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The Panamic Gorgonian Genus *Pacifigorgia* (Octocorallia: Gorgoniidae) in the Galápagos Archipelago, with Descriptions of Three New Species

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The eastern Pacific gorgonian genus *Pacifigorgia* Bayer, 1951, is here described from the northwestern fringe of the Galápagos Archipelago. The two small islands of Darwin and Wolf are relatively isolated from the rest of the archipelago. Two of the new taxa are apparently endemic to these outer islands, as previous subtidal surveys of the other Galápagos Islands, as well as other regions of the Panamic Biogeographic Province, have not encountered conspecific material. The third new species is apparently restricted to central islands of the archipelago. The previously described *P. darwini* (Hickson, 1928) is the most common and widespread species and is found throughout the archipelago, except for the outlying islands of Darwin and Wolf. A taxonomic assessment of Hickson's *Gorgonia darwini* var. *douglasii* is also included. The genus is restricted to the eastern Pacific (Gulf of California to Peru), with the exception of *Pacifigorgia elegans*, endemic to the tropical western Atlantic (Trinidad to Brazil). The addition of the new taxa described here makes twenty-one species belonging to the genus that are considered valid.

The marine fauna of oceanic islands have been subjects of great scientific interest chiefly because of their biogeographic relevance. Endemism, dispersal patterns, and other aspects of evolutionary biology might be better understood through comparisons to mainland faunas (Quammen 1996).

The main oceanic islands and archipelagos situated in the tropical eastern Pacific are Isla del Coco (Costa Rica); Isla Malpelo (Columbia); Islas Revillagigedo (Mexico), Île Clipperton (France); and Islas Galápagos (Ecuador). Even though numerous expeditions to explore the flora and fauna of these islands have been made, the octocorallian fauna remains as one of the least known faunal elements.

The literature pertaining to the Galápagos octocoral fauna is depauperate. The main sources here include Hickson (1928), Bayer (1978), and Breedy and Guzman (2003). Sources relevant to the genus *Pacifigorgia* are Bayer (1951, 1953, 1956), Breedy (2001), and Breedy and Guzman (2002, 2003). Hickson (1921, 1928) and Deichmann (1941) provided the first records of shallow water octocorals of the Galápagos Archipelago. Hickson (1921) described *Cavernularia darwini* (Pennatulacea) from Isla Cristobal (Chatham Island), and then seven years later, he described two new species of *Pacifigorgia* (under the generic name *Gorgonia*) (Hickson, 1928). Deichmann (1941) described the species *Muricea galapagensis* (Plexauridae) from Isla Isabela (Albemarle

Island), which was pulled up on an anchor chain from 53 fathoms (97 m depth). The validity of this species has to be corroborated.

Aside from Hickson's two species and the recently described *Pacifigorgia curta* Breedy and Guzman, 2003, from Isla del Coco, there are not published records from other oceanic islands of the tropical eastern Pacific. Two presently undetermined species of *Pacifigorgia* are known from Islas Revillagigedo. These are represented by two dried preserved specimens, CAS 097905 and CAS 097906.

The only published records of the genus *Pacifigorgia* from the Galápagos, appeared in Hickson's publication "The Gorgonacea of Panama Bay." He described two taxa: *Pacifigorgia darwinii* (Hickson, 1928), and *Pacifigorgia darwinii* var. *douglasii* (Hickson 1928). *Pacifigorgia darwinii* was revised and redescribed by Breedy and Guzman (2002), whereas *P. darwinii* var. *douglasii*, was originally figured only from sclerites, which is all that is known to exist from the type specimen (Breedy and Guzman 2002).

In this paper, we monograph all the known taxa from the Galápagos Archipelago, which includes the descriptions of three new species, based on the study of recently discovered taxa, and material found in several collections. The two previously described taxa are also included in the present paper, making a total of five species of the genus *Pacifigorgia* presently known to inhabit the shallow coastal waters of the Galápagos Archipelago. Four of these are considered valid, whereas one is here considered to be of dubious status.

The three new species of sea fans (gorgonian corals) were discovered during SCUBA operations conducted during the 1994 California Academy of Sciences marine expedition to the Galápagos Islands, Ecuador. McCosker (1994) briefly describes this expedition.

The genus *Pacifigorgia* was described by Bayer (1951:94) for net-like reticulated species with sclerites as spindles and capstans (scaphoids absent), geographically confined to the Pacific coast of tropical America (with one exception from the tropical western Atlantic). The following genera are known to comprise the shallow-water gorgonian fauna (<50 m) of the Galápagos Archipelago. These five genera represent approximately eleven species in the two families Plexauridae and Gorgoniidae: *Adelogorgia* (1 species), *Eugorgia* (1 species), *Leptogorgia* (1 species), *Muricea* (ca. 4 species), and *Pacifigorgia* (4 valid species, plus 1 dubious species) (pers. observ. and Cleve Hickman — pers. commun.).

METHODS

Specimens were collected by the senior author (GCW) from several islands in the Galápagos Archipelago, between 2°N to 1.5°S Latitude, and 89°W to 92°W Longitude, during the California Academy of Sciences marine expedition to the Galápagos Islands in May of 1994. All material was collected by SCUBA in shallow water (<50 m depth), and preserved in 70% ethanol. The specimens for study came from this recent collection as well as from expeditions by C. Hickman and P. Humann (1993–2001). Other material came from the collections of the California Academy of Sciences, San Francisco; the Charles Darwin Research Station, Galápagos; the voucher collection of the Museum of Comparative Zoology of Harvard University, Boston, made available to us by Ardis Johnston; and type specimens and microscope slides from The Natural History Museum, London, through the kindness of Sheila Halsey. Most of this material was collected by hand using SCUBA or skin diving. Most of the specimens are preserved in 70–75% ethanol and were originally fixed in ethanol. A few of the specimens were preserved dried. All collection sites are indicated on the maps (Figs. 5, 9, 16, 23), along with a range comparison map (Fig. 24).

Sclerites were isolated using sodium hypochlorite (household bleach); see the website:

<http://www.calacademy.org/research/izg/OctoResearchTech.htm> (Octocoral Research Center or Octocoral Home Page — Research Techniques), and Breedy and Guzmán (2002:784) for details. Also of relevance here are Bayer (1961:23–24), and Fabricius and Alderslade (2001:38).

The subject for Figure 1A was photographed in a small glass aquarium from freshly collected material, using a Pentax 35 mm camera, with a 50 mm macro lens and flash unit. Figure 1C is a scanprint made directly from the holotype, using a Umax Astdra 1200S flatbed scanner. Micrographs for figures 1B and 2 were made using a Nikon Coolpix 990 digital camera, a Nikon SMZ-10 dissecting microscope, and an Olympus CH-2 compound microscope. Scanning electron micrographs were made using a Leo 1400 Series or a N-2360 Hitachi scanning electron microscope. Sclerite drawings were made using an Olympus CH-2 compound microscope with an attached drawing tube. Digital images and plates of photographs, micrographs, and scanning electron micrographs were made using Adobe Photoshop software. Abbreviations used in the text are BM or NHM (The Natural History Museum, London; formerly British Museum — Natural History); CAS (California Academy of Sciences, San Francisco); CDRS (Charles Darwin Research Station, Puerto Ayora, Isla Santa Cruz, Galápagos Islands); MCZ (Museum of Comparative Zoology, Harvard University, Boston).

Specimens examined in this study are deposited in the CAS octocoral collection (Department of Invertebrate Zoology and Geology), the CDRS, and the MCZ. Type specimens were obtained by loan from the BM. Previous records of some species have been acquired from literature sources (Hickson, 1928; Stiasny, 1941, 1943; Breedy and Guzmán, 2002), as well as from personal observations and museum specimens.

Terminology used in this paper conforms to that of Bayer, Grasshoff and Verseveldt (1983), and Breedy and Guzmán (2002).

SYSTEMATIC ACCOUNT

Family Gorgoniidae Lamouroux, 1812

Pacifigorgia Bayer, 1951

Rhipidigorgia (partial) Valenciennes, 1855:13. Milne Edwards and Haime, 1857:173. Horn, 1860:233.

Rhipidogorgia (partial) Verrill, 1864:32. Duchassaing and Michelotti, 1864:20. Verrill, 1869:424.

Litigorgia (partial) + *Eugorgia* (partial) Verrill, 1868:414.

Leptogorgia (partial) Verrill, 1869:420. Verrill, 1870:548.

Gorgonia Bielschowsky, 1918:32. Kükenthal, 1924:338. Bielschowsky, 1929:141. Stiasny, 1941:268. Stiasny, 1943:74.

Pacifigorgia Bayer, 1951:94. 1953:103. 1956:212. Breedy, 2001:182. Breedy and Guzmán, 2002:791. 2003:3.

DIAGNOSIS.— Sea fans composed of reticulated networks by anastomosis (as in the western Atlantic genus *Gorgonia*), but with sclerites similar to those of the genus *Leptogorgia* from the eastern Pacific and Atlantic Ocean. The coenenchymal sclerites are girdled spindles and radiates, whereas scaphoids are absent. Color permanent, incorporated in the sclerites.

TYPE SPECIES.— *Gorgonia stenobrochis* Valenciennes, 1846; subsequent designation by Bayer, 1951:94.

DIVERSITY AND DISTRIBUTION (see Fig. 5, inset).— Twenty species from the Eastern Pacific (Baja California to Chile, Cocos Islands, Revillagigedo Islands and Galápagos Islands); one species in the western Atlantic (Trinidad and Venezuela to Brazil).

***Pacifigorgia dampieri* Williams and Breedy, sp. nov.**

(Figs. 1–5, 24)

MATERIAL EXAMINED.—HOLOTYPE: CAS 097040, Ecuador, Galápagos Islands, Isla Darwin, 15–21 m depth, (Station G8), 13 May 1994, collected by G.C. Williams with SCUBA, aboard “Mistral II”. One whole wet specimen, preserved in 75% ethanol. PARATYPE: CAS 097021, Ecuador, Galápagos Islands, Isla Wolf, 9–15 m depth, (Station G5), 12 May 1994, collected by G.C. Williams with SCUBA, aboard “Mistral II”. One whole wet specimen, preserved in 75% ethanol.

OTHER MATERIAL: CAS 097022, Ecuador, Galápagos Islands, Isla Wolf, 12–18 m depth, (Station G4), 12 May 1994, collected by G.C. Williams with SCUBA, aboard “Mistral II”. One whole wet specimen, preserved in 75% ethanol. CAS 097023, Ecuador, Galápagos Islands, Isla Wolf, 12–18 m depth, (Station G4), 12 May 1994, collected by G.C. Williams with SCUBA, aboard “Mistral II”. One whole wet specimen, preserved in 75% ethanol. CAS 097025, Ecuador, Galápagos Islands, Isla Wolf, 9–15 m depth, (Station G5), 12 May 1994, collected by G.C. Williams with SCUBA, aboard “Mistral II”. One whole wet specimen, preserved in 75% ethanol. CAS 097025, Ecuador, Galápagos Islands, Isla Wolf, 9–15 m depth (Station G5), 12 May 1994, collected by G.C. Williams with SCUBA, aboard “Mistral II”. One whole wet specimen, preserved in 75% ethanol. CAS 147483, Ecuador, Galápagos Islands, Isla Darwin, 15–21 m depth, (Station G8), 13 May 1994, collected by G.C. Williams with SCUBA, aboard “Mistral II”. One whole wet specimen, preserved in 75% ethanol. CDRS 02–39, Ecuador, Galápagos Islands, Isla Wolf, depth not recorded, 19 May 2001, collected by C. Hickman.

GENERAL DESCRIPTION.—Fans are relatively stiff, planar or comprised of a main fan with several secondary fans in different planes, which radiate outward from the central region of the main fan. Secondary fans may radiate perpendicularly from the main fan. Colonies are wider than high, often irregularly-shaped, up to 200 mm in height and 270 mm in width. Multiple fans are interconnected by relatively thick branches (up to 8 mm in width) that diverge upwards from the holdfast. In some cases, fans with separate holdfasts anastomose to produce a maze-like appearance. The fusion between fans may take place in the coenenchyme of the main stem or main branches. Colonies often have strong, encrusting, orange-colored holdfasts. In smaller colonies, the holdfast may spread out conspicuously over the substratum.

Networks are intricate, regular, and of open meshes. The meshes are often more-or-less square, but are also variable: circular, rounded-rectangular, elliptical or triangular meshes 2–5 mm long by 1–3 mm wide; elongated and trapezoidal meshes 4–12 mm long by 0.7–6.0 mm wide. Colonies average approximately six meshes/cm². Mesh branches are thin, up to 1.0 mm in diameter. Prominent, rounded midribs, up to 7 mm in width, extend up into the fans, or reach a short distance upwards from the base of the fans. They are of a distinct orange color, with distinct longitudinal grooves of yellow and orange sclerites, very apparent in dried specimens. The terminal branchlets are short, 2–5 mm in length. Free twigs emanating from the interior of the fans are short (up to 2 or 3 mm long) and scarce. The mound-like protuberances resulting from the retracted polyps are small (mostly ≤ 1 mm long), oval in shape with slit-like apertures, slightly raised, and red-orange at the bases with yellowish apices. These mounds are disposed in more-or-less distinct, usually four longitudinal rows along the branches. On a particular face of the fan, the mounds are arranged biserially, alternately so on narrow branches, alternate to opposite on thicker branches. Polyps are milky white with very thin points-like arrangements of sclerites.

The coenenchymal sclerites are mostly girdled spindles with blunt, rounded ends, but a dominance of spindles with acute ends is also observed in some specimens (e.g., CAS 097025). The spindles vary in length from 0.08 mm–0.16 mm and are up to 0.04 mm in width. They have 4–6

whorls of tubercles, with both ends acute or blunt, or with one end acute and the other blunt. Compact, relatively wide radiates or capstans (0.40–0.60 mm long), and relatively elongated eight radiates (0.60 mm–0.80 mm long and up to 0.04 mm wide), are also common in all the specimens. These characteristically have two whorls of tubercles and warty ends. The coenenchymal sclerites are entirely red or yellow, whereas some are bicolored (red and yellow). Anthocodial sclerites are elongated yellowish rods (up to 0.11 mm in length and 0.02 mm in width), with lobed or scalloped margins, and with short tubercles at the ends.

Color in life is brick-red to rust-orange, often with orange main branches. The mounds formed by retracted polyps are mostly brick-red to dull orange. The color is conserved in alcohol-preserved specimens or is slightly paler in dried specimens.

DESCRIPTION OF HOLOTYPE.— Growth form and size (Fig. 1A–B): The holotype measures 77 mm high by 163 mm wide, and is comprised of a single planar fan. Secondary fans are absent. The main stem is very short above the holdfast (<5 mm long). A strong main trunk-like branch is absent. Instead, two thickened branches (each approximately 4 mm in width) emanate from the basal stem, which form a more-or-less V-shape, and subtend the fan. The free terminal branches are 2–10 mm long. Networks are composed of relatively large, open meshes of variable shape. The meshes are mostly quadrilateral, trapezoidal, or deltoid in shape, whereas some are elongated. Meshes vary from 2–8 mm long and 2–3 mm wide; mostly 6–8 meshes/cm². Mesh branches are narrow, mostly 1.0–1.5 mm wide.

Polyps (Fig. 1B): The polyps are all retracted and form mound-like, rounded protuberances in longitudinal rows along the branches. The mounds are approximately 1.0 mm long, usually oval in shape with slit-like apertures.

Sclerites (Figs. 1C–D, 2–4): The coenenchymal sclerites are girdled spindles, some with blunt to rounded ends and others with acute tips, mostly 0.08–0.14 mm in length. Eight radiates are also present, mostly 0.05–0.07 mm long (Figs. 1C–D, 2–4). The terminal branches have a predominance of spindles (Fig. 2A–E, G–J, M), whereas the holdfast region has mainly radiates (Fig. 3). Some of these are ornately sculptured (Fig. 3J–K, O), but others are more sparsely ornamented (Fig. 3A, E–F, M). The anthocodial sclerites are bisquit-shaped rods, 0.03–0.04 mm long (Fig. 2K, N–P), or elongated rods with more or less scalloped margins, up to 0.06 mm long (Fig. 2F, L). Sclerites are red, yellow, or bicolored (Figs. 1C–D). The various kinds of sclerites are shown at the same scale in Fig. 4.

Color (Fig. 1A–B): The coenenchyme is brick-red to rust-orange throughout, with brick-red to dull orange mounds formed by the retracted polyps. The sclerites are mostly deep-red or bright yellow, whereas some are bicolored red and yellow. Wet preserved specimens appear deep red, dried specimens pale orange.

ETYMOLOGY.— This species is named for William Dampier, English explorer, naturalist, and buccaneer, who visited the Galápagos Archipelago between 31 May and 12 June of 1684, and described various aspects of the flora and fauna, over a century and a half before Charles Darwin's visit of 1835 (Dampier, 1927:75–83).

DISTRIBUTION.— Apparently restricted to outlying Darwin and Wolf Islands, in the extreme northwestern fringe of the Galápagos Archipelago; 9–21 m in depth (Figs. 5, 22).

REMARKS.— All colonies examined, including the holotype, have numerous pinkish white ophiuroids attached to the them (Fig. 1A). These brittle stars measure approximately 10–15 mm in length and presumably represent a single species, which is unidentified at present.

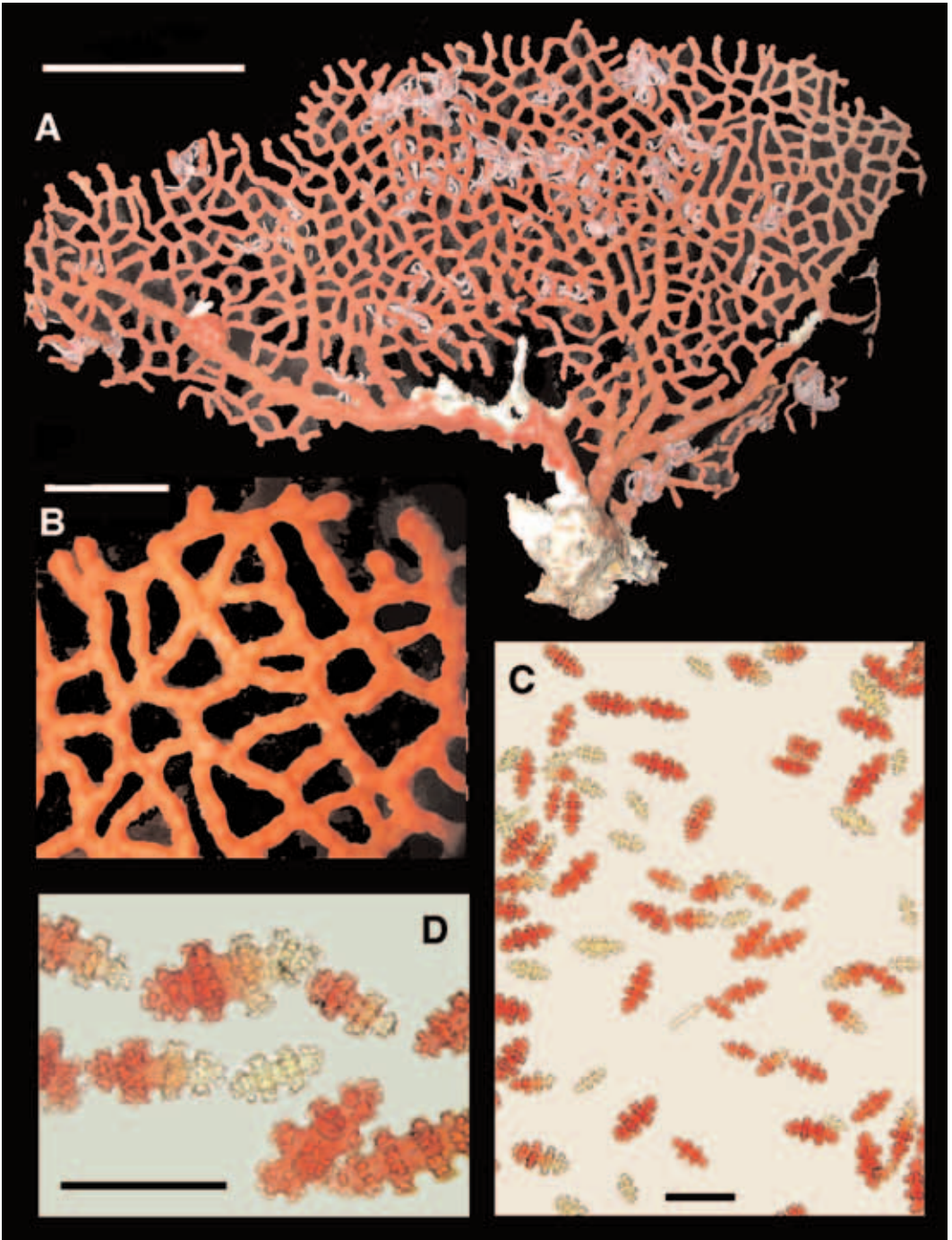


FIGURE 1. Holotype of *Pacifigorgia dampieri* sp. nov. A. Whole colony, wet-preserved; scale bar = 30mm. B. Detail of branching pattern; scale bar = 6 mm. C. Micrograph of coenenchymal sclerites; scale bar = 0.10 mm. D. Micrograph of coenenchymal sclerites including bicolored ones; scale bar = 0.08 mm.

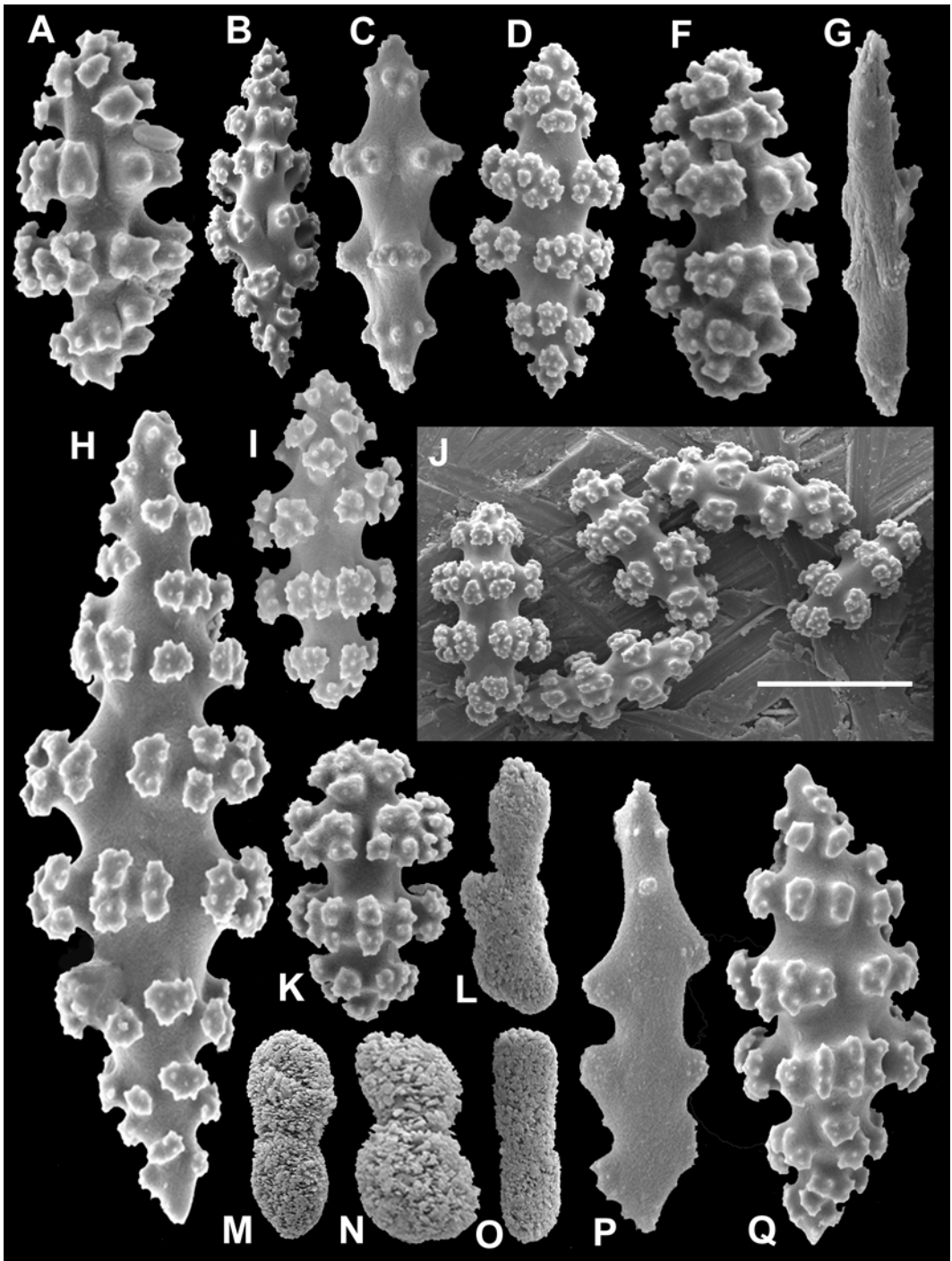


FIGURE 2. Holotype of *Pacifigorgia dampieri* sp. nov. Scanning electron micrographs of coenenchymal and anthocodial sclerites from the outermost branch tips. A. 0.06 mm. B. 0.11 mm. C. 0.08 mm. D. 0.09 mm. E. 0.05 mm. F. 0.06 mm. G. 0.14 mm. H. 0.06 mm. I. Scale bar = 0.06 mm. J. 0.05 mm. K. 0.03 mm. L. 0.06 mm. M. 0.10 mm. N. 0.04 mm. O. 0.03 mm. P. 0.04 mm. Anthocodial sclerites: K, N, O, P; all others are coenenchymal sclerites.

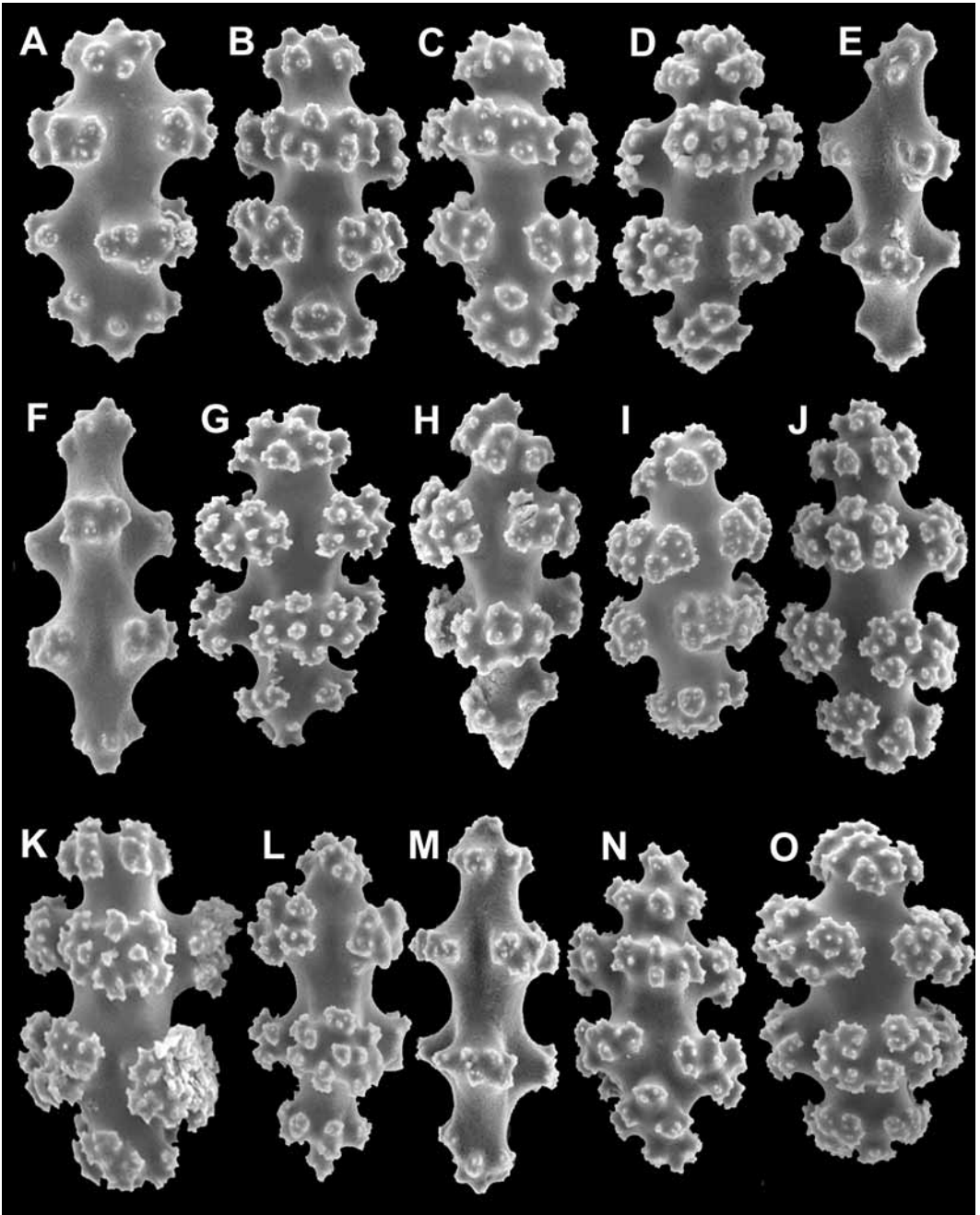


FIGURE 3. Holotype of *Pacifigorgia dampieri* sp. nov. Scanning electron micrographs of sclerites from the holdfast. A. 0.06 mm. B. 0.07 mm. C. 0.05 mm. D. 0.05 mm. E. 0.06 mm. F. 0.06 mm. G. 0.07 mm. H. 0.07 mm. I. 0.07 mm. J. 0.07 mm. K. 0.06 mm. L. 0.07 mm. M. 0.07 mm. N. 0.06 mm. O. 0.06 mm.

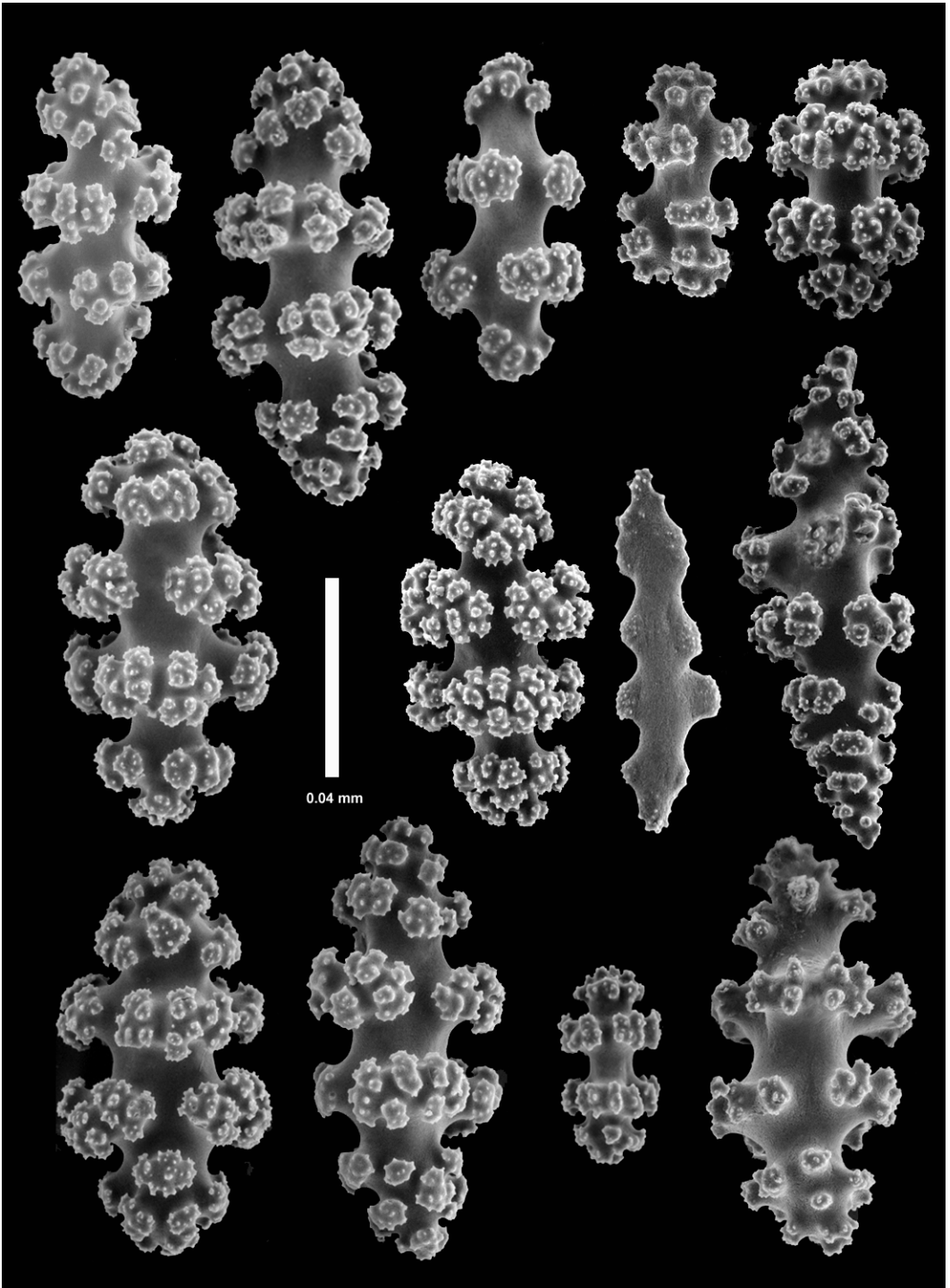


FIGURE 4. *Pacifigorgia dampieri* sp. nov. (CASIZ 097022). Scanning electron micrographs of sclerites shown at the same scale; scale bar = 0.40 mm.

Galápagos Islands, Isla Isabela, Punta Vicente Roca, <18 m depth (Station G10), 14 May 1994, collected by G.C. Williams with SCUBA aboard "Mistral II", twelve whole wet specimens, preserved in 75% ethanol. CAS 097117, Ecuador, Galápagos Islands, Isla Isabela, Punta Vicente Roca, 3–18 m depth (Station G9), 14 May 1994, collected by G.C. Williams with SCUBA aboard "Mistral II", one whole wet specimen, preserved in 75% ethanol. CAS 097901, Ecuador, Galápagos Islands, Isla San Cristobal, 21 m depth, June 1993, depth not recorded, collected by P. Humann with SCUBA, one whole dried colony. CAS 105031, Ecuador, Galápagos Islands, Isla Floreana, Devil's Crown, 6 m depth, date not recorded, collected by P. Humann with SCUBA, one portion of a colony originally fixed in 10% formalin and wet preserved in 75% ethanol. CAS 147486, Ecuador, Galápagos Islands, Isla Isabela, Punta Vicente Roca, 9 m depth, 19 June 2001, collected by C. Hickman with SCUBA, one portion of a colony wet preserved in 75% ethanol. CAS 147487, Ecuador, Galápagos Islands, Isla Fernandina, Punta Espinosa, 21 m depth, 21 June 2001, collected by C. Hickman with SCUBA, one portion of a colony wet preserved in 75% ethanol. CDRS 03–86 and 03–77, Ecuador, Galápagos Islands, Islas Los Hermanos, 9 m depth, 18 January 2003, collected by C. Hickman. CDRS 01–95, Ecuador, Galápagos Islands, Isla Pinzon, 9 m depth, 22 June 2001, collected by C. Hickman. CDRS 1994, Ecuador, Galápagos Islands, Isla Isabela, Punta Vicente Roca, 18 m depth, 3 May 1994, collected by C. Hickman. CDRS 1991, Ecuador, Galápagos Islands, Isla Fernandina, Punta Espinosa, depth not recorded, 24 June 1991, collected by C. Hickman.

GENERAL DESCRIPTION.— The lectotype was designated, examined, and described in detail by Breedy and Guzmán (2002: 808). Also included in their description was a specimen studied here (CAS 097035). We, therefore, provide only a brief descriptive account.

The colonies examined are up to 250 mm, dark purple, with yellow or white oval rings, and have open and evenly reticulated branching. Most colonies are composed of 2–3 parallel fans. The mesh branches are up to 1.5 mm in diameter. The network is composed of polygonal, oblong, or sometimes round meshes, up to 13 mm in length and 3 mm in width (approximately 7 meshes/cm²). The stem is short, not exceeding 5 mm in height, without distinct midribs. The free terminal branchlets are blunt and up to 10 mm in length. The oval mounds resulting from the retracted polyps are generally flat, and form yellow, cream, or white rings around the apertures of the polyps. These protuberances are mostly arranged in two longitudinal rows along most of the branches, and in multiple rows (4 or 5) on the thicker branches. The polyps are white with yellowish to pale pink sclerites arranged in points. The coenenchymal sclerites are mostly purplish red, whereas some are yellow and a few are bicolored. They are blunt spindles or capstans up to 0.09 mm long by 0.05 mm wide, and spindles with acute ends to 0.10 long and 0.04 mm wide. The anthocodial sclerites are flattened pale yellow rods up to 0.12 long and 0.02 mm wide, with scalloped or lobed margins.

The specimen figured (CAS 097035) is a flat, kidney-shaped fan with reticulations even and open throughout, 185 mm wide by 122 mm high (Fig. 5A). The network is composed of mostly rounded rectangular meshes (2–5 mm in diameter) to irregularly-shaped elongated ones (8–15 mm long by 1–4 mm wide) (Fig. 5B). The basal stem is very short, 5 mm in length. The retracted polyps form low rounded mounds in two opposite longitudinal rows along each face of the colony. The coenenchyme is dark reddish-purple, whereas the polyps mounds are mostly yellow (Fig. 5). Sclerites are mostly reddish purple (Fig. 5C), some are yellow, and a few are bicolored (red and yellow). Coenenchymal sclerites are mostly elongated spindles, some with tapering or distinctly pointed ends, 0.09–0.11 long (Figs. 5C, 6E–O), and mostly blunt eight radiates, 0.06–0.08 mm in length (Fig. 7). Some radiates lack ornate sculpture (Fig. 6A–D). Anthocodial sclerites are flattened rod-like sclerites with scalloped margins, up to 0.12 mm long (Fig. 6K).

DISTRIBUTION.— Southern islands of the Galápagos Archipelago (south of the Equator),

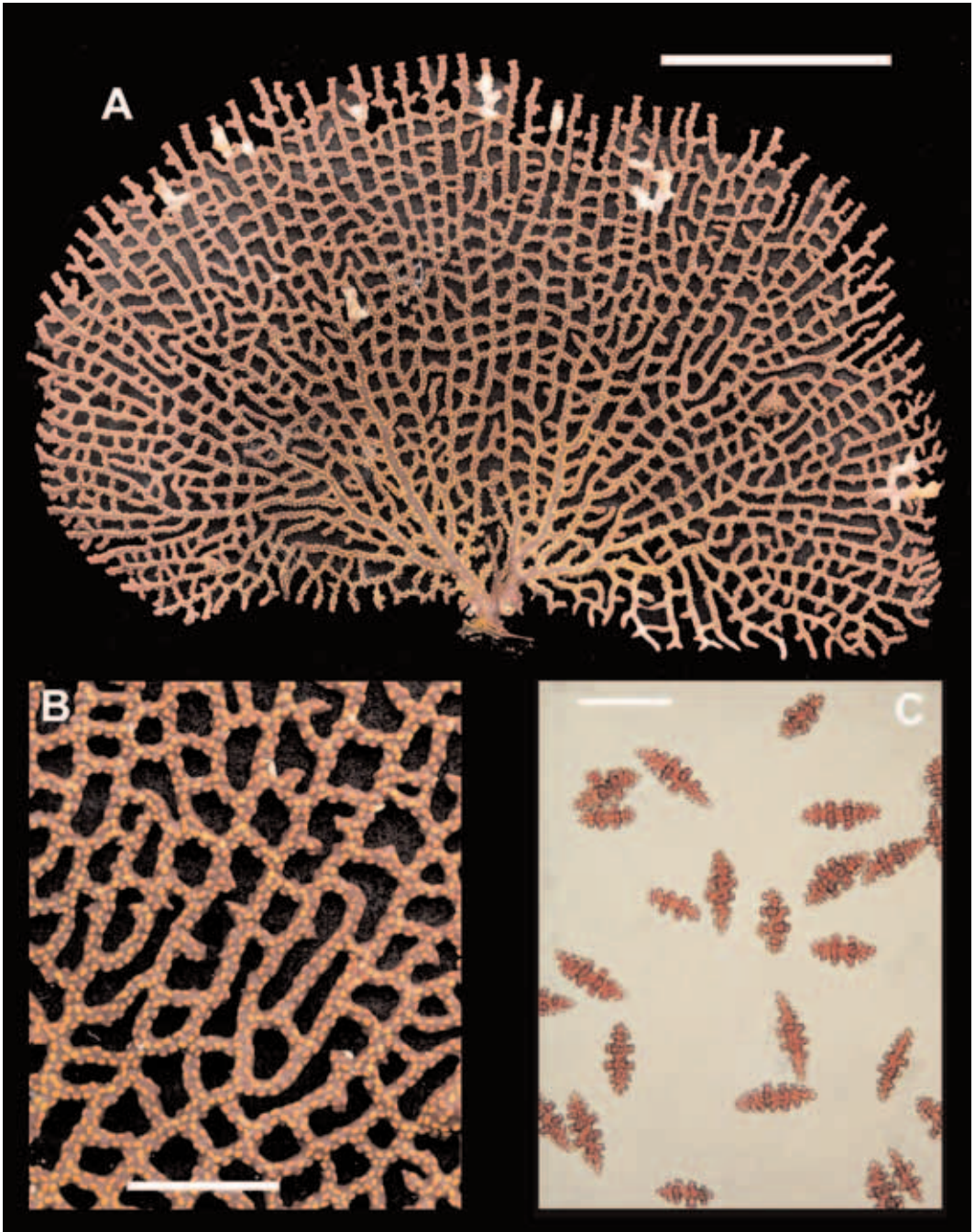


FIGURE 6. Non-type specimen of *Pacifigorgia darwinii* (CAS 097035) A. Whole colony, wet preserved; scale bar = 48 mm. B. Detail of branching pattern; scale bar = 13 mm. C. Micrograph of coenenchymal sclerites; scale bar = 0.15 mm.

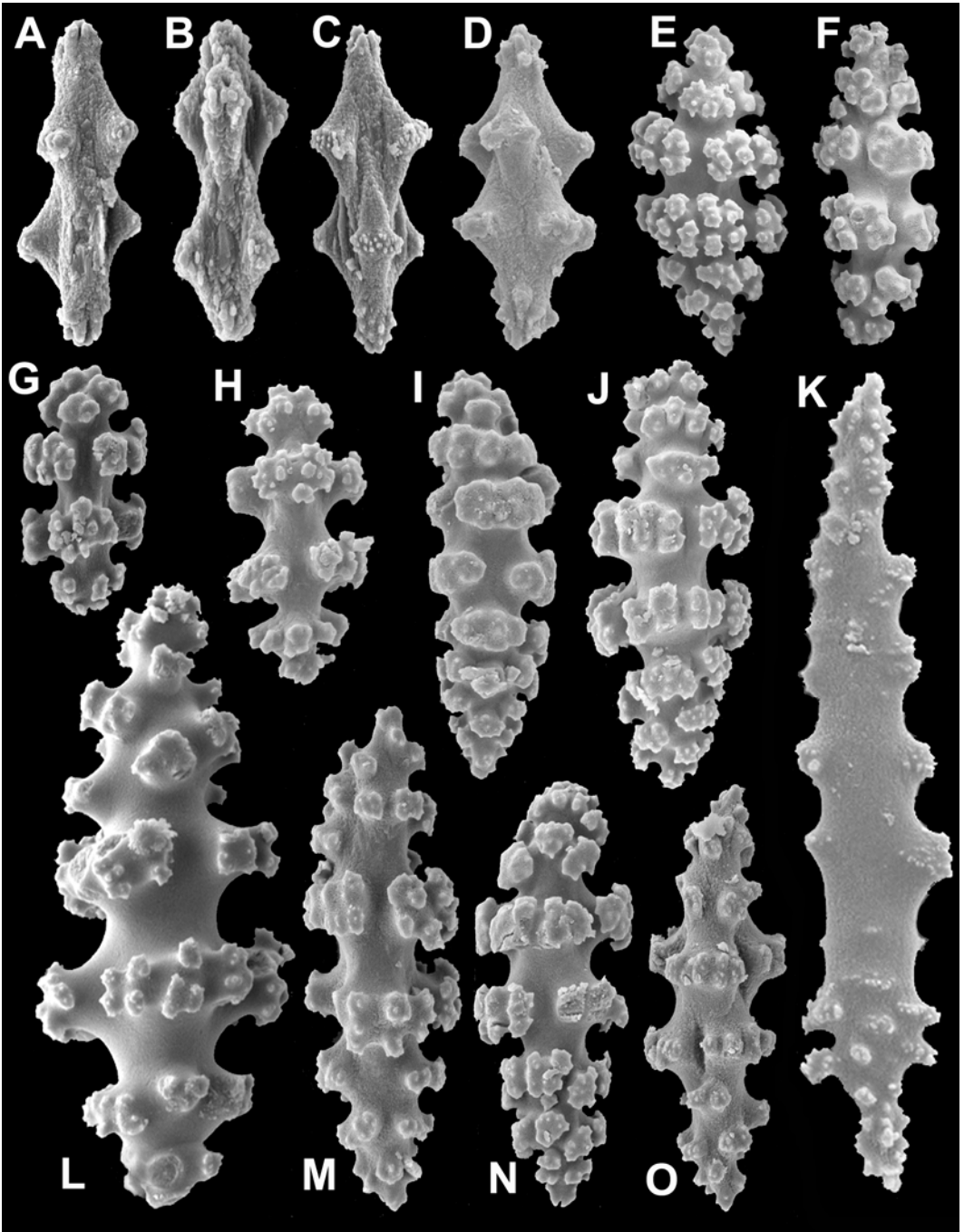


FIGURE 7. Non-type specimen of *Pacifigorgia darwinii* (CAS 097035). Scanning electron micrographs of sclerites from the tips of the ultimate branches. A. 0.06 mm. B. 0.04 mm. C. 0.06 mm. D. 0.07 mm. E. 0.09 mm. F. 0.09 mm. G. 0.05 mm. H. 0.06 mm. I. 0.10 mm. J. 0.10 mm. K. 0.12 mm. L. 0.10 mm. M. 0.10 mm. N. 0.10 mm. O. 0.11 mm.

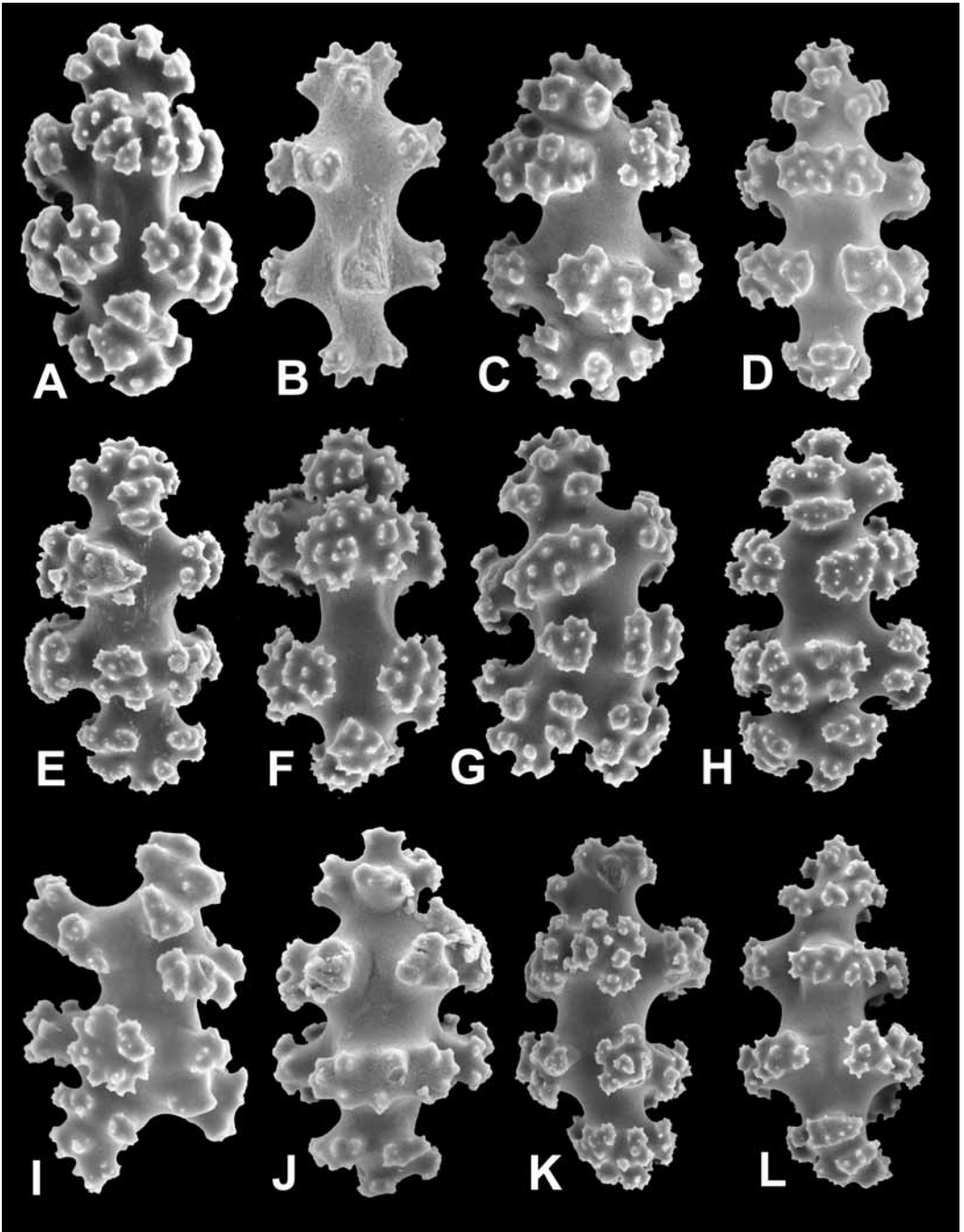


FIGURE 8. Non-type specimen of *Pacifigorgia darwinii* (CAS 097035). Scanning electron micrographs of sclerites from the holdfast. A. 0.06 mm. B. 0.06 mm. C. 0.06 mm. D. 0.08 mm. E. 0.07 mm. F. 0.06 mm. G. 0.07 mm. H. 0.07 mm. I. 0.06 mm. J. 0.06 mm. K. 0.07 mm. L. 0.07 mm.



FIGURE 9. *Pacifigorgia darwini*. Map of geographic distribution; % = collecting stations; \$ = location of Galápagos Islands.

including Isabela, Fernandina, Los Hermanos, Floreana, Gardner off Floreana or Gardner off Española (not specified), and San Cristobal; 3–26 m depth (Fig. 8). The presently known distribution forms a crescent-shaped arc from east to west in the southern part of the archipelago (Fig. 24).

REMARKS.— This species is the most common one of the genus around the islands. It is clearly distinct from the other taxa. We found some variation in the sclerites — there is a dominance of spindles with acute ends in some samples. This is the same situation with the other species found in Galápagos, which herein we describe. Also, the mound-like protuberances resulting from the retracted polyps varies from yellow to cream or white — San Cristobal (yellow, cream, or white); Isabela (cream or yellow); Fernandina (yellow); Floreana (white).

Pacifigorgia douglasii (Hickson, 1928)

(Figs. 10–11, 24)

Gorgonia darwini var. *douglasii* Hickson, 1928:392–393.

Pacifigorgia douglasii (Hickson, 1928). Breedy and Guzmán, 2002:813–815.

PREFATORY NOTE.— Breedy and Guzman (2002:813) considered Hickson's *Gorgonia darwini* var. *douglasii* as a member of the genus *Pacifigorgia*, and raised the variation to specific status as a new combination. They believed the differences between *Pacifigorgia darwini* and Hickson's taxon to be significant enough to justify raising the latter to species level. They designated the material cited below as lectotype. They also provided a description of the surviving material.

MATERIAL EXAMINED.— LECTOTYPE: BM 1961.2.6.161, 162, two microscope slides of sclerites only, Ecuador, Galápagos Islands, Isla Onslow, 8 m in depth, 1923–24, original material collected by Major Douglas.

DESCRIPTION.— See Breedy and Guzmán (2002:813–815) for a detailed description and evaluation. The sclerites are figured in the present paper (Fig. 10).

DISTRIBUTION.— Reported from one locality, Onslow Island (off the north shore of Floreana), Galápagos Archipelago, 8 m depth, attached to a fishing line (Fig. 11).

REMARKS.— We have not found a specimen of the colony that matches the lectotype sclerite preparation. These colonies appear to be missing and presumably all that remains of material representing this taxon are two microscope slides of sclerites.

We recently found in the NHM collection, a non-type specimen lot (BM 30.6.17.11) labeled as *Gorgonia darwinii* var. *douglasii*, containing three fragments of what we consider to be *Pacifigorgia darwinii*. One of the fragments represents the variety of *P. darwinii* with white rings, whereas the other two fragments are more representative of the typical form with yellow to cream

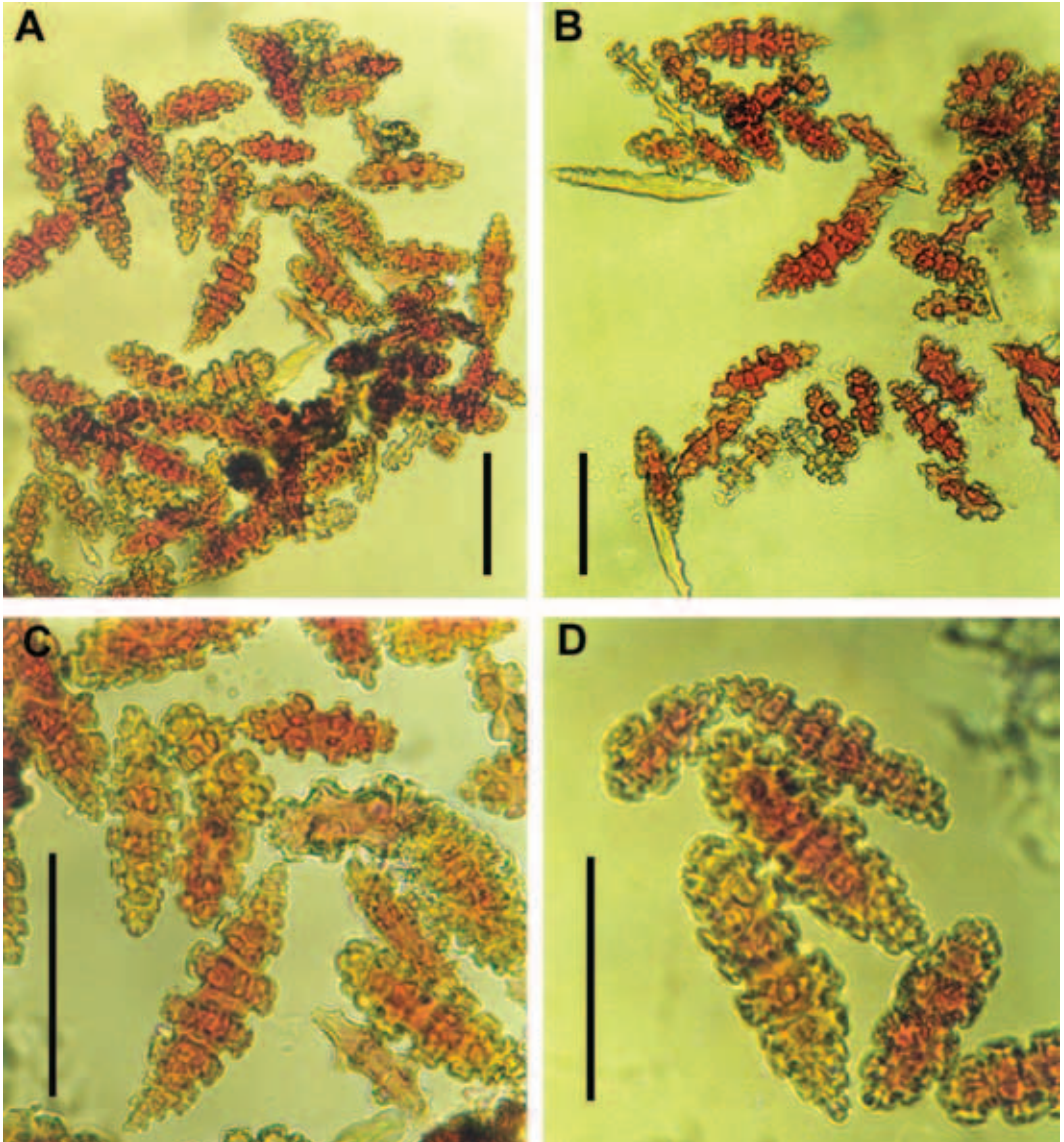


FIGURE 10. Type specimen of *Pacifigorgia douglasii*. A–D Micrographs of sclerites. Scale bars = 0.1 mm.

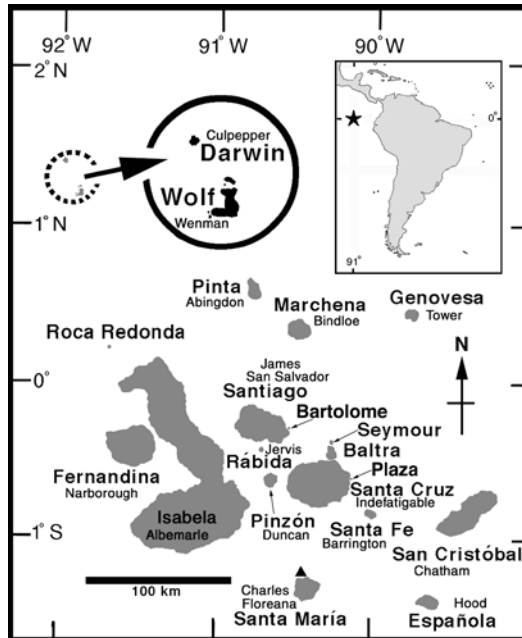


FIGURE 11. *Pacifigorgia douglasii*. Map of geographic distribution; % = collecting stations; \$ = location of Galápagos Islands.

polyps mounds. Even though the morphology of the three fragments agrees in many respects to Hickson's description of *Gorgonia darwinii* var. *douglasii*, the sclerites are more consistent with those of *P. darwinii*. They differ in form and size from the sclerites on the lectotype slides (see the assessment of Breedy and Guzmán 2002). After examining many specimens, we conclude that the fragments can all be aligned with *P. darwinii*. There is not sufficient reason to separate the white-ringed variety from the typical form. It should therefore be viewed within the range of variability for the species.

Because of the depauperate nature of the type material, and the lack of any other specimen that matches Hickson's description, it is not possible to validate the taxonomic status of *Pacifigorgia douglasii*, and we must therefore consider this to be a dubious taxon. In addition, northern Floreana Island is also a collecting station for typical specimens of *Pacifigorgia darwinii* (Figs. 9, 24).

Pacifigorgia rubripunctata Williams and Breedy, sp. nov.

(Figs. 12–16, 24)

MATERIAL EXAMINED.—HOLOTYPE: CAS 167958, Ecuador, Galápagos Islands, Isla Santa Cruz, Academy Bay, 3–6 m depth, 1964 (day and month not recorded), collected by Andre and Jacqueline De Roy. One whole wet specimen preserved in 75% ethanol. PARATYPE: CAS 147485, Ecuador, Galápagos Islands, Isla Rabida, 6 m depth, (Station 01–37), 17 June 2001, collected by Cleave Hickman. One whole specimen preserved in 75% ethanol.

OTHER MATERIAL: CAS 167959, same data as holotype, two dried fragments of colonies. CAS 053266, same data as holotype, one whole dried colony. CAS 101762, Ecuador, Galápagos Islands, Isla Española, Punta Suárez, 7.6 m depth, 4 March 1977, collected by John McCosker and party. Two whole wet specimens, originally preserved in formalin, later transferred to 75% ethanol. CAS 096904, Ecuador, Galápagos Islands, Isla Santiago, Sullivan Bay near Isla Bartolomé, depth not

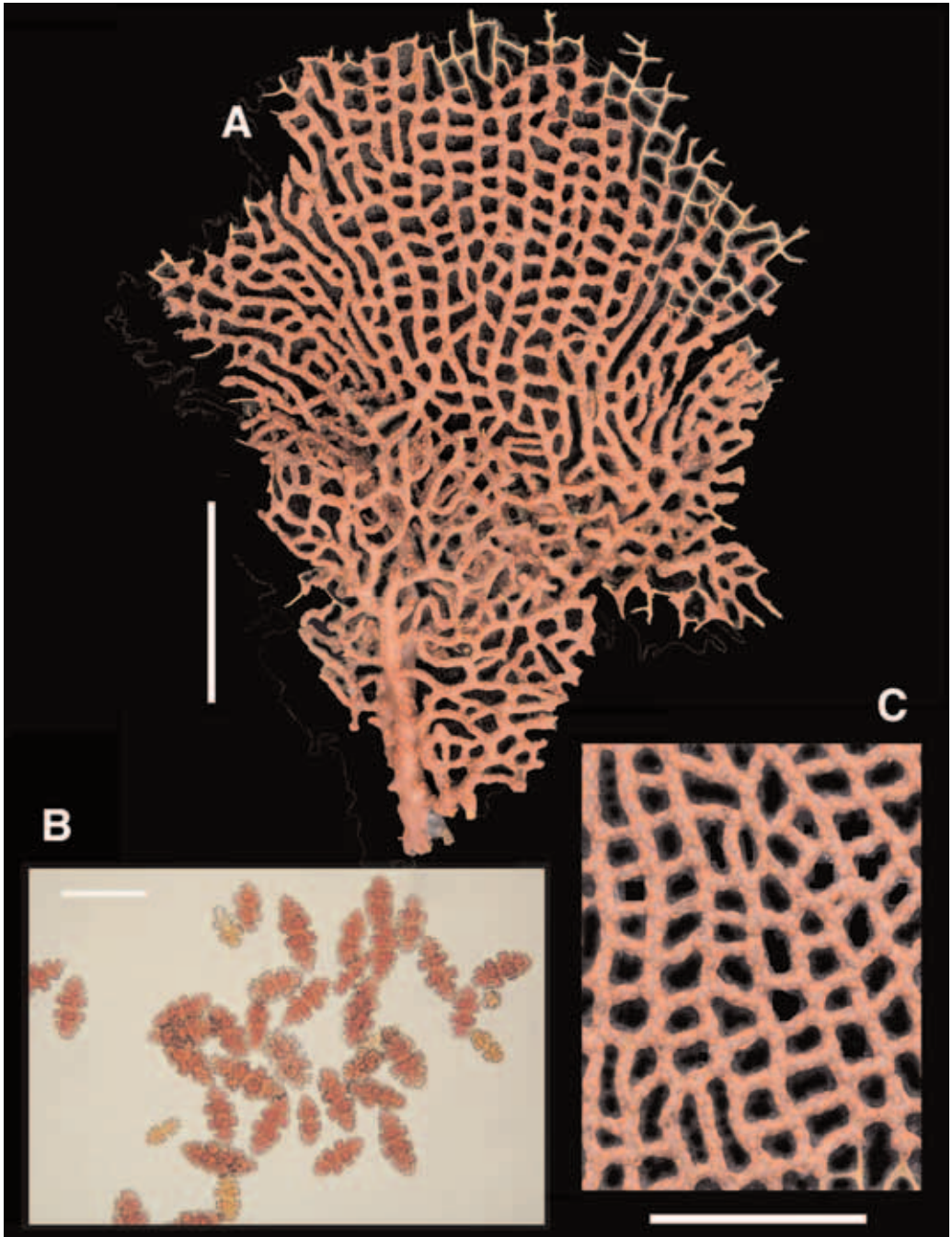


FIGURE 12. Holotype of *Pacifigorgia rubripunctata* sp. nov. A. Whole colony, wet-preserved; scale bar = 30 mm. B. Micrograph of coenenchymal sclerites; scale bar = 0.10 mm. C. Detail of branching pattern; scale bar = 20 mm.

recorded, 21 January 1938, collector not identified, one fragment of a colony wet preserved in 75% ethanol. CAS 147484, Ecuador, Galápagos Islands, Isla Rabida, 6 m depth, (Station 01–32), 17 June 2001, collected by Cleave Hickman. CAS 105033, Ecuador, Galápagos Islands, Nameless Islet off west coast of Isla Santa Cruz, 20 m depth, date not recorded, collected by Paul Humann, one whole specimen wet preserved in 75% ethanol. MCZ 36260 and MCZ 36262, Ecuador, Galápagos Islands, Isla Santa Cruz, Punta Astrada, 8–10 m depth, 1977, collected by S. Taylor.

GENERAL DESCRIPTION.— Colonies wider than high, up to 120 mm in height, and 150 mm in width, composed of a single primary fan and 2–3 smaller secondary fans. Secondary fans stick out from different parts of the main fan, and radiate in right angles, hence, they grow perpendicularly to the main fan. Colonies seem to have encrusting holdfasts. Color when dry is a light violet with red spots, which are sparsely or closely disposed, and bright reddish-orange polyp mounds. Wet preserved specimens are yellowish to white, spotted with red and purple, and polyp mounds reddish-orange, rarely yellowish.

Networks are regular and comprised of angular meshes. The meshes are up to 15 mm in length and 3 mm in width (density averages approximately 6 meshes/cm²). Mesh branches up to 1.5 mm in diameter. No distinct midribs crossing the fans are observed, only thick short branches (up to 10 mm width) at the base. These extend for a short distance to one side of the fan, parallel to the substratum. Short stems raise the colony a little from the substratum. Terminal branchlets are short, up to 2 mm in length. Free twigs are very scarce. Polyp mounds are slightly raised, arranged in pairs in longitudinal rows, on the external part of the branches, and separated by branches of dark purple coenenchyme in the middle of the lines of polyps. Polyps are white with flattened anthocodial sclerites arranged in weak points.

Coenenchymal sclerites (Fig. 15) are mostly spindles with blunt ends, and radiates (capstans) with elongated ends, but a dominance of spindles with acute ends is also observed (e.g. CAS 105033). The sclerites are red, orange, and colorless with different predominance of colors, but some are bicolored. Spindles are long (up to 0.15 mm in length, and 0.04 mm in width) and with 4–8 whorls of tubercles, with both ends acute or blunt, or with one acute and the other blunt. Radiates (capstans) are wide (up to 0.09 mm in length, and 0.05 mm in width) with two whorls of tubercles and warty ends. A few crosses with acute or round ends (up to 0.09 long by 0.06 mm wide) are also present. Anthocodial sclerites are pale yellow rods (up to 0.10 mm in length, and 0.02 mm in width) with smooth or lobed margins (Fig. 15 shows all sclerites at the same scale).

DESCRIPTION OF HOLOTYPE.— Growth form and size (Fig. 12A, C). The holotype measures 120 mm in height by 94 mm in width. It is comprised of two similarly sized parallel fans that are joined by a common basal main stem. Only one of these fans can be seen in Fig. 12A. The main stem is flattened and measures 2 mm by 7 mm in transverse section. The holdfast portion is missing since the specimen was cut just above the holdfast to separate it from the substratum. The surviving portion of the main stem is approximately 40 mm in length and gives rise to an intricate and uniform network without conspicuous secondary branches. The networks are regular and comprised of meshes of variable shape. The meshes in the upper portion of one of the fans are mostly more or less square and arranged in longitudinal rows. Meshes of the upper portion of the other parallel fan vary from narrow and elongated to square or rectangular, and are not disposed in distinct rows. Meshes vary in size from 2 mm minimum width to 15 mm maximum length. The mesh branches are mostly 1.0–1.5 mm in width. The density of meshes varies from approximately 5–9 meshes/cm². The free tips of terminal branches are up to 5 mm in length.

Polyps (Fig. 12C): The polyp mounds formed by the retracted polyps are only slightly raised, often irregularly-shaped (deltoid to trapezoidal) as well as circular, with slit-like apertures. The mounds are distributed in four longitudinal rows (two rows on each face of a particular fan) along

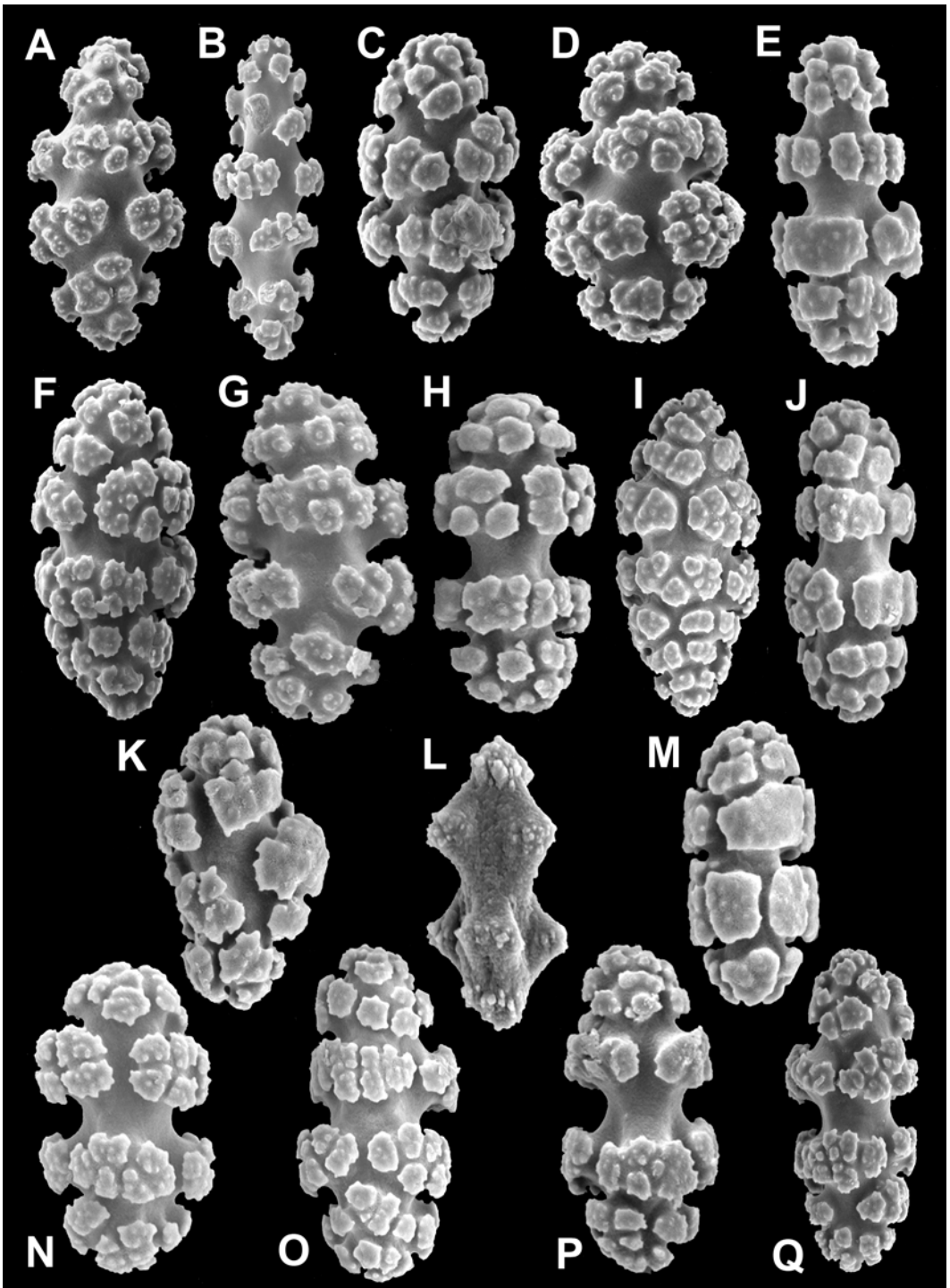


FIGURE 13. Holotype of *Pacifigorgia rubripunctata* sp. nov. Scanning electron micrographs of sclerites from the outermost branch tips. A. 0.08 mm. B. 0.09 mm. C. 0.06 mm. D. 0.06 mm. E. 0.06 mm. F. 0.08 mm. G. 0.06 mm. H. 0.05 mm. I. 0.09 mm. J. 0.07 mm. K. 0.05 mm. L. 0.04 mm. M. 0.04 mm. N. 0.06 mm. O. 0.07 mm. P. 0.06 mm. Q. 0.08 mm.

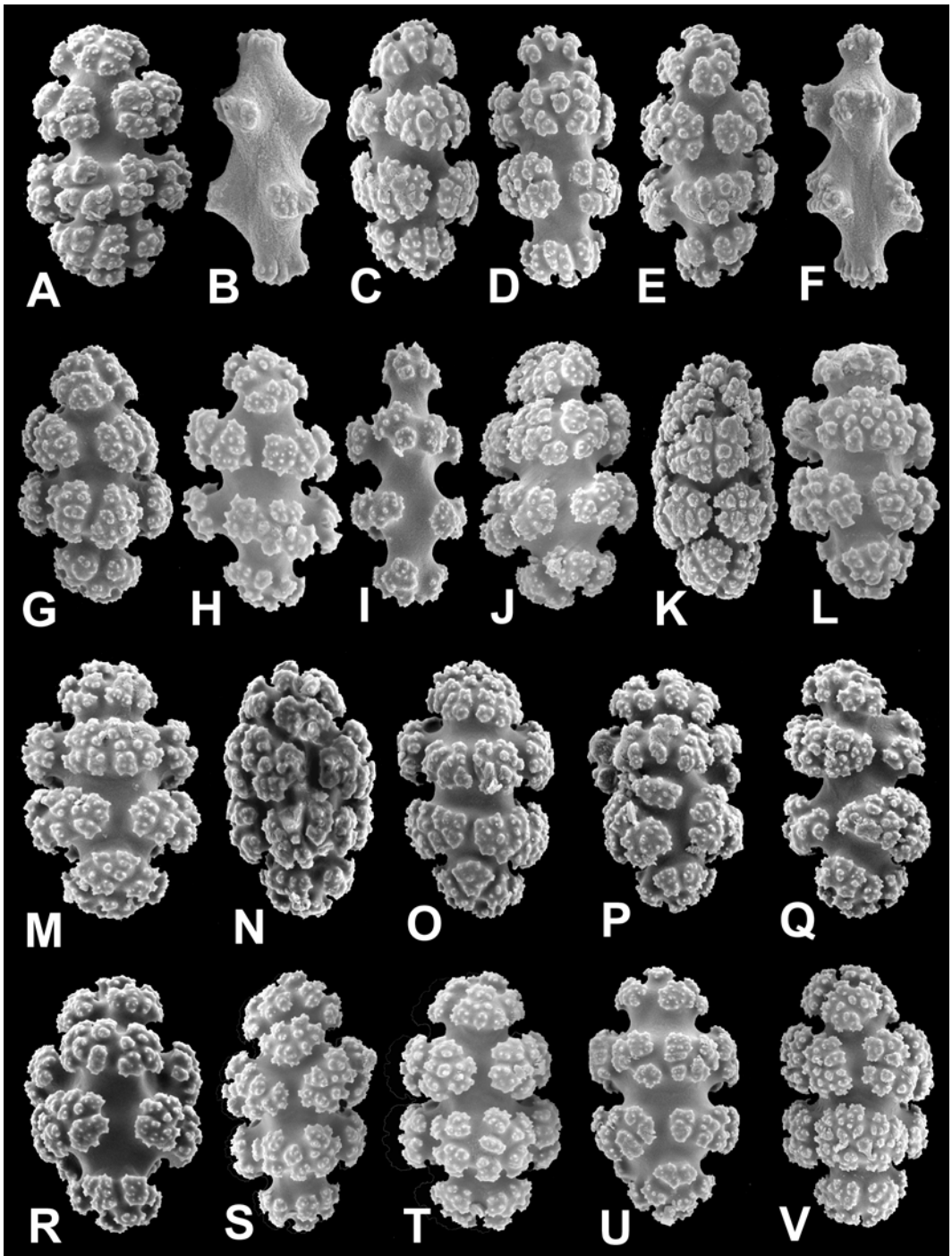


FIGURE 14. Holotype of *Pacifigorgia rubripunctata* sp. nov. Scanning electron micrographs of sclerites from the holotype. A. 0.08 mm. B. 0.06 mm. C. 0.08 mm. D. 0.09 mm. E. 0.08 mm. F. 0.07 mm. G. 0.07 mm. H. 0.06 mm. I. 0.07 mm. J. 0.08 mm. K. 0.09 mm. L. 0.06 mm. M. 0.06 mm. N. 0.07 mm. O. 0.08 mm. P. 0.07 mm. Q. 0.08 mm. R. 0.07 mm. S. 0.08 mm. T. 0.07 mm. U. 0.08 mm. V. 0.09 mm.

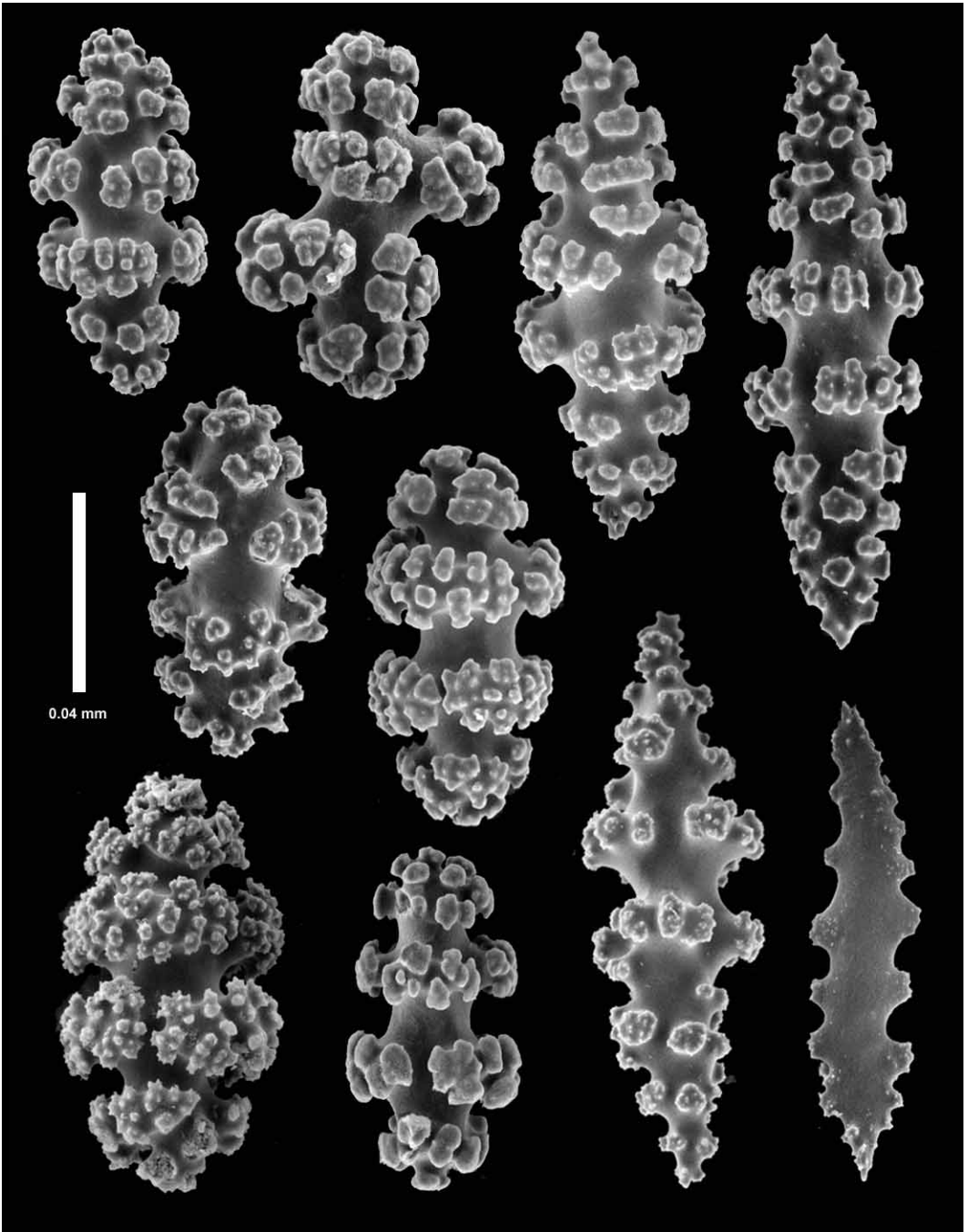


FIGURE 15. *Pacifigorgia rubripunctata* sp. nov. (CASIZ 147484). Scanning electron micrographs of sclerites shown at the same scale; scale bar = 0.04 mm.

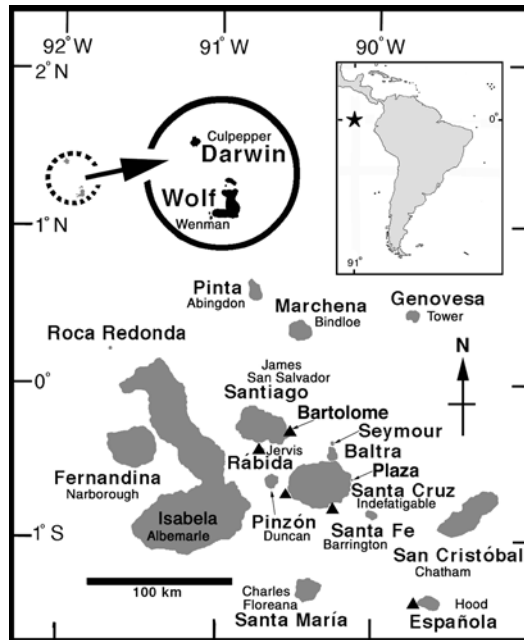


FIGURE 16. *Pacifigorgia rubripunctata* sp. nov. Map of geographic distribution; % = collecting stations; \$ = location of Galápagos Islands.

the mesh branches. Polyps have weak points sparsely disposed anthocodial sclerites that are elongated and flattened.

Sclerites (Figs. 12B, 13–15): Sclerites are red-purple, orange, or bicolored (orange at one end and colorless at the opposite end) (Fig. 12B). Coenenchymal sclerites are robust spindles or more elongated spindles with acute ends (0.08–0.11 mm long by 0.03–0.05 mm wide), and eight radiates (capstans) (0.04–0.08 mm long by 0.03–0.04 mm wide) (Figs. 13–14). A few cross-like sclerites are also present (approximately 0.08 mm long by 0.05 mm wide). Anthocodial sclerites are flattened rods with undulating margins (mostly ≤ 0.10 mm long).

Color (Fig. 12A, C): The coenenchyme throughout is a deep purplish red. The polyp mounds are orange, and contrast sharply with the surrounding coenenchyme. The polyps are white.

ETYMOLOGY.— The specific epithet of this new species is derived from the Latin *rubra* (red) and *punctatus* (spotted); in reference to the fine red-orange spots along the branches of most specimens, which are created by the retracted polyps.

DISTRIBUTION (Figs. 16, 24).— The range of this species is apparently restricted to a line extending from northwest to southeast, running through the center of the Galápagos Archipelago (Fig. 24); known from Islas Santiago, Bartolomé, Rábida, Santa Cruz, and Española (Fig. 16).

VARIATION.— A considerable amount of color variability is evident in this species. The coenenchyme varies from deep red or dark reddish purple to greyish-white, or yellow. The polyp mounds can vary from red to orange in most material, or pale yellow in one specimen (CAS 167959). The colors between the coenenchyme and the polyp mounds contrast sharply in all specimens.

***Pacifigorgia symbiotica* Williams and Breedy, sp. nov.**

(Figs. 17–24)

MATERIAL EXAMINED.— HOLOTYPE: CAS 097118, Ecuador, Galápagos Islands, Isla Darwin, Arch, 12–18 m depth, (Station G6), 13 May 1994, collected by Gary C. Williams with SCUBA, aboard “Mistral II”. One whole wet specimen preserved in 75% ethanol. PARATYPE: CAS 097115, same data as holotype. One whole wet specimen preserved in 75% ethanol.

OTHER MATERIAL: CAS 097041, same data as holotype. One whole wet specimen preserved in 75% ethanol. CAS 097948, Ecuador, Galápagos Islands, Isla Wolf, depth not recorded, 15 December 1898, collector not recorded, two dried fragments of colonies. CAS 097902, Ecuador, Galápagos Islands, Isla Wolf, 14 m depth, June 1993, collected by Paul Humann, one dried fragment of a colony.

GENERAL DESCRIPTION.— Fans are stiff, planar or with smaller secondary fans. The main fans are wider than high (71–285 mm in width by 65–122 mm in height). Colonies have holdfasts that are strong and spreading (12–60 mm in maximum dimension). The main stem and primary branches are somewhat flattened and relatively wide (4–10 mm wide). This characteristic, along with the somewhat thickened mesh branches, gives the colonies a relatively rigid aspect.

The networks are intricate with open meshes. The meshes are highly variable in shape and size. They are often rectangular or deltoid, but very narrow and elongated ones as well as small circular ones are also evident. Meshes vary from 2–5 mm in width by 2–12 mm in length. Colonies usually have 6–8 meshes/cm². Mesh branches are relatively thick (1.5–2.5 mm in width). The thickened mesh branches make the meshes appear relatively small. The free terminal branchlets at the distal margin of the colonies are 2–8 mm in length, thick and blunt or truncated at the tips. The mound-like protuberances produced by the retracted polyps are relatively robust, hemispherical or mammiform, 1–2 mm in diameter, with ovoid or slit-like apertures. They cover most of the surface area of the mesh branches.

The coenenchymal sclerites are of two kinds. In the holdfast and main stem region, there is a predominance of relatively elongated eight radiates (0.06–0.08 mm long) with a relatively wide separation between the whorls of tubercles. In the mesh branches and the distal extremities of the colonies, the sclerites are girdled spindles, many of which have strongly attenuated ends (0.08–0.12 mm long); as well as compact, ovoid eight radiates (0.03–0.08 mm long). Some of the smaller radiates lack ornate tuberculation. The anthocodial sclerites are flattened, elongated rods with more or less scalloped or undulating margins (0.05–0.13 mm long). These are arranged in eight weakly disposed points. A crown is not apparent.

The color of the sclerites is mostly either dark red or bright yellow. However, some sclerites are bicolored — yellow and red. The superficial coenenchyme is deep reddish purple, whereas the polyp mounds are golden yellow to lemon yellow or orange-yellow. The polyps are white, with eight weak points of mostly yellow rod-like sclerites.

DESCRIPTION OF HOLOTYPE.— Growth form and size (Fig. 17A, C; 18). The holotype measures 98 mm high by 138 mm wide, composed of a single planar fan. An incipient secondary fan arises from near the distal terminus of the colony, and is parallel to it (22 mm high by 44 mm wide). The origin of this secondary fan is approximately 8 mm below the distal terminus of the main fan. The holdfast is spreading (23 mm wide by 28 mm long). The main stem is very short and flattened (approximately 6 mm long by 7 mm wide by 3 mm thick). This main stem gives rise to four primary branches, 12–18 mm long. An intricate network of mesh branches emanates from the distal regions of the primary branches. Networks are comprised of relatively small meshes with thickened mesh branches; approximately 6–8 meshes/cm². Meshes are highly variable and irregularly

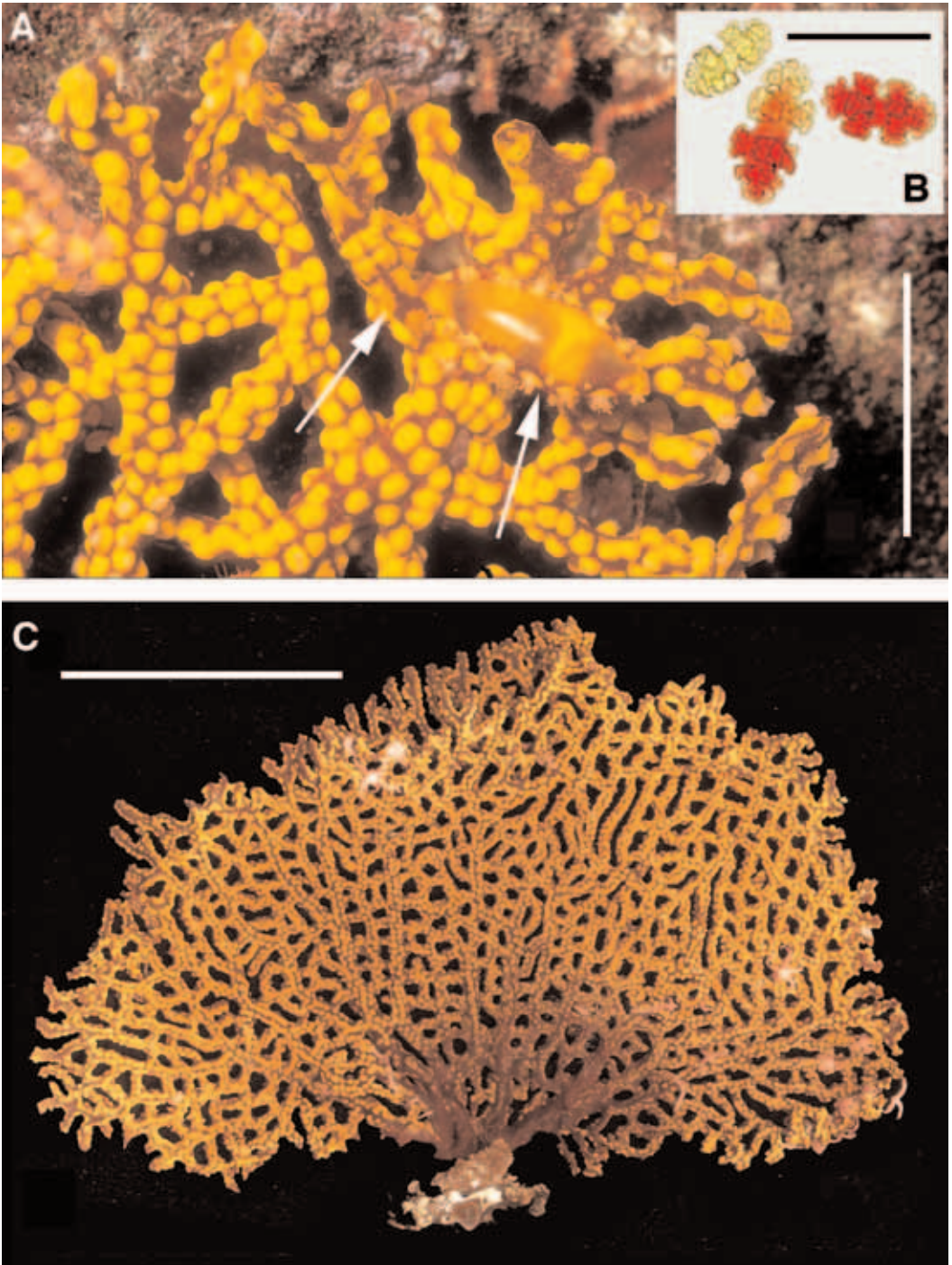


FIGURE 17. *Pacifigorgia symbiotica* sp. nov. A. Living coral with two epizoid mimics, a palaemonid shrimp (left arrow), and an ovulid gastropod (right arrow); scale bar = 10 mm. B. Three coenenchymal sclerites from the holotype showing variation in color; scale bar = 0.8 mm. C. Wet-preserved holotype; scale bar = 45 mm.

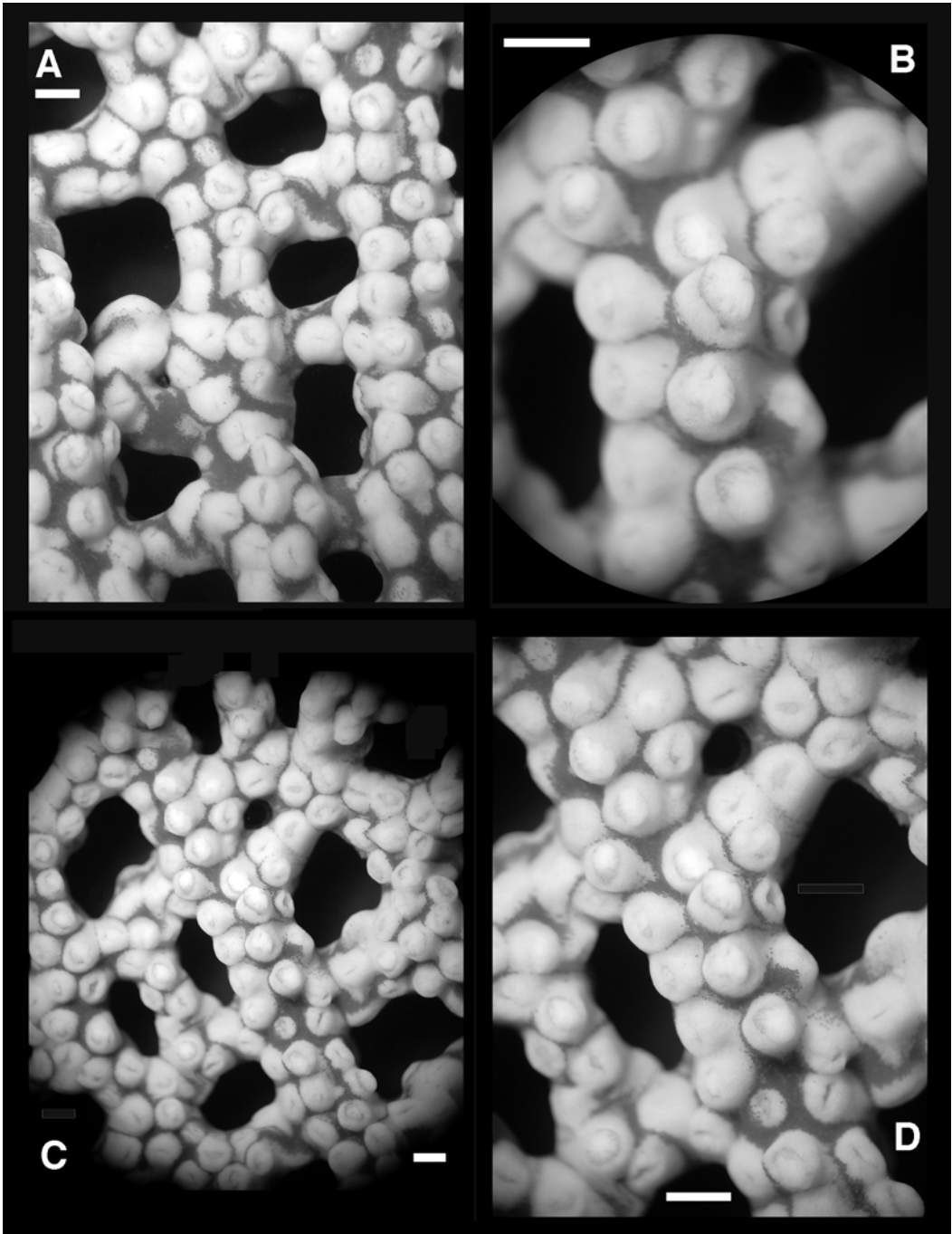


FIGURE 18. *Pacifigorgia symbiotica* sp. nov. A-D. Micrographs of colony external morphology from the preserved holotype - branching, reticulation, and retracted polyps. Scale bars = 1 mm.

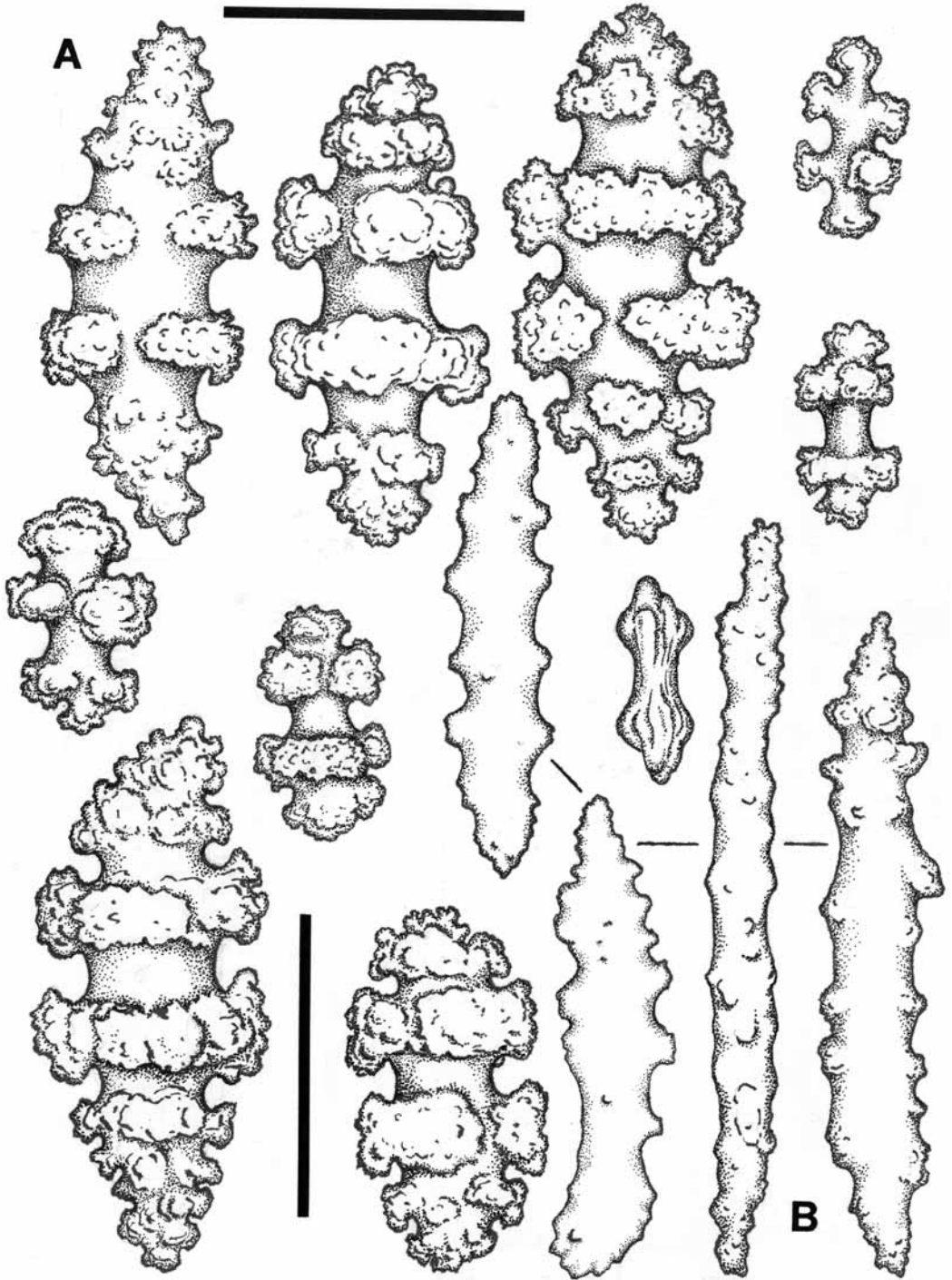


FIGURE 19. *Pacifigorgia symbiotica* sp. nov. A. Coenenchymal sclerites. B. Polyp sclerites. Scale bars = 0.05 mm.

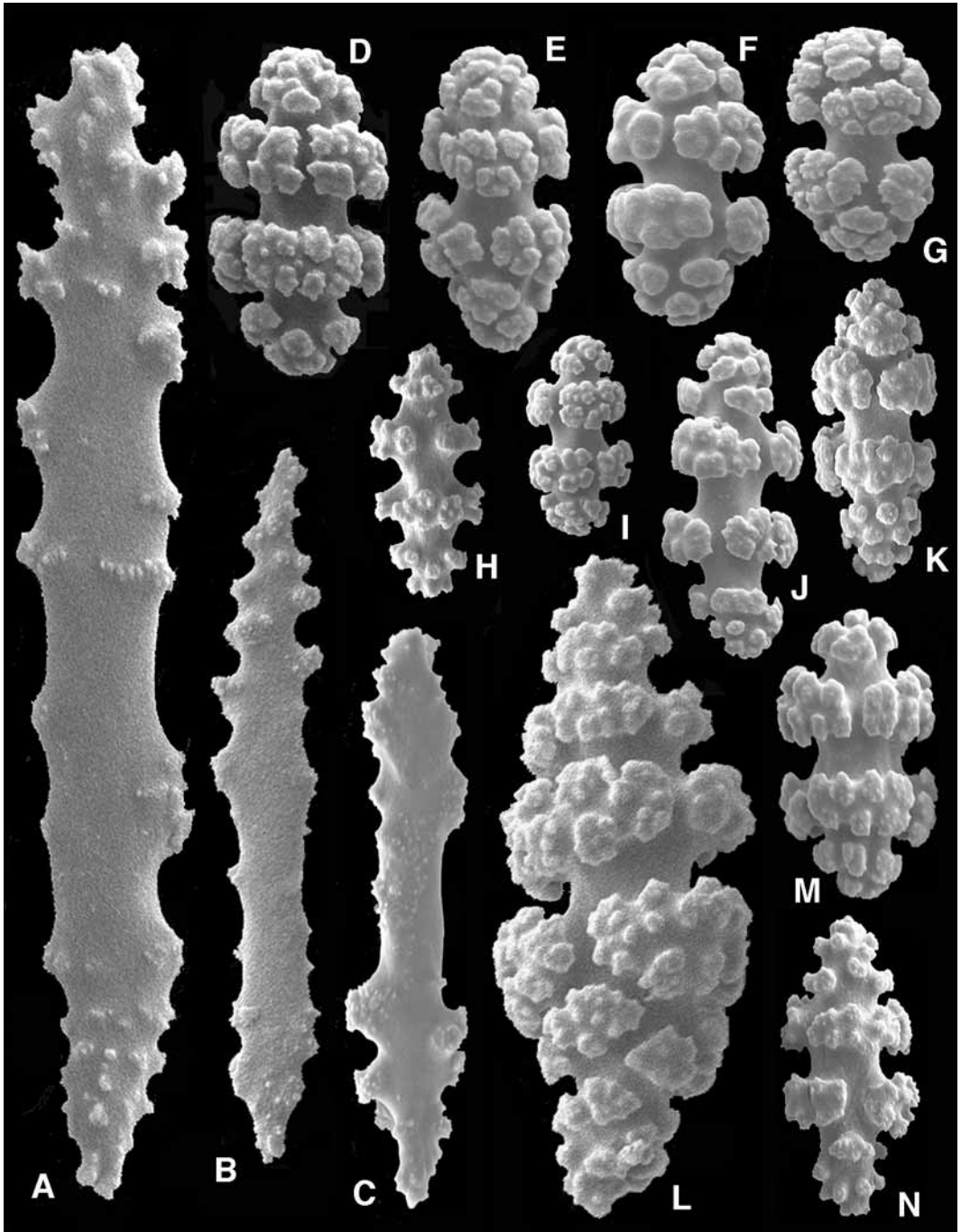


FIGURE 20. *Pacifigorgia symbiotica* sp. nov. Scanning electron micrographs of sclerites. A-C. Polyp sclerites. A. 0.14 mm. B. 0.12 mm. C. 0.10 mm. D-N. Coenenchymal sclerites. D. 0.06 mm. E. 0.06 mm. F. 0.06 mm. G. 0.05 mm. H. 0.06 mm. I. 0.06 mm. J. 0.09 mm. K. 0.08 mm. L. 0.10 mm. M. 0.07 mm. N. 0.08 mm.

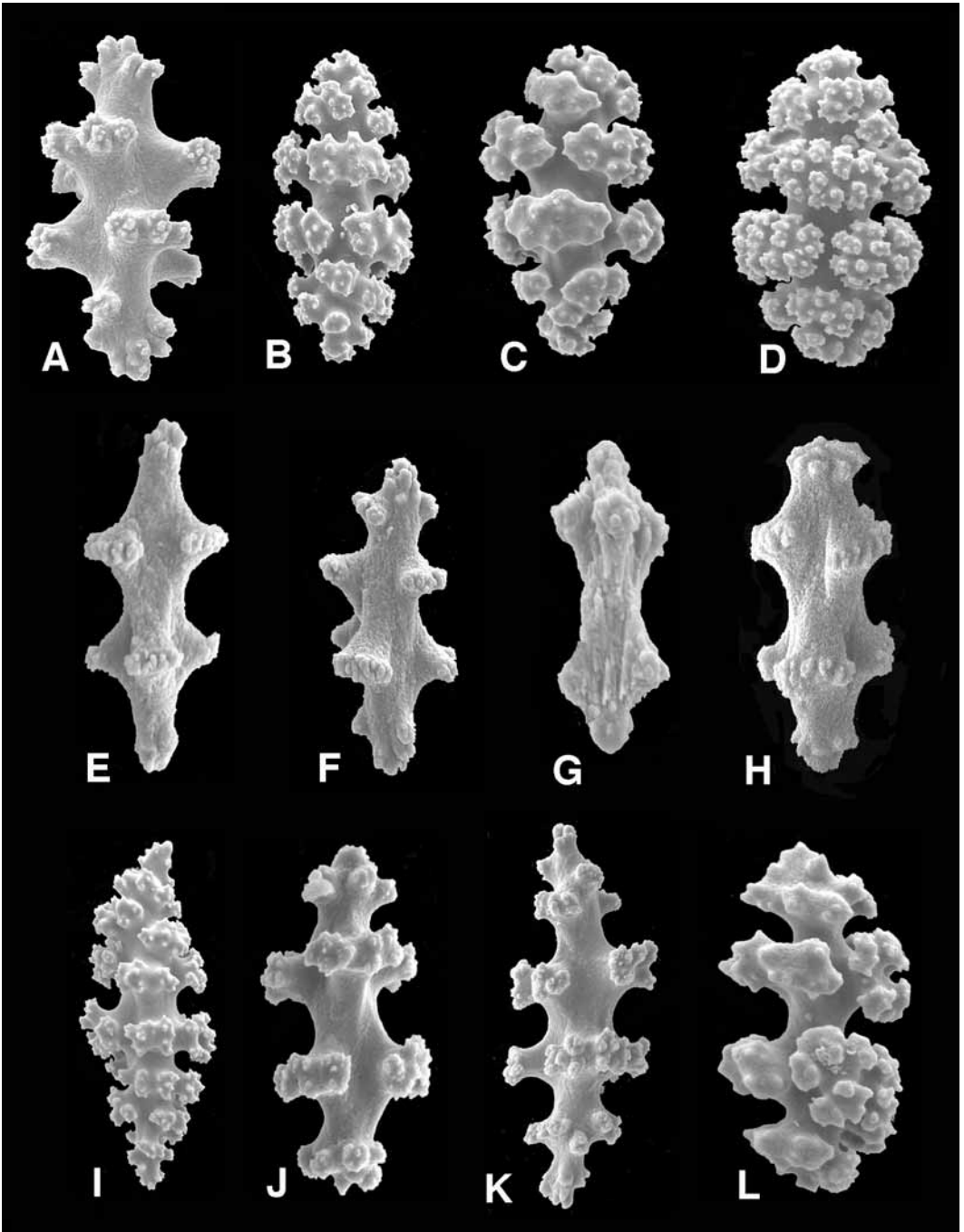


FIGURE 21. *Pacifigorgia symbiotica* sp. nov. Scanning electron micrographs of coenenchymal sclerites from the branch tips. A. 0.07 mm. B. 0.08 mm. C. 0.07 mm. D. 0.07 mm. E. 0.06 mm. F. 0.06 mm. G. 0.03 mm. H. 0.05 mm. I. 0.12 mm. J. 0.06 mm. K. 0.11 mm. L. 0.06 mm.

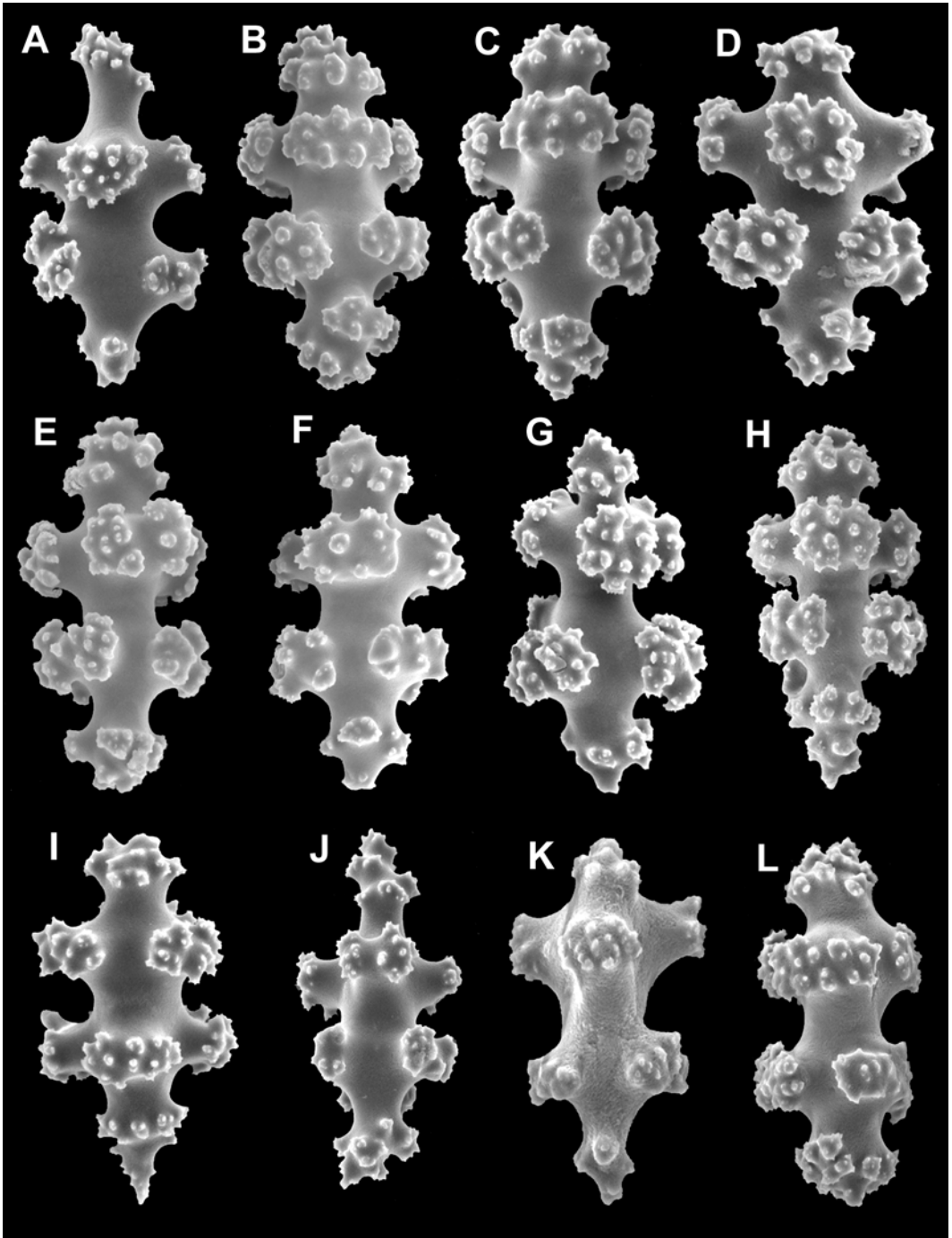


FIGURE 22. *Pacifigorgia symbiotica* sp. nov. Scanning electron micrographs of coenenchymal sclerites from the holdfast. A. 0.06 mm. B. 0.08 mm. C. 0.07 mm. D. 0.06 mm. E. 0.07 mm. F. 0.07 mm. G. 0.06 mm. H. 0.07 mm. I. 0.07 mm. J. 0.08 mm. K. 0.06 mm. L. 0.07 mm.

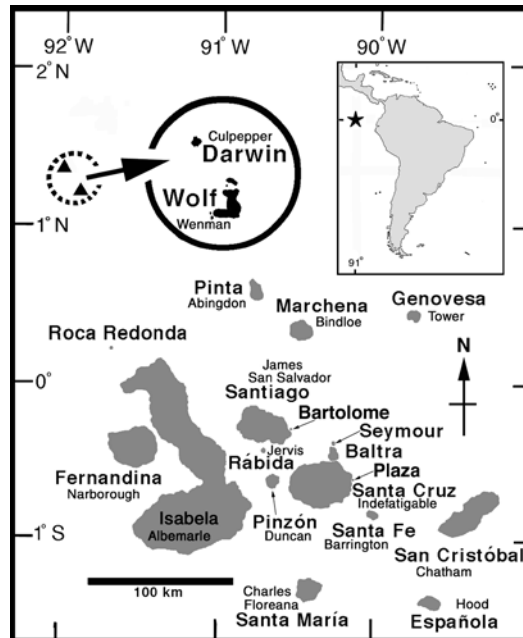


FIGURE 23. *Pacifigorgia symbiotica* sp. nov. Map of geographic distribution; % = collecting stations; \$ = location of Galápagos Islands.

shaped: ovoid to rectangular (2–4 mm wide by 2–5 mm long), deltoid (1–2 mm wide by 3–4 mm long), or distinctly elongate (1–2 mm wide by 7–17 mm long). Mesh branches are relatively thick, mostly approximately 2 mm in diameter. Free terminal branches are thick and blunt with truncated tips, 3–8 mm long.

Polyps (Fig. 17A, 18). Polyp mounds are distinctive, mostly robust, hemispherical and mamiform, 0.8–1.0 mm in diameter, with ovoid or slit-like apertures. These are arranged in two longitudinal series along the mesh branches of each face of the fan. The polyps have eight weak points and no observable crown.

Sclerites (Figs. 17B, 19–22). The sclerites from the coenenchyme of the mesh branches and branch tips are girdled spindles, mostly wide in the middle with tapering and pointed ends (0.08–0.12 mm in length and 0.04–0.05 mm in width), as well as compact eight radiates (capstans) (0.05–0.08 mm long by 0.02–0.04 mm wide). Most of these are ornately tubercated (Fig. 20D–G). However, some are small (approximately 0.3 mm long) and are very sparsely ornamented (Fig. 21G). The sclerites of the holdfast region are radiates that are less compact, 0.06–0.08 mm in length (Fig. 22). Anthocodial sclerites are flattened rods with scalloped or undulating margins (0.08–0.11 mm long) (Figs. 19B, 20A–C).

Color (Fig. 17). The coenenchyme is a dark red-purple. Polyp mounds are bright yellow. The main stem and four primary branches do not contain polyps and are therefore deep reddish purple in color. Coenenchymal sclerites are red, yellow, or bicolored (red and yellow). Although anthocodial sclerites are mostly golden yellow, some are pale red.

ETYMOLOGY.— The specific epithet of this new species is derived from the Greek, *symbios* (living together); in reference to the remarkable mimicry and interactions of crustacean (caridean shrimp) and molluscan (ovulid snail) epizoites (Fig. 17A, arrows) that live on the surface of this new species of gorgonian coral.

DISTRIBUTION.— Apparently restricted to outlying Darwin and Wolf Islands, in the extreme northwestern fringe of the Galápagos Archipelago; 12–18 m in depth (Figs. 23–24).

DISCUSSION

The shallow-water (<50 m depth) gorgonian fauna of the Galápagos Islands is comprised of taxa in five genera of the two families Plexauridae (36% of the species) and Gorgoniidae (64% of the species). Of the eleven species that are considered valid, four of these (or 36%) belong to the genus *Pacifigorgia*. Marked morphological variability within each of the four species of *Pacifigorgia* is evident. Little is known of the geographic ranges of the various species, since only a limited number of collecting stations on a few islands have been sampled to date (Fig. 24).

TABLE 1. Species of *Pacifigorgia* considered valid.
(Type species: *Gorgonia stenobrochis* Valenciennes, 1846)

<u>Species</u>	<u>Distribution</u>
<i>P. adamsii</i> (Verrill, 1868)	Mexico to Panama
<i>P. agassizii</i> (Verrill, 1864)	Mexico to Panama
<i>P. arenata</i> (Valenciennes, 1846)	Mexico
<i>P. bayeri</i> Breedy, 2001	Costa Rica
<i>P. cribrum</i> (Valenciennes, 1846)	Mexico
<i>P. dampieri</i> sp. nov.	Galápagos Islands
<i>P. darwinii</i> (Hickson, 1928)	Galápagos Islands
<i>P. elegans</i> (Milne Edwards and Haime, 1857)	Trinidad to Brazil
<i>P. engelmanni</i> (Horn, 1860)	Mexico
<i>P. exilis</i> (Verrill, 1870)	Mexico to Panama
<i>P. eximia</i> (Verrill, 1868)	Costa Rica to Panama
<i>P. gracilis</i> (Kükenthal, 1924)	Mexico to Panama
<i>P. irene</i> Bayer, 1951	Costa Rica to Panama
<i>P. media</i> (Verrill, 1864)	Mexico to Nicaragua
<i>P. pulchra</i> (Verrill, 1870)	Mexico
<i>P. rubinoffi</i> Breedy and Guzman, 2003	Panama
<i>P. rubripunctata</i> sp. nov.	Galápagos Islands
<i>P. rutila</i> (Verrill, 1868)	Mexico
<i>P. stenobrochis</i> (Valenciennes, 1846)	Mexico to Peru
<i>P. symbiotica</i> sp. nov.	Galápagos Islands
<i>P. tabogae</i> (Hickson, 1928)	Panama

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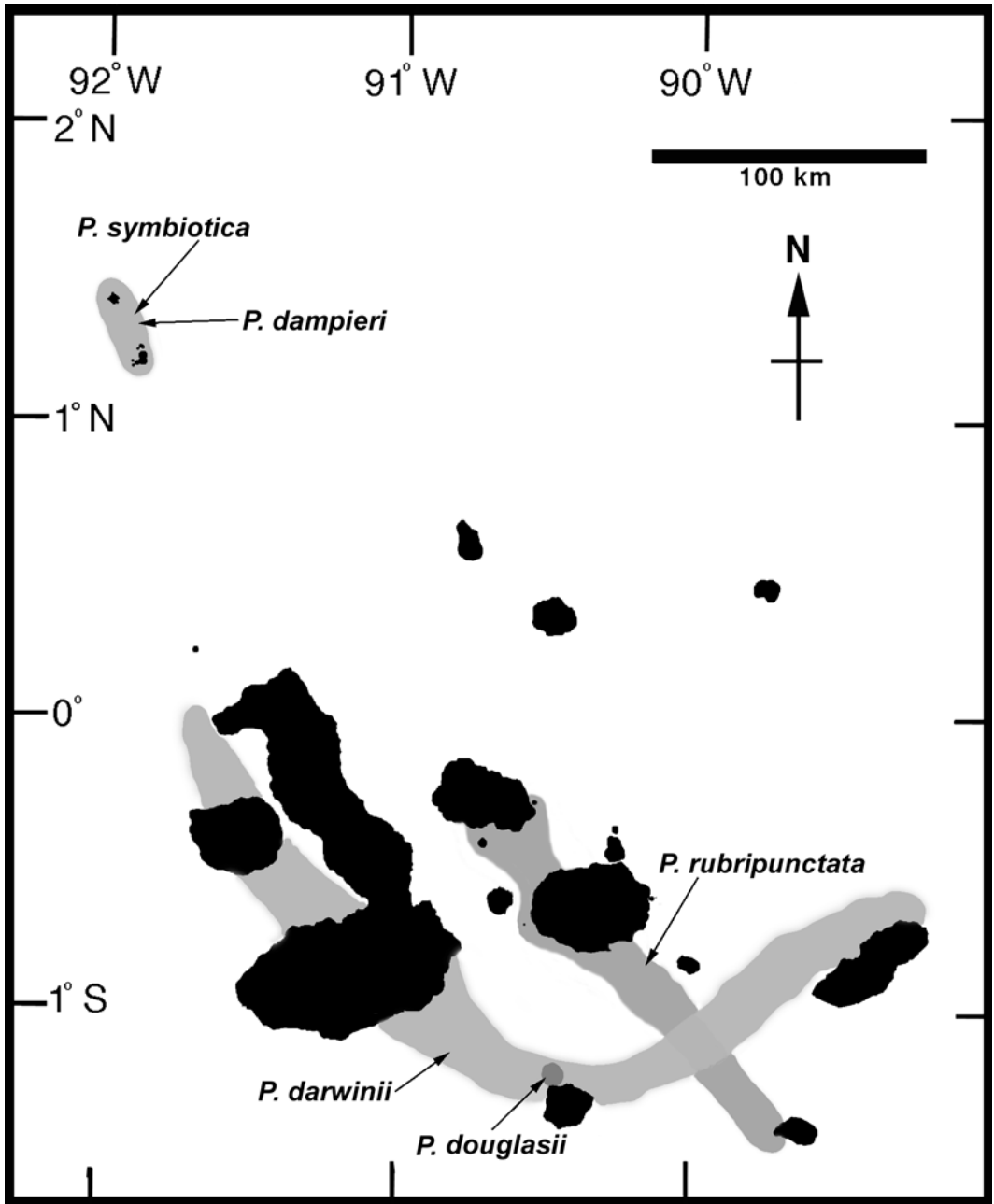


FIGURE 24. Range comparisons for the five species of the genus *Pacifigorgia* inhabiting the Galápagos Islands: *P. dampieri* sp. nov., *P. darwinii* (Hickson, 1928), *P. douglasii* (Hickson, 1928), *P. rubripunctata* sp. nov., and *P. symbiotica* sp. nov.

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