* indicate that these two species may have a common origin. In fact, the analyses by Pante *et al.* (2012) (e.g. NIWA 28821, NIWA 45304 and NORF47/2-NIWA) show a common origin of *Radicipes* species from Alaska (*R. stonei* sp. nov.), Solomon Islands, Western Australia, New Caledonia and New Zealand.

If we consider one of the specimens sequenced by Pante *et al.* (2012) as being *R. pleurocristatus*, there is at least one more undescribed species inhabiting the Indo-Pacific.

Distribution. Gulf of Alaska (Derickson Seamount) and Aleutian Islands, 1207–3580 m.

Radicipes spiralis (Nutting, 1908)

Fig. 7

Lepidogorgia spiralis Nutting, 1908: 588, P. 45, fig. 5.

Radicipes spiralis, Kükenthal 1919: 549.—Grigg & Bayer, 1976: 172, tab. 2 (listed).—Parrish & Baco, 2007: 188, Appendix 4.1. (listed).—Watling *et al.*, 2011: 66, tab. 2.2 (listed).

Types and Type-locality. Syntypes: USNM 25355 (one colony and four fragments) and USNM 22558 (three small fragments), Alb-4103, 21°02'20"N, 156°46'20"W, 241–258 m (Hawaii).

New record. Okeanos Station D2-EX1504-L2-16, 25°38'37.32"N, 168°50'49.2"W, 1462 m, photo only—no specimen, thus record not confirmed (Fig. 1A,D). ? Alb-3989, 22°06'55"N, 159°16'51"W, 704–914 (USNM 1438878).

Description. Brittle colonies, slightly flexible in mid and terminal portions, coiled in clockwise ascendent manner from base to apex. Axis diameter from 0.2 mm to 1.3 mm. Presence of non-horny nodes at proximal portion of larger colony. Polyps 1.2 to 3.2 mm long, uniserially and longitudinally distributed, two to four polyps per centimeter (usually three), with 0.3 mm to 2.0 mm distance between polyps. In their distal portion, polyps juxtaposed with almost no space between. Polyps completely naked or covered with sparse body wall rods that lack order, 0.15–0.25 mm long and 0.01–0.03 mm wide (Fig. 7). Tentacular and pinnular flattened rods, when present, 0.08–0.15 mm long and 0.01–0.03 mm wide. Coenenchymal sclerites rare or completely absent. Some areas of axis with tiny isolated, flattened rods embedded in coenenchyme. Presence of many micro-silicoclastic inclusions in tentacles of some polyps.

Comparisons. There are no species in the genus similar to *R. spiralis*. The virtual absence of sclerites in the body wall and the delicate nature of the colonies resemble in some ways the Atlantic species *Radicipes challengerii* (Wright & Studer, 1889) and *Radicipes kopolatos* Cordeiro, Castro & Pérez, 2015. However, *R. spiralis* is the only species with no conspicuous sclerites.

Remarks. The syntype consists of brittle basal fragments and one entire colony without a holdfast collected from a single station (*Albatross* 4103). Although the original description (Nutting, 1908) of this species mentions no sclerites, with some effort it is possible to find some rods in the body wall.

An additional specimen (USNM 1438878), named *Radicipes* sp., resembles the general morphology of *R. spiralis*, with a virtually naked body wall (Fig. 8A), however its “saddle bag” region is densely filled by flattened rods and scales, usually with a low, irregular longitudinal ridge (Fig. 8B). The tract between two full-sized polyps might have a narrow line of the same sclerites from saddle bag region (Fig. 8A). The mentioned specimen was collected in Hawaii by the USFWS *Albatross* (sta. 3989), several kilometers from the type locality of *R. spiralis*. Due to the lack of colonies with intermediate morphological features between the latter and *Radicipes* sp., we consider it inadequate to adjust the diagnosis of *R. spiralis* to include this specimen. Descriptions made by C. C. Nutting are often challenged and must be considered with caution.

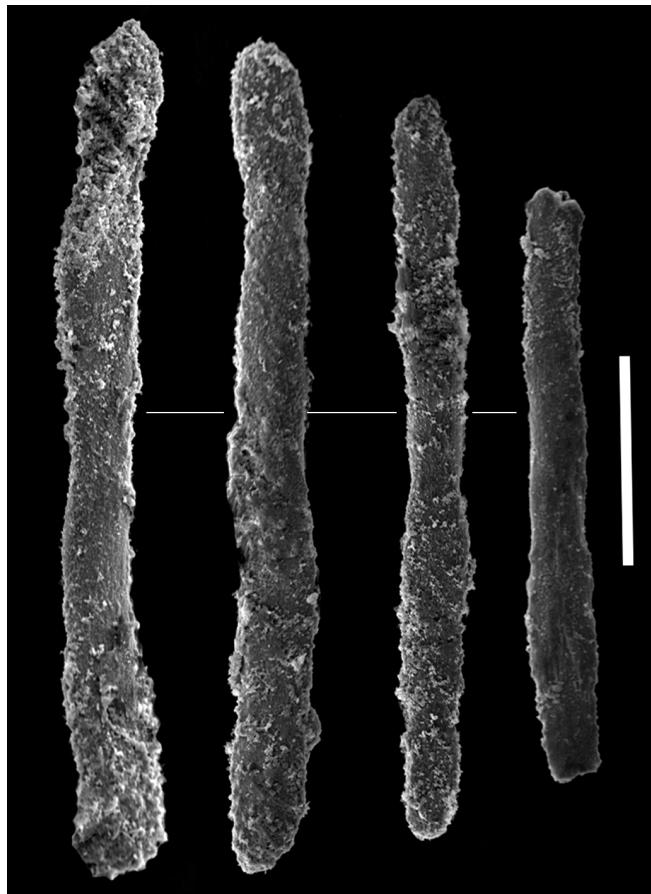


FIGURE 7. Sclerites of *Radicipes spiralis* (Nutting, 1908) (Syntype): rods from body wall. Scale bar: 0.05 mm.

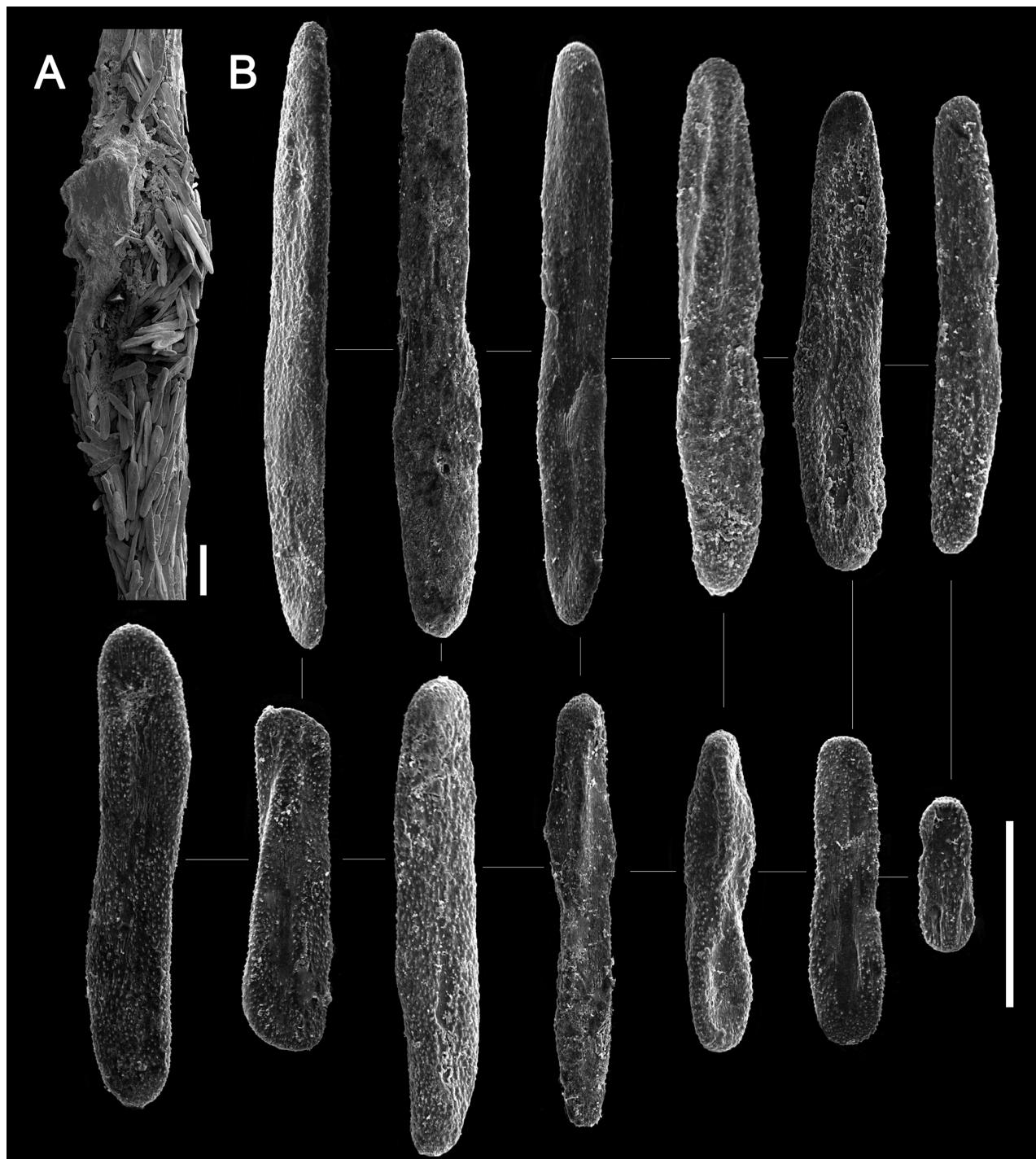


FIGURE 8. Polyp and sclerites of *Radicipes* sp. (USNM 1438878). A: polyp without conspicuous sclerites surrounded by a saddle bag filled with flattened rods and scales; B: scales and flattened rods. Scale bars: A: 0.2 mm; B: 0.1 mm.

Since its original description, no new collections of *R. spiralis* have been made. Thus, all subsequent publications about this species are simply compilations of Versluys' (1902) statements.

Today the area where this species occurs belongs to the Papahānaumokuākea Marine National Monument, the world's largest marine protected area. Recent NOAA deep-sea surveys visually documented several chrysogorgiid communities in Hawaii (please visit <http://oceanexplorer.noaa.gov/oceanos>), including colonies of *Radicipes* (Figs. 1A,D), which could be *R. spiralis* or *Radicipes* sp. (as discussed above). If the identification is *R. spiralis*, the deepest bathymetric record of that species would be extended from 257 to 1462 m. Only future collection efforts will better characterize this species and test this hypothesis.

Distribution. Known only in the type locality, 241–?1462 m depth.

***Radicipes gracilis* (Verrill, 1884)**

Figs. 2E–F, 9, 10

Lepidogorgia gracilis Verrill, 1884: 220; 1885: 512, 533, pl. 2, fig. 10, 10a.—Versluys, 1902: 16.—Thomson & Henderson, 1906: 27 (tabular key).

Strophogorgia fragilis Wright & Studer, 1889: 4, pl. 2, fig. 2, pl. 5a, fig. 4.

Lepidogorgia fragilis.—Versluys, 1902: 16–17.—Thomson & Henderson, 1906: 27.

Radicipes gracilis.—Kükenthal, 1919: 548; 24: 412.—Verrill, 1922: 42, fig 10, 10a.—Deichmann, 1936: 237.—Madsen, 1944: 46–49, text-figs. 37–41.—Bayer, 1979: 882, fig. 2c.—Bayer & Macintyre, 2001: 342 (mineralogy).—Watling & Auster, 2005: 28 (listed).—McFadden *et al.*, 2006: 525, figs. 1–3.—Wareham & Edinger, 2007: 295, 298, 302, fig. 1J.—Cogswell *et al.*, 2009: fig. 10G.—Buhl-Mortensen *et al.*, 2010: 43 (mentioned).—Pante & France, 2010: 597.—Watling *et al.*, 2011: 59 (listed).—Baker, *et al.*, 2012: 239, 240, 244.—Pante & France, 2012: figs. 2–3, supplemental table 1 (listed).—Cordeiro *et al.*, 2015: 94, 95 (tabular key).—Buhl-Mortensen *et al.*, 2015: 39–61, figs. 2f, 3i, 4, 5.

?*Lepidogorgia challengereri*.—Jungersten, 1915: 1184.

Radicipes fragilis.—Kükenthal, 1924: 143.—Tixier-Durivault & d'Hondt, 1975: 1410.—Braga-Henriques *et al.*, 2013: 4026 (listed).—Cordeiro *et al.*, 2015: 95 (tabular key).

Lepidogorgia verrilli.—Thomson, 1927: 20–21, pl. 3, fig. 18, pl. 5, fig. 20.

Types and Type Localities. *Radicipes gracilis*: USNM 9118 (syntype), Alb-2072, 41°53'N, 65°35'W (off Massachusetts), 1569 m; USNM 8877, USNM 9350, USNM 26030, USNM 30283, USNM 33570, YPM 8768 and YPM 10045 (syntypes), Alb-2037, 38°53'N, 69°23'30"W, 3166 m (off Massachusetts); part of the syntype series (from Alb-2036) is lost.

Strophogorgia fragilis: BM 1889.5.27.4 (holotype, one specimen), Chall-70: 38°25'N, 35°50'W (west of Azores), 3063 m.

Material Examined. Del-23, 39°55'55"N, 67°11'W, 1155 m (USNM 1111944, YPM 35442 and YPM 36838); Alb-2569, 39°26'N, 68°03'30"W, 3259 (USNM 11913 and YPM 10049); Del-29, 39°53'N, 67°23'W, 1395 (USNM 1110402); Alb-2209, 39°34'45"N, 71°31'30"W, 1975 m (USNM 8193 and YPM 10051); Alb-2570, 39°54'05"N, 67°05'30"W, 3316 m (USNM 11914); Alb-2575, 41°07'N, 65°26'30"W, 3128 m (USNM 11908); Alb-2563, 39°18'30"N, 71°23'30"W, 2601 m (USNM 11929 and YPM 10106); Del-14, 39°53'N, 67°26'24"W, depth unknown (USNM 100900); Del-47-Bear, 39°52'58"N, 67°25'58"W, 1195–1402 (USNM 1010390); Del-24, 39°52'12"N, 67°20'18.6"W, 1428–1650 m (YPM 36783); Pisces-16, 40°10'54"N, 67°26'40.2"W, 1961 m (YPM 72083).

Description. Colonies golden, stiff, tall, up to 90 cm in height, coiled in clockwise or counterclockwise manner; axis 2.2 mm, maximum diameter. Young colonies brittle and iridescent. Holdfast calcareous, profusely branched, usually thinner than axis. Coenenchyme thin, fragile and easily detachable from axis. At least one quarter of lower part of colony devoid of polyps. Distance between polyps about 1.5 mm in proximal portions to 10.0 mm distally. Polyps 2.5–5.0 mm long, cylindrical to slightly trumpet-shaped (Fig. 2E–F), disposed in a single longitudinal line (polypar side), spaced 4.0–10.0 mm apart in a frequency of three to five per centimeter (usually three). Eight longitudinal rows of rods in the body wall of completely developed polyps, with adaxials usually less developed, 0.18–0.7 mm long and 0.02–0.06 mm wide. Longest rods of body wall aligned with abaxial side, but no large supporting rods in abaxial side. Abaxial line from the lower portion of polyp to distal portion with four to six juxtaposed pairs of rods in alternate lines, relatively homogeneous in size. Sclerite size decreases from abaxial to outer lateral rows. Inner lateral and adaxial rows composed of loosely placed rods, sometimes naked. Oral portion with rods similar in size to those from lower portion of polyp. Infrabasal and adaxial portions filled with flattened rods, slightly 8-shaped, 0.15–0.26 mm long and 0.04–0.05 mm wide (Figs. 9A, 10A). Infrabasal and abaxial rods with slightly flattened tips becoming more rounded and sparse in oral portion. Abaxial row of rods extending through coenenchyme between polyps, connecting them. Coenenchymal sclerites rare or completely absent, when present, similar to those of infrabasal and adaxial portions. Tentacular rods 0.07–0.18 mm long and 0.01–0.04 mm wide, becoming flatter in proximal-distal wall (Figs. 9B, 10C). Pinnules filled with small scales, 0.1–0.13 mm in length and 0.01–0.04 mm in width (Figs. 9C, 10B).

Comparisons. Colonies of *R. gracilis* differ from the Atlantic species *R. challengereri* and *R. kopelatos* by having larger polyps (Table 1) and by having their body wall densely filled with sclerites (Fig. 2). Although the longest polyps in *R. kopelatos* reach up to 3.3 mm, most polyps in a colony are very short in comparison to those in *R. gracilis*, usually half their length. As well, the axis diameter in *R. gracilis* is usually thicker. The Pacific species *Radicipes stonei* has a similar polyp shape, but differs in having one or two long supporting rods in the lower abaxial side, having irregular infrabasal flattened rods, and having body wall rods with at least one flat tip.

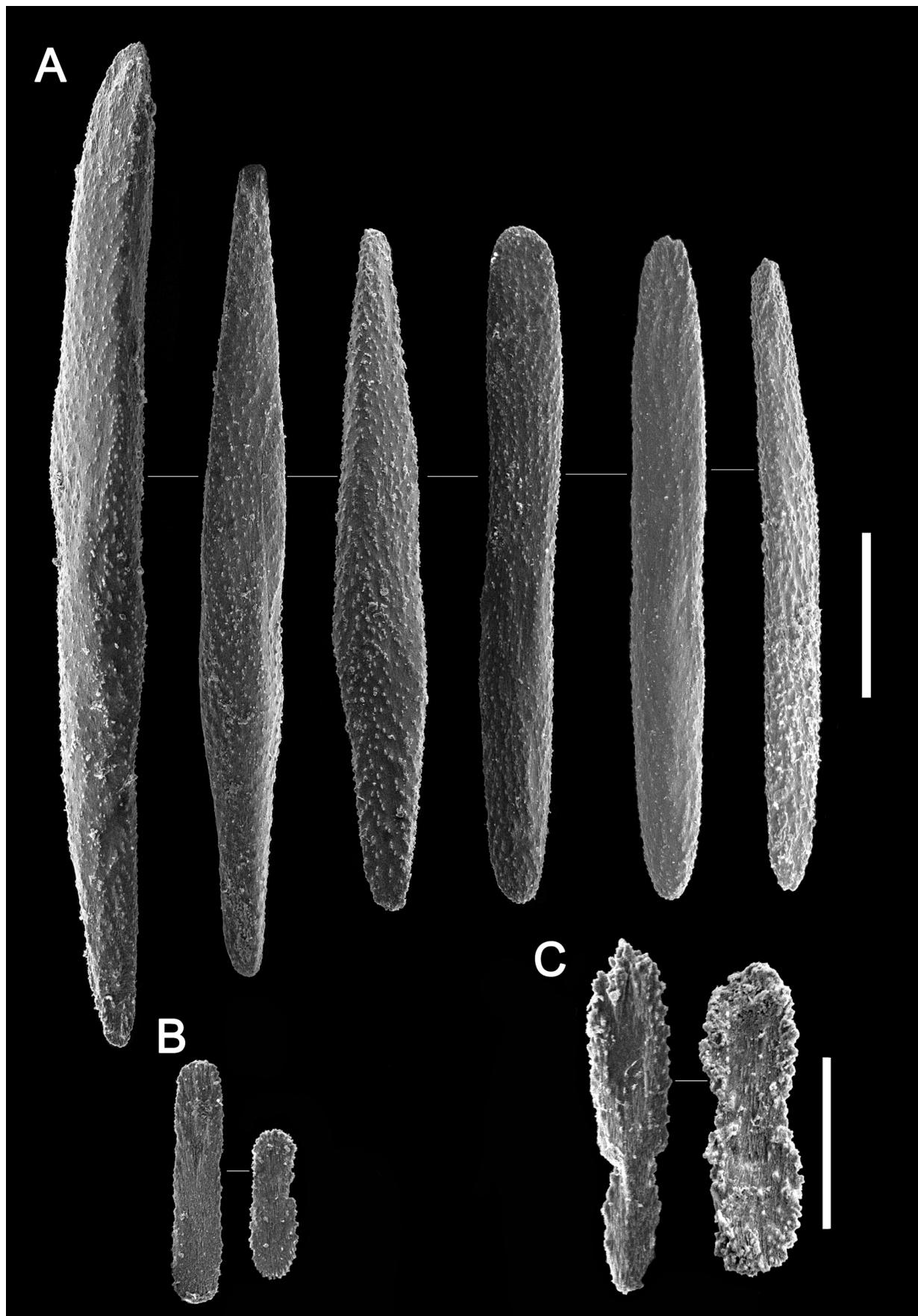


FIGURE 9. Sclerites of *Radicipes gracilis* (Verrill, 1884) (USNM 8877, syntype). A: rods from polyp body wall; B: flattened tentacular rods; C: pinnular scales. Scale bars: A, B: 0.1 mm; C: 0.05 mm.

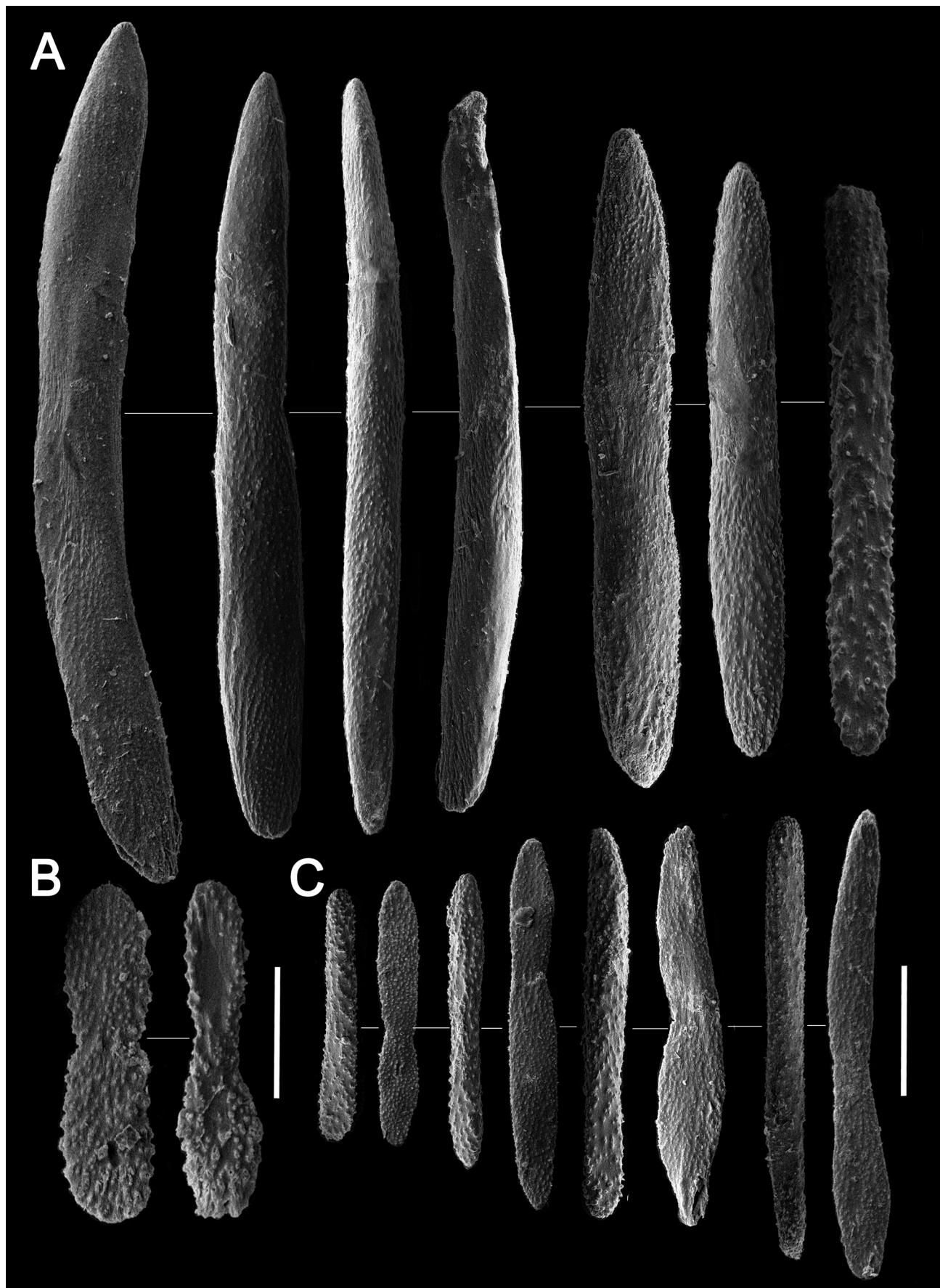


FIGURE 10. Sclerites of *Radicipes gracilis* (Verrill, 1884) (BMNH1889.5.27.4, holotype of *R. fragilis* (Wright & Studer, 1889)). A: rods from body wall; B: pinnular scales; C: tentacular rods. Scale bars: A,C: 0.1 mm; B: 0.05 mm.

Remarks. *Radicipes gracilis* is the most frequently recorded species in the genus, with at least 12 records presented herein and several others gleaned from the literature (Fig. 3, Supplementary file). Most studies have treated mid-Atlantic (*R. fragilis*) and western Atlantic (*R. gracilis*) populations as separate species. Nonetheless, no revisions including examinations of both types have been carried out until now. The type remains of *R. fragilis* consist of just a fragment of tissue (no axis) with several polyps. But this is enough to determine that the types are indistinguishable (compare Fig. 2E,E' with 2F and Fig. 9 with Fig. 10). Several misconceptions about the morphological features of *R. gracilis* can be seen in the available literature. Thomson & Henderson (1906), for example, implied that the species has more coenenchymal sclerites than *R. pleurocristatus* (see Thomson & Henderson, 1906: p. 27, comparative table of species of *Lepidogorgia*). According to Madsen (1944) and Cordeiro *et al.* (2015), the main differences between the two species can be seen in the measurements of the polyps, twice as long in *R. gracilis*, and the longer body wall rods in *R. fragilis* (Cordeiro *et al.*, 2015). We understand that the ‘polyp distinction’ is due to the measurements given by Madsen (1944), which included tentacles in the total polyp length determination, whereas no other author has included the tentacles to describe this character. Actually, both species have the same polypar length range, from 2.5 to 4.0 mm, not 5.0 to 10.0 mm as stated by Madsen. Rods from the body wall were slightly longer in the *R. fragilis* type (up to 0.75 mm long, whereas usually just up to 0.5 mm in western Atlantic specimens). Even though we only examined one mid-Atlantic colony, we consider it to be the same species, considering the sclerite size to be more related to age of the colony and sexual maturation.

It remains to be seen if the sequenced mid-Atlantic specimen ‘VER2041’ (Pante *et al.*, 2012) fits our *R. gracilis* definition, or *R. challengereri*, or is a different species. Considering Pante’s phylogenies, in the first case, one could consider treating *R. gracilis* as a cryptic species complex or one could suggest the reestablishment of *R. fragilis* as a valid name. Our examinations however do not allow us to keep both as valid.

Distribution. In western Atlantic from North Carolina to Canada; Mid-Atlantic Ridge, Seamounts and Portugal (Azores), from 500–3259 m.

Radicipes challengereri Wright & Studer, 1889

Figs. 2A,B , 11, 12

Strophogorgia challengereri Wright, 1885: 691 (nom. nud.).

Strophogorgia challengereri Wright & Studer, 1889: 3–4, pl. 1, fig. 1, pl. 5a, fig. 2.

Lepidogorgia challengereri: Versluys, 1902: 14–15, text-figs. 18–18–19.—Thomson & Henderson, 1906: 27 (tabular key).—Thomson, 1927: 20, pl. 4, fig. 17.

Radicipes challengereri: not Jungersen, 1915: 1183–1184 (=*R. gracilis*).—Kükenthal, 1919: 543–544; 1924: 411–412.—not Kramp, 1932: 10.—Deichmann, 1936: 237.—Madsen, 1944: 44–46, text-figs. 33–37.—Watling & Auster, 2005: 294 (listed).—Altuna, 2010: 10.—Watling *et al.*, 2011: 59 (listed).—Cordeiro *et al.*, 2015: 95 (tabular key).

Types and Type Locality. BMNH 1889.5.27.3 (holotype, several fragments); *Chall-4*, 36°25'N, 8°12'W (off Cadiz, Spain), 1097 m.

Material Examined. *Ger*-142, 24°28'N, 80°12'W, 805 (USNM 57314); *Pill*-586, 23°32'N, 82°33'W, 1682–1737 (USNM 57317); *Or*-1341, 22°55'N, 79°16'W, 439 (USNM 50184).

Description. Colonies delicate, coiled in a clockwise manner towards the tip, with a calcareous and delicate holdfast. Axis with a maximum diameter of 0.75 mm. Small polyps, 0.7 to 1.7 mm long (Fig. 2A,B), disposed in a single line, 1.5–4.0 mm apart. Polyps with more conspicuous sclerites on abaxial and outer lateral sides, more conspicuous distally. Body wall filled with slightly to completely flattened rods, being more flattened on polyp base, tentacles and in adaxial rows, more rounded in abaxial rows. Body wall rods longitudinally arranged and fairly uniform in length, being slightly longer near oral portion, 0.15–0.53 mm long and 0.02–0.06 mm in width (Figs. 11A, 12A). Infrabasal sclerites rare or absent, slightly to completely flattened, variable in size, immersed in a dense coenenchyme, appearing as a naked base. Tentacular rods homogeneous in size (Figs. 11C, 12B), 0.15–0.35 mm long and 0.02–0.03 mm in width, with length equal to or smaller than those from the base, distally becoming rare or absent. Pinnular sclerites also sparse towards the tips of tentacles, 0.1–0.15 mm long and 0.02–0.04 mm in width (Fig. 11B). Adaxial side of polyps naked or with few conspicuous sclerites. Spaces between polyps completely naked in both polypar and abpolypar faces of the colony. Coenenchymal sclerites rare or absent. When present, coenenchymal sclerites are 8-shaped scales.

Comparisons. *Radicipes challengereri* is one of the species in the genus having few sclerites, but not essentially absent as in *R. spiralis*, and has the smallest polyps of those in the genus. Morphologically, the most closely-related species is *R. koppelatos* (southwestern Atlantic), but the species described here is distinguished from *R. koppelatos* by showing rare or no coenenchymal sclerites, by not having rods in the body wall in the coenenchyme between polyps, and less conspicuous and more flattened body wall rods. Young parts (terminal portions of branch) in *R. gracilis* might be confused with colonies of *R. challengereri* by showing inconspicuous sclerites in the body wall of polyps.

Remarks. Of all available western Atlantic records of *Radicipes*, only three match the eastern Atlantic type of *R. challengereri*. This is the first record of this species in the western Atlantic. However, western Atlantic specimens have slightly more conspicuous body wall rods and infrabasal sclerites surrounding the axis beneath the polyp.

There are no recent eastern Atlantic records of *R. challengereri*, but it is possible that most of the records published as *Radicipes* sp. belong to this species (see Distribution section under genus *Radicipes*). It remains to be determined which species correspond to the West African record (see Fig. 3).

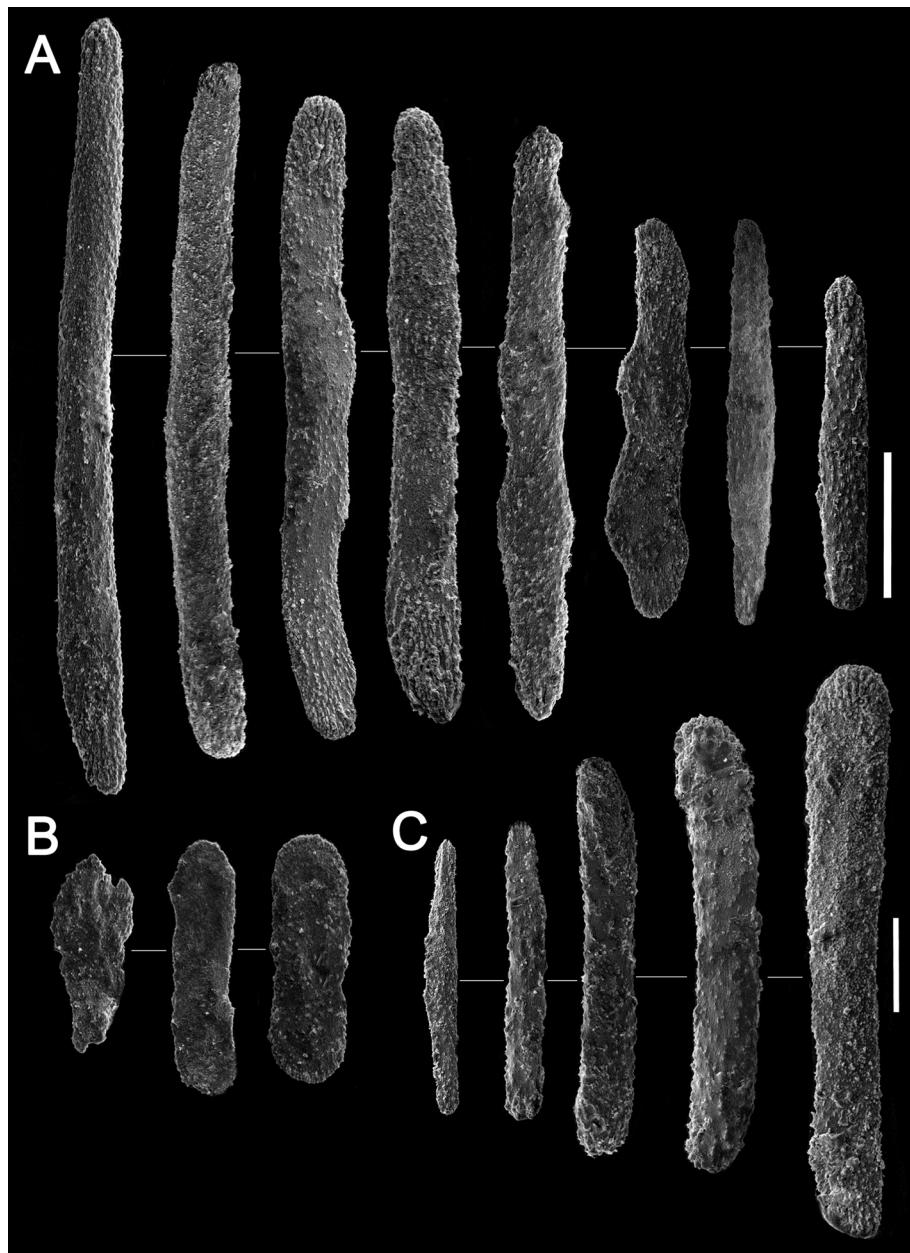


FIGURE 11. Sclerites of *Radicipes challengereri* (Wright & Studer, 1889) (BMNH1889.5.27.3, holotype). A: rods from body wall; B: pinnular scales; C: tentacular rods. Scale bars: A: 0.1 mm; B–C: 0.05 mm.

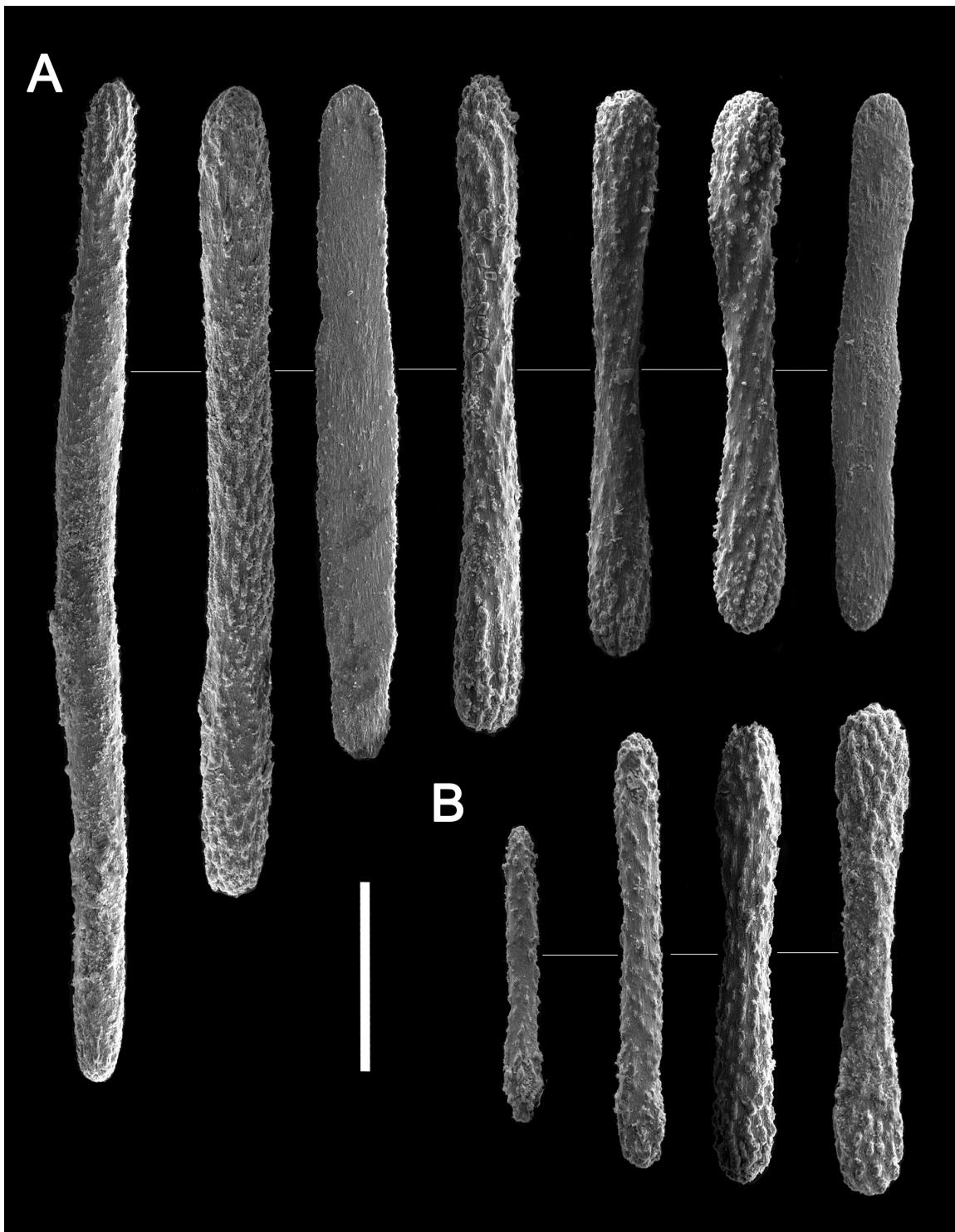


FIGURE 12. Sclerites of *Radicipes challengerii* (Wright & Studer, 1889) (USNM 57314). A: rods from body wall; B: rods from tentacles. Scale bar: 0.1 mm.

It is not unusual to find amphi-Atlantic coral species, especially in groups restricted to deep waters. Known examples that demonstrate this geographic pattern include scleractinians (Cairns & Chapman, 2001), octocorals (Pires & Castro, 2010) and possibly chrysogorgiids (Grasshoff, 1981; Cairns, 2001). Braga-Henriques *et al.* (2013: 4024) also argued that 35 % of the deep-water coral species occurring in the central northeast Atlantic (Azores) have amphi-Atlantic distributions; these authors found depth-related trends of faunal change in their dataset, i.e. the proportion of amphi-Atlantic species increased from 19% at 100–600 m to 23% at the 1000–1500 m. The scarcity of data makes it difficult to understand how these populations were connected in the past. Lastly, as occurs

in the scleractinian *Lophelia pertusa* (see Goff-Vitry *et al.*, 2004), it is even possible that eastern and western Atlantic populations of *R. challengerii* form a complex of cryptic species.

Distribution. Western Atlantic: Straits of Florida and Cuba; Eastern Atlantic: Iceland and Portugal (mainland), 439–1737 m.

***Radicipes kopelatos* Cordeiro, Castro & Perez, 2015**

Figs. 2D, 13

Radicipes kopelatos Cordeiro, Castro & Perez, 2015: 94–96, figs. 2H, 8–9.

Radicipes sp. 1: Castro *et al.*, 2006: 170 (listed).

Radicipes sp. 2: Castro *et al.*, 2006: 170 (listed)

Types and Type Locality. MNRJ 8566 (holotype), Thal-464, 21°48'49"S, 40°01'53"W, 592.4–618.8 m (off Rio de Janeiro).

Material Examined. Paratypes: Thal-522, 13°22'17"S, 38°36'56"W, 750 m (MNRJ 5968, three colonies); MNRJ 4361, same collection data as that of the holotype (55 colonies).

Description. Colonies flexible, white or yellowish, with clockwise or counterclockwise upward spiraling trend, up to 60 cm long. Axis with iridescent aspect, 0.7–1.0 mm diameter, calcareous holdfast with projections up to 6.0 mm long. Coenenchyme easily detachable from axis. Polyps 0.8–3.5 mm long (Fig. 2D), disposed in a single row, 1.0–4.0 mm distant from each other, in a frequency of two to five polyps per centimeter, but usually four. Frequency of polyps usually decreasing in base to apex direction, with up to five polyps per centimeter on the proximal two-thirds of the colony, two to four polyps per centimeter on the distal third. Body wall with rods 0.16–0.60 mm long, longitudinally arranged, homogeneous in diameter (0.03–0.08 mm), sometimes flattened, usually with flattened ends, sparse in some areas of the colony (Fig. 13A). Coenenchymal scales (8-shaped) 0.15–0.25 mm long (Fig. 13B) and 0.03–0.07 mm in width. Sclerites on abpolypar face rare or absent except on polyp bases. Adaxial and infrabasal portion of polyps frequently filled with scales similar to those of coenenchyme, slightly smaller than the spindles, 0.10–0.18 mm long. Rods from tentacles longitudinally striated and slightly constricted, sometimes twisted in the middle, 0.08–0.12 mm long and 0.02–0.04 mm in width (Fig. 13C). Pinnular sclerites represented by small scales, 0.1–0.14 mm long and 0.02–0.04 mm wide (Fig. 13D).

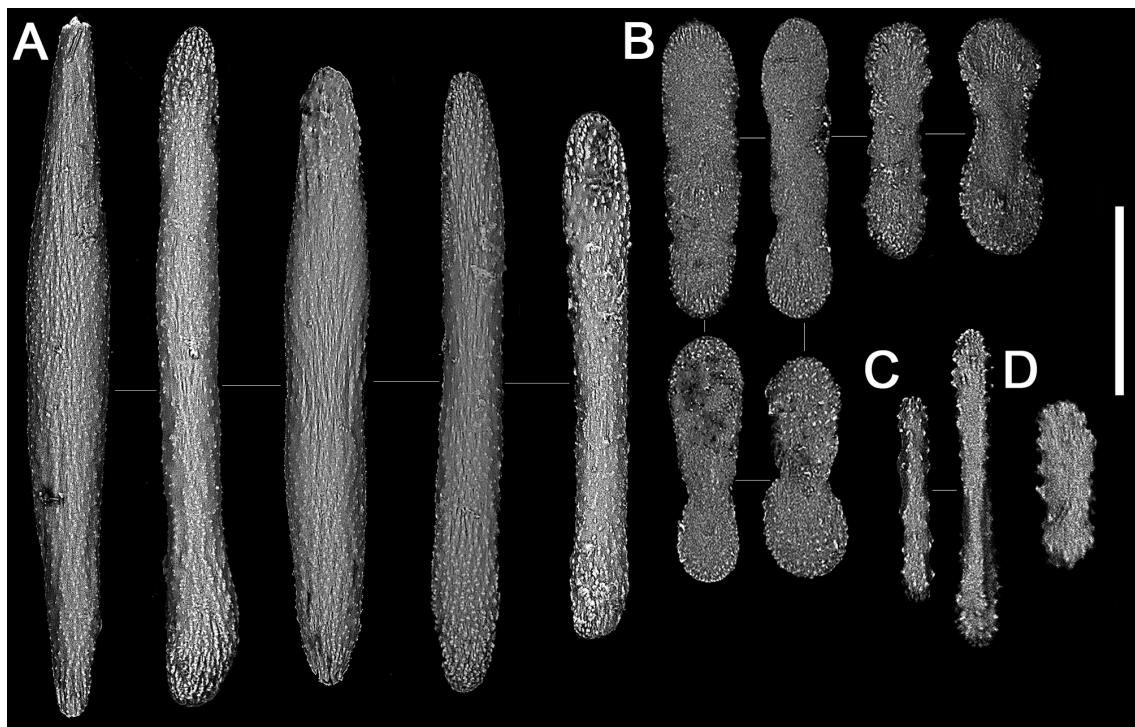


FIGURE 13. Sclerites of *Radicipes kopelatos* Cordeiro, Castro & Pérez, 2015 (MNRJ 8566, holotype). A: rods from polyp body wall; B: coenenchymal 8-shaped scales; C: tentacular rods; D: pinnular scale. Scale bar: 0.15 mm.

TABLE 1. Distinguishing macro-structural characters of *Radicipes* species based on examination of type specimens from museum collections and recent material. Information based on Kükenthal (1919) is indicated with an asterisk (*).

Characters/Species	<i>Radicipes aureus</i> Kükenthal, 1919	<i>Radicipes challengerii</i> Wright, 1885	<i>Radicipes gracilis</i> (Verrill, 1884)	<i>Radicipes kopelatus</i> Cordeiro, Pérez & Castro, 2015	<i>Radicipes pleurocrystatus</i> Stearns, 1883	<i>Radicipes spiralis</i> (Nutting, 1908)	<i>Radicipes stonei</i> sp. nov.
Maximum diameter of axis (mm)	1.0*	0.75	2.2	1.0	4.3	1.3	2.9
Polyt length (mm)	3.0–5.0*	0.7–1.7	2.5–5	0.8–3.5	2.8–5.1	1.2–3.2	1.0–3.0
Number of polyps/ cm (most common)	2–3 (3)*	Unknown	3–5 (3)	2–5 (4)	1–4 (3)	2–4 (3)	1–5 (3)
Coenenchymal sclerites	Present	Rare/absent	Present	Present	Rare/absent	Present	Present
Distribution of coenenchymal sclerites	Entirely surrounding the axis, even between polyps.	Occasional; no sclerites between full-sized polyps	Only body wall rods between full-sized polyps	Usually only on polypar face of colony; frequent body wall rods between polyps	Entirely surrounding axis, except between most of the full-sized polyps, where body wall rods cover the space between them	Occasional; no sclerites between full-sized polyps	Entirely surrounding the axis, except between most of the full-sized polyps, where body wall rods cover the space between them
Shape of the coenenchymal sclerites	Scales with lobate margins	8-shaped	8-shaped	8-shaped	Longitudinally curved scales (woody appearance)	Longitudinally curved scales	Longitudinally grooved, with at least one flattened tip
Length of coenenchymal sclerites (mm) (L:W)	0.2–0.6 (5–6)	–	0.15–0.26 (3.75–5.2)	0.15–0.25 (3.6–5)	0.15–1.0 (3.75–8.3)	–	0.15–0.68 (3–5.7)
Arrangement of body wall sclerites	Scales and flattened rods longitudinally arranged. In sexually mature polyps, presence of an infrabasal bulb formed by same scales transversely or obliquely arranged	Rods longitudinally arranged and sparse infrabasally	Rods longitudinally arranged (but in a longitudinal trend)	Scattered (but in a longitudinal trend)	Rods longitudinally disposed. In sexually mature polyps, presence of an infrabasal bulb formed by transversely arranged rods	Rods longitudinally arranged, some with a flat end and (rarely) completely flattened (scale-like)	Rods longitudinally arranged, some with a flat end and (rarely) completely flattened (scale-like)
Length of polypar sclerites (mm) (L:W)	0.7–1.2 (9.2–10)	0.15–0.53 (7.5–8.8)	0.18–0.7 (9–11.7) (presence of infrabasal 8-shaped, 0.15–0.26 mm long and 0.04–0.05 mm in width)	0.16–0.60 (5.3–7.5)	0.6–2.3 (14.4–15)	0.15–0.25 (8.3–15)	0.13–0.86 (4.3–8.6)
Tentacular sclerites	Flattened rods	Flattened rods	Flattened rods	Flattened rods	Flattened rods	Flattened rods	Slightly or completely flattened rods
Length of tentacular sclerites (mm) (L:W)	0.15–0.4 (7.9–20)	0.15–0.35 (7.5–11.7)	0.07–0.18 (4.5–7)	0.8–0.12 (3–4)	0.2–0.46 (4.6–10)	0.08–0.15 (5–8)	0.14–0.3 (5–7)
Distribution and bathymetric range	Somalia to South Africa, 463–1644 m	Northwestern and northeastern Atlantic, 439–1737 m	Western and mid-Atlantic (northern hemisphere), 500–3259 m	Southern Brazil, 592–750 m	Eastern Pacific (Japan) to Indo-Pacific (Indonesia), 629–1301 m	Hawaii, 241–?1462 m	Gulf of Alaska and Aleutian Islands, 1207–3580 m

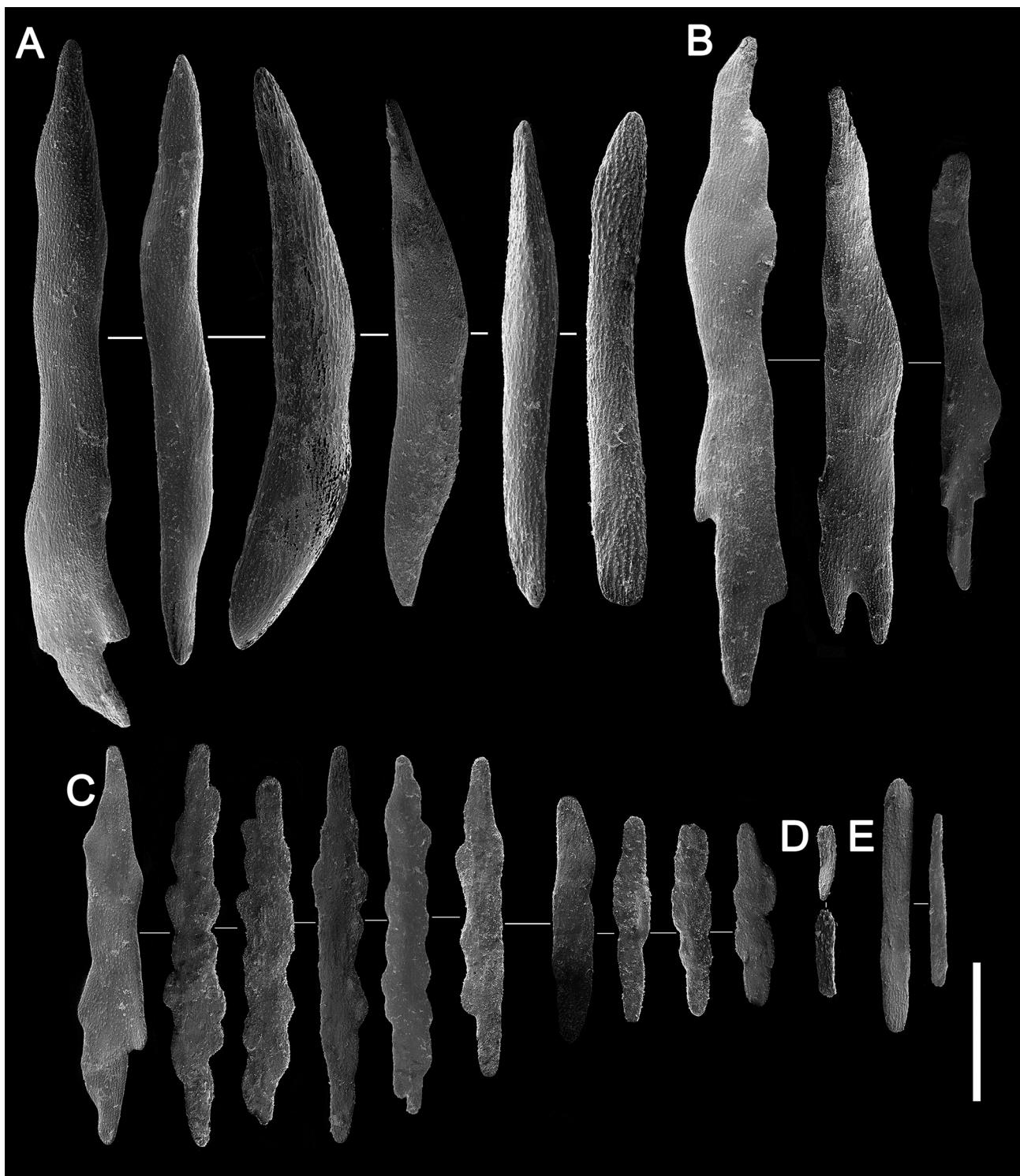


FIGURE 14. Sclerites of *Radicipes aureus* Kükenthal, 1919 (ZMB 8565, holotype). A: rods from the body wall; B: infrabasal scales; C: coenenchymal scales; D: pinnular scales; E: tentacular rods. Scale bar: 0.2 mm.

Comparisons. This species is morphologically close to *R. challengerii* (Table 1), with similar sclerite sizes. However, *R. kopelatos* has body wall rods proportionally thicker than those in *R. challengerii*, with a more homogeneous diameter in these sclerites. The latter also has usually smaller polyps.

Remarks. There are no new records for this species since its recent discovery in southern Brazil (Cordeiro *et al.*, 2015). Besides the west coast of the African continent, the Brazilian slope is one of the most poorly known areas in the Atlantic. Thus, it is essential to collect new material in those areas and invest in integrative taxonomic

studies that could help to better understand the relationship between eastern and western populations of the Atlantic Ocean (*R. kopelatos*, *R. challengerii* and *R. gracilis*).

Distribution. Western Atlantic, Southeastern Brazil, 592–750 m.

***Radicipes aureus* Kükenthal, 1919**

Figs. 2G, 14

Radicipes aureus Kükenthal, 1919: 544–545, text-figs. 237–239; 1924: 412.—Cordeiro *et al.*, 2015: 95 (tabular key).
?*Radicipes* sp. Williams, 1992: 253.

Types and Type Locality. Part of the syntype series, from *Valdivia* 245, is lost. Thus, the remaining part, from *Valdivia* 257 (ZMB 8565), is herein designated as the lectotype; 1°48'N, 45°42'30"E (Somalia), 1644 m.

Material Examined. Lectotype (several fragments).

Description of the lectotype. Colony coiled with maximum axis diameter of 1.0 mm. Axis basally quadrangular with rounded edges in cross-section, but round in remainder of colony. Polyps around 5.0 mm long (Fig. 2G), 1.3 mm wide and uniserially placed, separated by an average distance of 5.0 mm, sometimes less. Polyps upwardly oriented at least 45°, cylindrical, having an enlargement at the base. Basal enlargement usually filled with gametes. Sclerites from polyp body wall longitudinally arranged (Fig. 2G). Most abundant sclerites from body wall represented by elongate rods, with at least one much flattened tip, 0.7–1.2 mm long and 0.07–0.13 mm in width (Fig. 14A). Abaxial supporting rods more elongated at the polyp base, decreasing in length towards the tentacles. Outer lateral and inner lateral rows composed of one to three long rods. Adaxial rows with several smaller rods. Infrabasal pointed scales transversely arranged in six to ten rows, 0.5–1.0 mm long, forming a bulb-like base (Fig. 14B). Coenenchyme and base of polyp formed by elongate scales, with irregular margins and pointed tips, sometimes forked, 0.2–0.6 mm long and 0.04–0.1 mm wide (Fig. 14C). Tentacular rods homogeneous in diameter, 0.15–0.4 mm long and 0.019–0.020 mm wide (Fig. 14E). Pinnular scales 0.08–0.13 mm long (Fig. 14D).

Comparisons. *Radicipes aureus* has large body wall sclerites, as do all Indo-Pacific species (except for *R. spiralis*), but is distinguished from all species of the genus by having long pointed body wall rods with one flat tip, and pointed scales in the base. Generally, this species is the only one to show polyps covered by conspicuous scales.

Remarks. We only had access to a single polyp from lot ZMB 8565. Therefore, characters related to the colony and arrangement of polyps were described based on drawings and description given by Kükenthal (1919). For example, according to Kükenthal, colonies can reach 56 cm in length.

This is another species with only a single record since its description. We suppose that the *Radicipes* sp. record of Williams (1992) may belong to this species, based on the proximity of the geographic distribution. Only the original was identified to species level. All further records are compiled or identified to genus level. There are no additional reports of *Radicipes* species in the Indian Ocean.

Distribution. Western Indian Ocean, from Somalia to South Africa, 463–1644 m.

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