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A new species of alcyonacean octocoral from the Galápagos Archipelago

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The genus *Heterogorgia* is reported for the first time from the shallow waters of the Galápagos Archipelago, and a new species found in the southern islands is described. The new species is distinguished from the other species of the genus described thus far by having thick branches with large, densely packed calyces, being mostly unbranched, and having larger sclerites. The occurrence of *Heterogorgia verrucosa* is also reported.

INTRODUCTION

Recent expeditions in the Galápagos Archipelago have yielded several new octocoral species and provided a basis for taxonomic knowledge of this group in the region. The shallow-water (<50 m) gorgonian fauna of the Galápagos Archipelago comprises about 11 species in five genera in the two families Plexauridae and Gorgoniidae: *Adelogorgia* (one species, Bayer, 1978), *Eugorgia* (one species, Williams & Breedy, 2004), *Leptogorgia* (one species, Williams & Breedy, 2004), *Muricea* (one species, Deichmann, 1941; about three other species, Williams & Breedy, 2004), and *Pacifigorgia* (four valid species, and one considered doubtful, Williams & Breedy, 2004; Breedy & Guzman, 2002).

We have had the opportunity to investigate the octocoral collection of the Charles Darwin Research Station, Galápagos for the last two years, which has been sent to us by Dr Cleveland Hickman, and is the subject of this paper. Here we report the occurrence of the genus *Heterogorgia* Verrill, 1868 for the first time, and describe a new species, making a total of six genera presently known to inhabit the shallow coastal waters of the region with six valid species, plus five more species that need future evaluation.

MATERIALS AND METHODS

Specimens were collected by C.P. Hickman from two islands in the Galápagos Archipelago: Pinzón Island and Floreana Island. This material was collected using SCUBA diving in shallow water (<50 m depth) and preserved in 70% ethanol. Fragments of colonies were treated with sodium hypochlorite (household bleach) for sclerite dissociation. Sclerites were prepared following the standard methodology for light and scanning electron microscopy (see Bayer, 1961; Breedy & Guzman, 2002 for details). Scanning electron micrographs were made using a N-2360 Hitachi scanning electron microscope. The sclerites were measured from the pictures and directly from a light microscope using an optical micrometer; the size-ranges given in the text correspond to the smallest and the largest sclerites measured for each morphological group. Diameter of the colonies was measured at the widest branch including calyces. Number of calyces per cm was taken from the central branches of the colonies. The holotype and a paratype are deposited in the Museo de Zoología, Universidad de Costa Rica, and two paratypes in the Charles Darwin Research Station, Galápagos Islands, Ecuador. We compared the new species with type material of *Heterogorgia verrucosa* Verrill, 1869; *Heterogorgia tortuosa* Verrill, 1869; *Heterogorgia papillosa* Verrill, 1870; *Heterogorgia uatumani* Castro, 1990; *Heterogorgia magna* Nutting, 1910; and *Heterogorgia clausa* Nutting, 1910. Terminology used in the taxonomic description conforms to that of Bayer et al. (1983).

MUSEUM ABBREVIATIONS

Charles Darwin Research Station, Galápagos Islands, Ecuador (CDRS)

Museum of Comparative Zoology, University of Harvard (MCZ)

National Museum of Natural History; Smithsonian Institution (NMNH, former USNM)

Natural History Museum, London (BM)

Yale Peabody Museum of Natural History, Yale University (YPM)

SYSTEMATICS

Class ANTHOZOA
Subclass OCTOCORALLIA
Order ALCYONACEA
Family PLEXAURIDAE Gray, 1859
Genus *Heterogorgia* Verrill, 1868

Heteorogorgia Verrill, 1868: 413–414.

Heterogorgia (emended) Verrill, 1869: 450; Wright & Studer, 1889: 55; Nutting, 1910: 87; Kükenthal, 1919: 844; Kükenthal, 1924: 229–230; Bayer, 1956: F206; Harden, 1979: 112; Bayer, 1981: 931; Castro, 1990: 412.

Type species

Heterogorgia verrucosa Verrill, 1868, by subsequent designation (Nutting, 1910: 87).

Description

Axis is horny with a wide, chambered central chord. Colonies are unbranched, or branched dichotomously or irregularly. Coenenchyme thin to moderately thick, with a granulose or smooth surface. Coenenchymal sclerites are five- to eight-radiates, strongly and irregularly tuberculated spindles, with straight or crooked ends, or branched. Polyps are retractile within a protruding calyx, neck zone of the anthocodiae with or without few sclerites. When alive, polyps project spectacularly from the branches; they are from a bright yellow colour to translucent. Anthocodiae armed with collaret and points, consisting of a transverse row of long, bent spindles, and long, spiny rods arranged *en chevron* below the tentacles. Calyces are prominent, with a lobed rim and with strong spine-like rods which project from the calicular lobes forming a bristling barricade (Bayer, 1981) around the polyp aperture. These sclerites have a warty base and a projecting spine that may have thorn-like warts scattered on the surface.

Remarks

The genus *Heterogorgia* was established by Verrill (1868) for two species from Las Perlas Archipelago (Pacific coast, Panamá), *H. verrucosa*, and *H. tortuosa*.

The original spelling of the genus was '*Heteorogorgia*', but Verrill changed it to '*Heterogorgia*' in the following year.

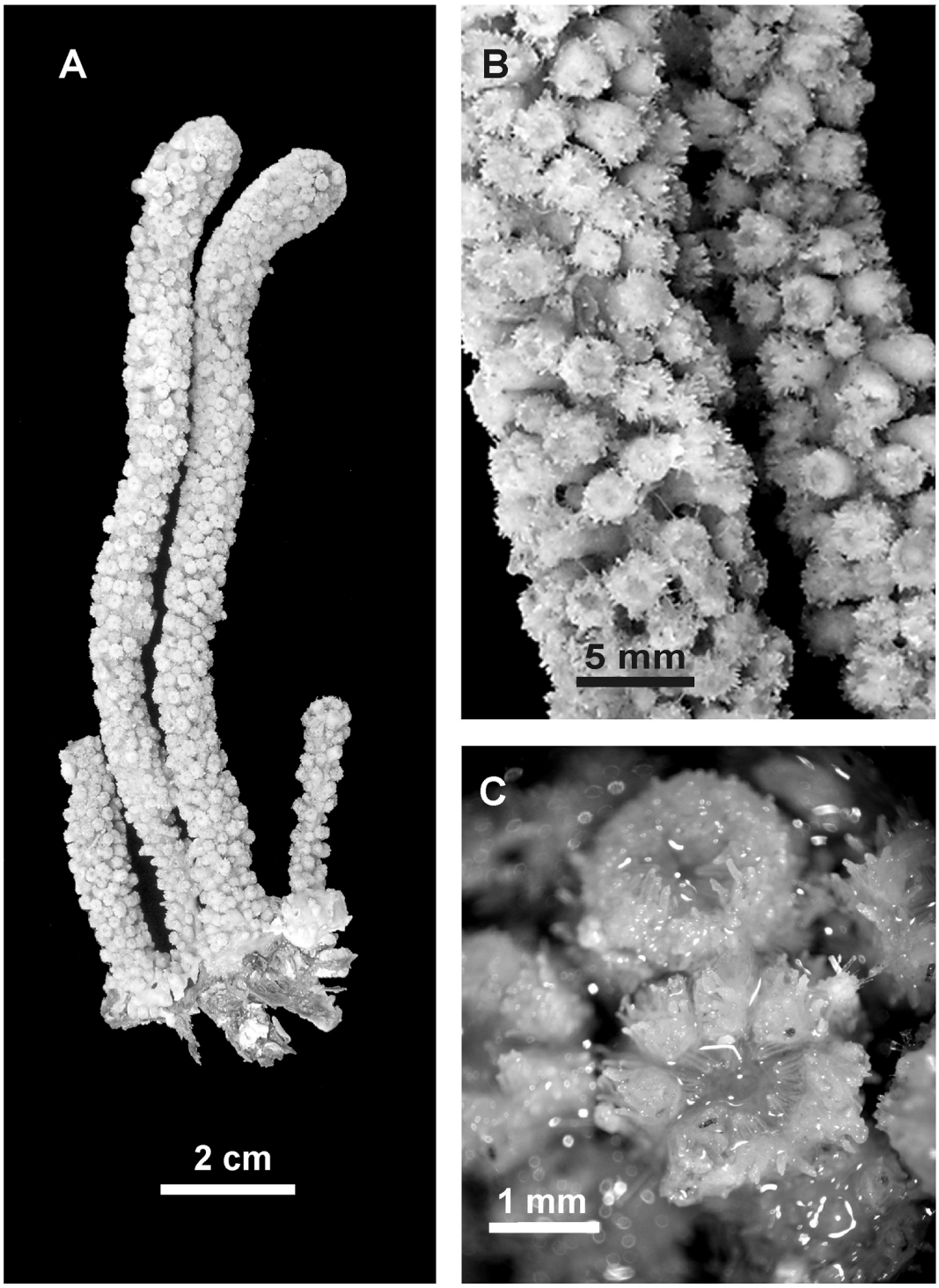

Figure 1. *Heterogorgia hickmani* sp. nov. (A) Holotype; (B) detail of the stem; (C) detail of the calyces.

According to Article 32.2 of the Code, '*Heteorogorgia*' has to be considered as the 'correct original spelling'; therefore, Verrill's subsequent spelling '*Heterogorgia*' is considered, according to Article 33.2.3 of the Code, an unjustified emendation. The unjustified emendation, however, is in prevailing usage, and Article 33.2.3.1 of the Code allows its retention.

Later, Verrill (1870) included in this genus, one more species from La Paz (Pacific coast, Mexico), *H. papillosa*. Other species were transferred to this genus by Nutting (1910). However, Verrill (1912) stated that '*Heterogorgia* has been entirely misunderstood by Nutting and some other writers. Its larger interior spicules are all simple tuberculated spindles. Its surface has a layer of small spicules of varied forms'. Later, Kükenthal (1924) also transferred some species to this taxon which actually belong to other genera (Castro, 1990). The genus was thought to be restricted to the eastern Pacific, but Castro (1990) described *H. uatumani* from Ilha Grande, Brazil, and Humann (1994) reported its occurrence in Bahamas, thus widening the range of distribution.

Heterogorgia hickmani sp. nov.
(Figures 1–4)

Type material

Holotype: colony preserved in ethanol (La Botella, Isla Floreana, Galápagos; water depth: 7.5 m) [CDRS 03-95]. Collected by C. Hickman, 19 January 2003.

Paratypes: colony preserved in ethanol (Isla Pinzón, Galápagos; water depth: 7.5 m) [CDRS 03-699]. Collected by C. Hickman, 18 November 2003. Four fragments preserved in ethanol (La Botella, Isla Floreana, Galápagos; water depth: 6 m) [CDRS Ang 156]. Collected by Angel Chiriboga, 25 May 2004. Fragment preserved in ethanol (La Botella, Isla Floreana, Galápagos; water depth: 11 m) [CDRS Ang 139]. Collected by Angel Chiriboga, 8 February 2004.

Comparative material examined

Heterogorgia uatumani. Paratypes, two colonies, preserved in ethanol (Amendoim Island, Brazil; water depth: 9–13 m) [USNM 73431]. Collected by C.B. Castro, 6 November 1981. *Heterogorgia uatumani*. Paratypes, three colonies, preserved in ethanol (Laje dos Moleques Sao Senastiao Channel, Brazil; water depth: 6 m) [USNM 735694]. Collected by P.S. Young, May 1984. *Heterogorgia clausa*. Syntype, preserved in ethanol (Irian Jaya, Salawati Island, Indonesia; water depth: 32 m) [USNM 91921]. Collected by Siboga Expedition, 20 August 1899. *Heterogorgia magna*. Paratype, preserved in ethanol (Sumbawa Island, Saleh Bay, Lesser Sunda Islands, Flores Sea, Indonesia; water depth: 36 m) [USNM 43083]. Collected by Siboga Expedition, 14 February 1899. *Heterogorgia papillosa*. Holotype, dry preserved (La Paz, Baja California, México; water depth: 11–13 m) [YPM 8609]. Collected by J. Pedersen, date unknown. *Heterogorgia tortuosa*. Syntypes, three colonies, dry preserved (Islas Perlas, Golfo de Panamá, Panamá; water depth: not given) [YPM 1555]. Collected by F.H. Bradley, 1866–1867. *Heterogorgia tortuosa*. Syntype, dry preserved (Islas Perlas, Golfo de Panamá, Panamá; water depth: not given) [YPM 1555B-D]. Collected by, F.H. Bradley, 1866–1867. *Heterogorgia tortuosa*. Syntype, dry preserved (Islas Perlas, Golfo de Panamá, Panamá; water depth: not given) [MCZ 4910]. Collected by F.H. Bradley, 1866–1867. *Heterogorgia tortuosa*. Syntype, fragment, dry preserved (Islas Perlas, Golfo de Panamá, Panamá; water depth: not given) [BM 1950.3.16.245]. Collected by F.H. Bradley, 1866–1867. *Heterogorgia verrucosa*. Syntypes, three colonies, dry preserved (Islas Perlas, Golfo de Panamá, Panamá; water depth: not given) [YPM 1554A]. Collected by F.H. Bradley, 1866–1867. *Heterogorgia verrucosa*. Syntype, dry preserved (Islas Perlas, Golfo de Panamá, Panamá; water depth: not given) [YPM 1554B]. Collected by F.H. Bradley, 1866–1867. *Heterogorgia verrucosa*. Syntype, dry preserved (Islas Perlas, Golfo de Panamá, Panamá; water depth: not given) [MCZ 730]. Collected by F.H. Bradley, 1866–1867. *Heterogorgia verrucosa*. Fragment, preserved in ethanol (Gordon's Rock, Galápagos; water depth: 25 m) [CDRS Ang 122]. Collected by Angel Chiriboga, 23 January 2004.

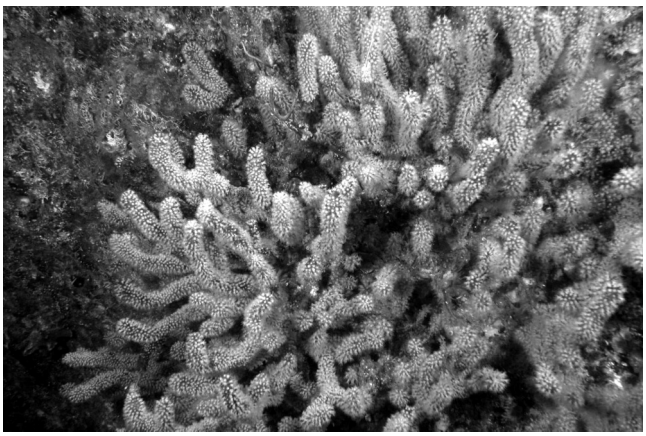

Figure 2. *Heterogorgia hickmani* sp. nov. Living colony photographed under water at La Botella, Isla Floreana, Galápagos; 7.5 m in depth. Photograph by C. Hickman.

Description

The species is represented by two colonies and several fragments. The first, here designated as the holotype (Figure 1A–C) is composed of four single, unbranched stems measuring 35, 130, 135, and 40 mm in length; the latter is broken. The tips of the stems are rounded, and slightly crooked. Stems are connected at the base by a continuous encrusting holdfast. Diameter of the stems including calyces is about 7 mm at the base, 8 mm in the middle, and about 12 mm at the tips. The holotype was part of a large arrangement of stems growing close together on a rocky substrate, and some of the stems were bifurcated at the ends (Figure 2).

The second colony (paratype CDRS 03-699) is a single unbranched stem, measuring 160 mm in length. Diameter of the stem including calyces is about 6 mm at the base, 8 mm in the middle, and 7 mm at the tip; it is of more uniform thickness than the stems of the holotype. The base of the stem is deprived of coenenchyme leaving a dark brown axis. A small part of the holdfast remains. The stem is bent in a 'c' shape, probably due to the preservation process. The paratype CDRS Ang 139 is an unbranched fragment 80 mm in height. The paratype

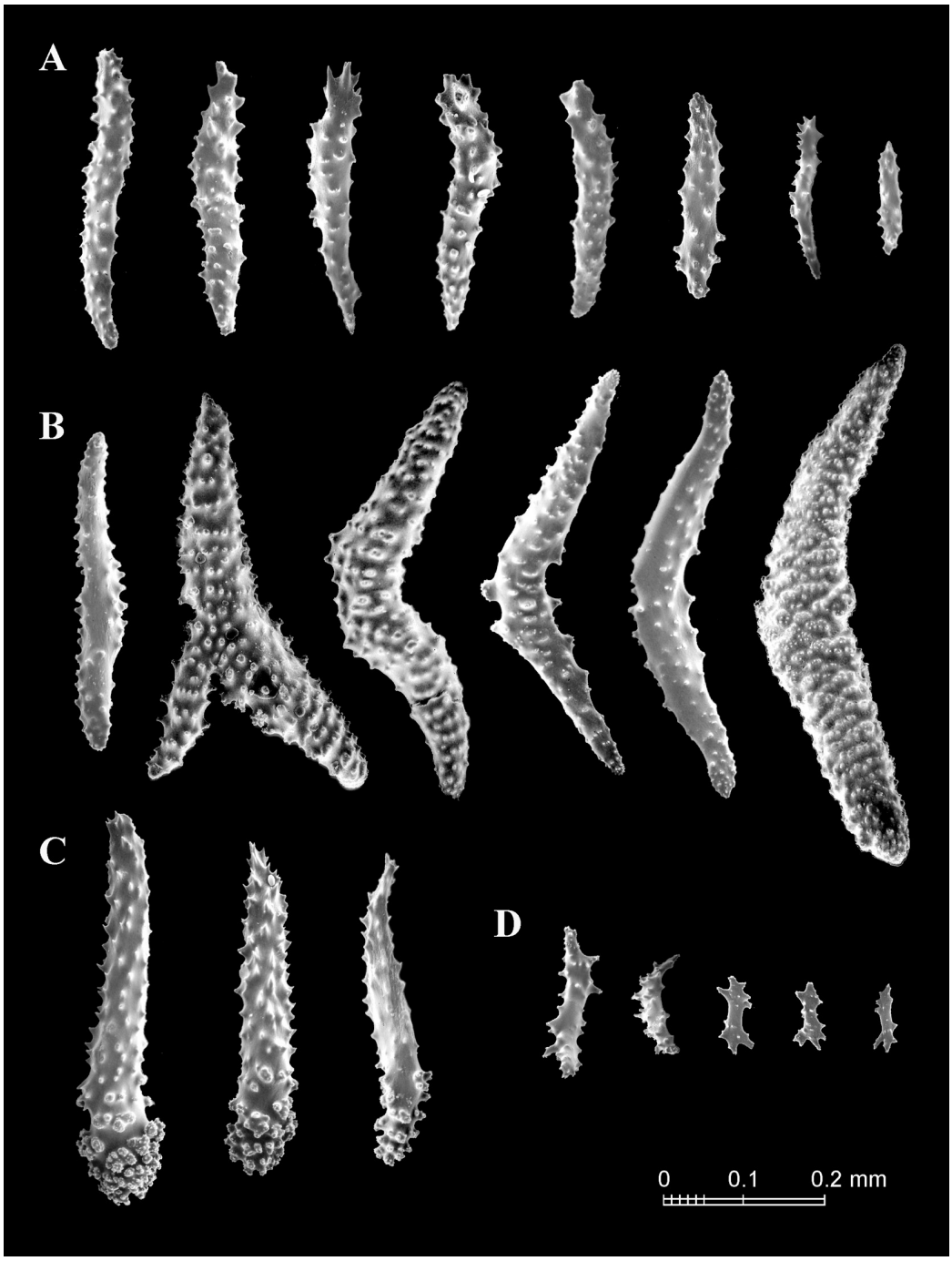

Figure 3. *Heterogorgia hickmani* sp. nov. Sclerites of the holotype. (A) Points; (B) collaret; (C) calyx; (D) tentacles.

CDRS Ang 156 is represented by four fragments, the largest is 90 mm in height composed of four branches that sprout irregularly, at angles of 45°, from a common stem and ascend parallel. The branches are very thick, up to 13 mm in width.

The colonies are whitish to beige or greenish in ethanol or dry preserved. When alive, polyps are bright yellow, and the coenenchyme looks brownish (Figure 2).

Polyps are densely packed around the branches (40–50 calyces/cm), more scarcely distributed on the holdfast, and at the base of the branches. Polyps withdraw into wide calyces, up to 2 mm in diameter. The calyces are prominent, spiny, with eight marked grooves around the polyp aperture producing a lobed rim (Figure 1C). Anthocodial armature with a well developed collaret and points. Collaret composed of three rows of long curved spindles, 0.50–0.66 mm in length, 0.05–0.13 mm in width, some with one or two short, lateral, branch-like projections. These spindles are covered on their surface with small spines, (Figure 3B). Points formed from about five pairs of rods, 0.30–0.50 mm in length, 0.04–0.06 mm in width, and arranged *en chevron*; several of them have a spiny distal end (Figure 3A). The tentacles bear small, thorny rods, 0.09–0.20 mm in length, 0.02–0.05 mm in width; they are branched, tuberculate, and some have more developed tubercles on the convex side (Figure 3D).

The calyces contain spine-like rods projecting from the calycular rim, forming a strong, bristling barricade

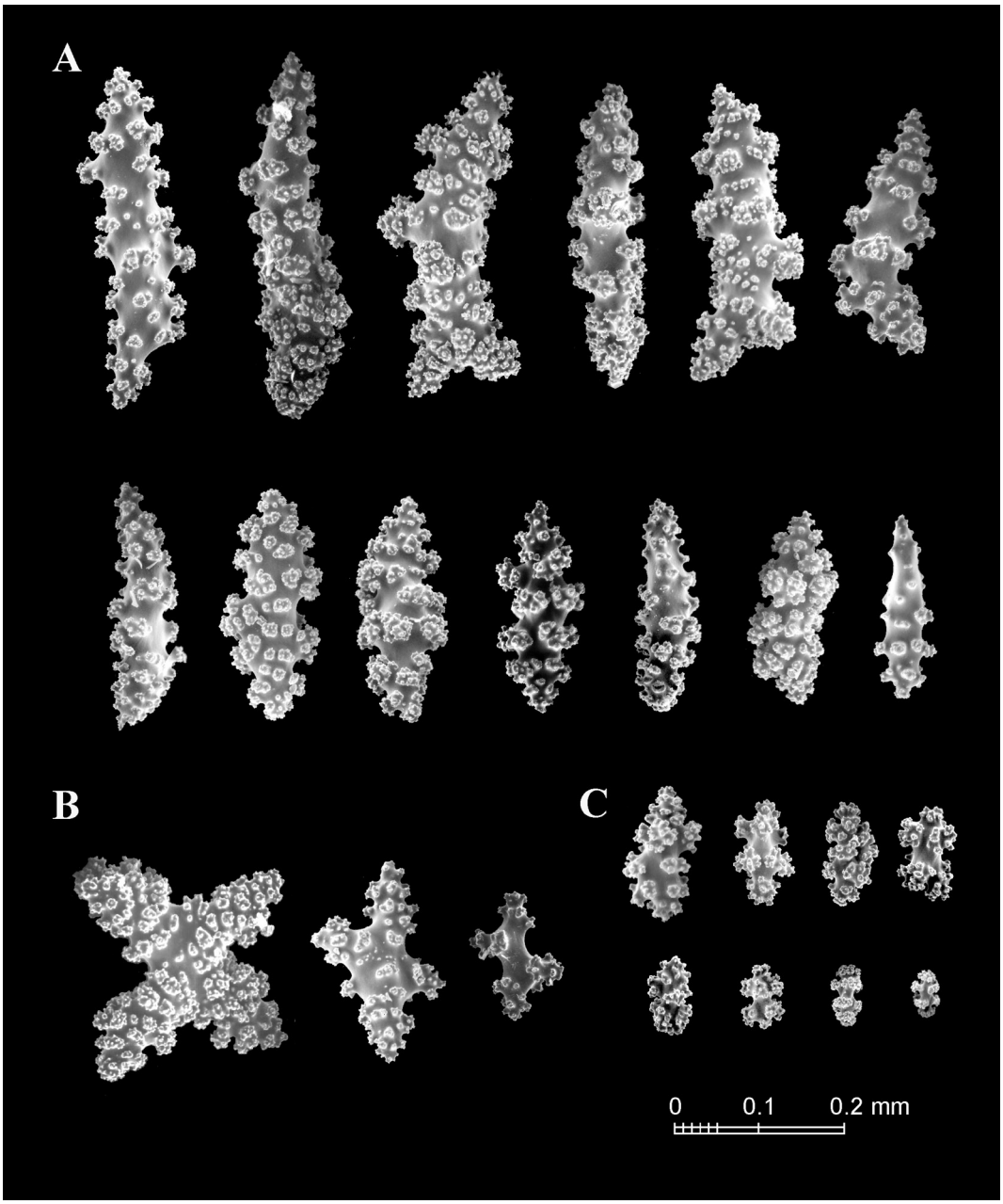

Figure 4. *Heterogorgia hickmani* sp. nov. Coenenchymal sclerites of the holotype. (A) Spindles; (B) crosses; (C) radiates.

Table 1. *Comparative characteristics of the eastern Pacific, and Atlantic species of the alcyonacean genus* Heterogorgia. *Diameter of the branches and size of the sclerites are given in mm, and for the sclerites represent the maximum length measured for each species.*

Species	*H. hickmani*, sp. nov.	*H. verrucosa*	*H. tortuosa*	*H. papillosa*	*H. uatumani*
Branching pattern	unbranched stems	dichotomous	dichotomous	dichotomous	irregular
Diameter of stem	10–13	7–12	4–6	4–4.5	4–4.5
No. calyces/cm	40–50	20	14	25	12
Diameter calyces	2	1	1	0.5	1
Collaret	0.66	0.50	0.34	0.43	0.41
Calyx sclerites	0.50	0.42	0.23	0.30	0.35
Spindles	0.45	0.36	0.30	0.30	0.30
Branched spindles	0.42	0.34	0.22	absent	absent
Crosses	0.32×0.35	0.30×0.17	0.18×0.12	0.12×0.11	0.20×0.12
Radiates	0.12	0.10	0.10	0.10	0.11

(Figure 1B,C). These sclerites have a wide, warty base and a strong echinulate projecting spine ornamented with scattered prickles; these sclerites are long, ranging from 0.38–0.50 mm in length, 0.06–0.11 mm in width measured at the base, and about 0.02 mm in width at the sharp tips (Figure 3C). The proximity of the calyces gives the entire colony a thorny aspect (Figure 1B,C).

The coenenchymal sclerites are small tuberculate five- to eight-radiates, 0.06–0.12 mm in length, and 0.04–0.07 mm in width (Figure 4C); crosses up to 0.15 mm by 0.10 mm, with tuberculate ends, or tuberculated all over (Figure 4B); irregularly tuberculate spindles, 0.21–0.45 mm in length, and 0.08–0.15 mm in width, with acute ends, that are straight or bent; and conspicuously branched spindles, 0.26–0.42 mm in length, and 0.10–0.13 mm in width (Figure 4A), covered with numerous complex tubercles.

All the sclerites are white to colourless.

Etymology

This species is named after Dr Cleveland P. Hickman, Jr in recognition of his valuable contribution to the knowledge of Galápagos marine invertebrates.

Distribution

Type locality. La Botella, Isla Floreana, Galápagos Archipelago, Ecuador. It is also reported for Isla Pinzón, Galápagos Archipelago, Ecuador.

DISCUSSION

This new species of *Heterogorgia* differs from the others in colony morphology (Table 1), by its robust stems, with crowded, large calyces, and sparse branching; most colonies are unbranched or simply bifurcated at the ends. Although young colonies of *Heterogorgia* are unbranched, only *H. uatumani*, in some cases, reaches up to 5 cm before it starts branching; the others tend to branch very early in the growing process. The predominance of large sclerites also distinguishes this new species from all species of the genus. The larger size of sclerites, given by Verrill (1869) for *H. verrucosa* was not verified from his material by either us or Castro (1990). Similarly with *H. tortuosa* and *H. papillosa*, the sizes of sclerites do not in every case agree with Verrill's descriptions (Verrill, 1869; 1870). Polyp sclerites in species of *Heterogorgia* are all very similar, although some variation is observed in the degree of curvature. Those observed in *H. hickmani* are the largest in the genus. The spine-like calyx sclerites of this species are also the largest in the genus, thus far found. The coenenchymal spindles are also larger in the new species than in other *Heterogorgia* species, but very similar in shape and ornamentation. The conspicuous branched spindles were not found in *H. papillosa* or *H. uatumani*, and are very large in the new species compared to those found in the other two species.

A small branch of *H. verrucosa* was collected at 25 m depth from the Galápagos. This species is common in Pacific Panamá, and Costa Rica, where we have observed it from 25–35 m depth. It has been also reported for Bahía Málaga, Pacific Colombia (von Prahl et al., 1986). Its occurrence in Galápagos represents a new record, and extends its geographic range to the southeast Pacific.

We had the opportunity to study some of the Nutting's (1910) species of *Heterogorgia* and conclude that they cannot be considered to belong in this genus. This confirms Verrill's statement that this genus was misinterpreted by other authors (Verrill, 1912). The same applies to other species described from Indonesia (Castro, 1990; L. van Ofwegen, personal communication).

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REFERENCES

Bayer, F.M., 1956. Octocorallia. In *Treatise on invertebrate paleontology. Part F. Coelenterata* (ed. R.C. Moore), pp. 163–231, figs. 134–162. Kansas: Geological Society of America and University of Kansas Press.

Bayer, F.M., 1961. *The shallow water Octocorallia of the West Indian Region. A manual for marine biologists*. The Hague: Martinus Nijhoff.

Bayer, F.M., 1978. *Adelogorgia telones*, a new species of gorgonacean coral (Coelenterata: Octocorallia) from the Galapagos Islands. *Proceedings of the Biological Society of Washington*, **91**, 1026–1036.

Bayer, F.M., 1981. Key to the genera of Octocoralia exclusive of Pennatulacea (Coelenterata: Anthozoa), with diagnosis of new taxa. *Proceedings of the Biological Society of Washington*, **94**, 902–947, figs. 1–75.

Bayer, F.M., Grasshoff, M. & Verseveldt, J., 1983. *Illustrated trilingual glossary of morphological terms applied to Octocorallia*. Leiden: E.J. Brill.

Breedy, O. & Guzman, H.M., 2002. A revision of the genus *Pacifigorgia* (Coelenterata: Octocorallia: Gorgoniidae). *Proceedings of the Biological Society of Washington*, **115**, 787–844.

Castro, C.B., 1990. A new species of *Heterogorgia* Verrill, 1868 (Coelenterta, Octocorallia) from Brazil with comments on the type species of the genus. *Bulletin of Marine Science*, **47**, 411–420.

Deichmann, E., 1941. Coelenterates collected on the Presidential Cruise of 1938. *Smithsonian Miscellaneous Collections*, **99**, 1–17.

Gray, J.E., 1859. On the arrangement of zoophytes with pinnated tentacles. *Annals and Magazine of Natural History*, **4**, 439–444.

Harden, D.G., 1979. *Intuitive and numerical classification of east Pacific Gorgonacea (Octocorallia)*. PhD thesis, Illinois State University, USA.

Humann, P., 1994. *Reef coral identification. Florida, Caribbean and Bahamas*. Jacksonville: Paramount Miller Graphics, Inc.

Kükenthal, W., 1919. Gorgonaria. *Wissensschaftliche Ergebnisse der Deutschen Tiefsee-Expedition auf dem Dampfer 'Valdivia'*, 1898–1899, **13**, 1–946.

Kükenthal, W., 1924. *Gorgonaria*. Das Tierreich, 47, i–xxviii, 1–478 pp. Berlin und Leipzig: Walter de Gruyter & Co.

Nutting, C.C., 1910. The Gorgonacea of the Siboga Expedition III. The Muriceidae. *Siboga-Expedition Monograph*, **13b**, 1–108, pls. 1–22.

Prahl, H. von, Escobar, D. & Molina, G., 1986. Octocorales (Octocorallia: Gorgoniidae y Plexauridae) de aguas someras del Pacífico Columbiano. *Revista de Biología Tropical*, **34**, 13–33.

Verrill, A.E., 1868. Critical remarks on the halcyonoid polyps in the Museum of Yale College, with descriptions of new genera. *The American Journal of Science and Arts*, **45**, 411–415.

Verrill, A.E., 1869. Notes on Radiata in the Museum of Yale College, Number 6: Review of the corals and polyps of the West Coast of America. *Transactions of the Connecticut Academy of Arts and Sciences*, (Second Edition), **1**, 422–502.

Verrill, A.E., 1870. Notes on Radiata in the Museum of Yale College, Number 6: Review of the corals and polyps of the West Coast of America. *Transactions of the Connecticut Academy of Arts and Sciences*, (Second Edition), **1**, 503–534.

Verrill, A.E., 1912. The Gorgonians of the Brazilian coast. *Journal of the Academy of Natural Sciences of Philadelphia*, **15**, 373–404, 1 fig., pls. 29–35.

Williams, G. & Breedy, O., 2004. The Panamic genus *Pacifigorgia* (Octocorallia: Gorgoniidae) in the Galápagos archipelago. *Proceedings of the California Academy of Sciences*, **55**, 54–86.

Wright, E.P. & Studer, T., 1889. Report on the Alcyonaria collected by H.M.S. Challenger during the years 1873–1876. *Challenger Zoology*, **31**, 314 p., 43 pls.

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