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Primnoidae (Octocorallia: Calcaxonia) from the Emperor Seamounts, with Notes on *Callogorgia elegans* (Gray, 1870)[1]

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Abstract: Six primnoid species are reported from depths of 280–480 m from the southern Emperor Seamounts, including two new species (*Callogorgia imperialis* and *Thouarella taylorae*). Only the new species are fully described and illustrated. Also, *Callogorgia elegans*, which has a confused taxonomic history, is discussed and illustrated. Not unexpectedly, the Emperor Seamount primnoids have a strong affinity with the fauna of the Hawaiian Islands, an affinity that is expected to increase as more collecting is done in the region.

The United Nations General Assembly approved Resolution 61/105 in December 2006 (United Nations General Assembly 2007) that calls on States to directly, or through Regional Fisheries Management Organizations, apply a precautionary ecosystem approach to sustainably manage fish stocks and protect vulnerable marine ecosystems (VMEs) in deep-sea fisheries on the high seas (FAO 2009). Some deep-sea corals are indicator species of VMEs, and accordingly fishing nations around the world are developing protocol and policy on fishing encounters with the sensitive biota (Durán Muñoz et al. 2012). Here we report on collections made on fishing vessels in the Emperor Seamounts, North Pacific Ocean, as part of a joint project between the United States and the Republic of Korea.

The Emperor Seamounts are a series of very old and heavily eroded guyots (flat-topped) and seamounts stretching approximately 6,700 km from the Aleutian Trench to the Northwestern Hawaiian Islands (Figure 1). Several nations, including the Republic of Korea and Japan, conduct fishery operations for two important fish species, North Pacific armorhead (*Pseudopentaceros wheeleri*) and splendid alfonsino (*Beryx splendens*), with gear that occasionally contacts the seafloor.

Materials and Methods

Coral specimens were collected during fishing operations aboard the FV *Oryong501* in 2014 and the FV *Oyang96* in 2014, 2015, and 2016 (see Table 1). Specimens were frozen (–20°C) onboard the fishing vessels and transferred to the National Institute of Fisheries Science (Busan, Republic of Korea) where they were preliminarily identified to family. Whole specimens or samples of primnoid octocorals were shipped to the U.S. National Museum of Natural History (NMNH), Smithsonian Institution (Washington D.C.), where they were ultimately identified to species. Specimens are deposited primarily at the National Marine Biodiversity Institute of

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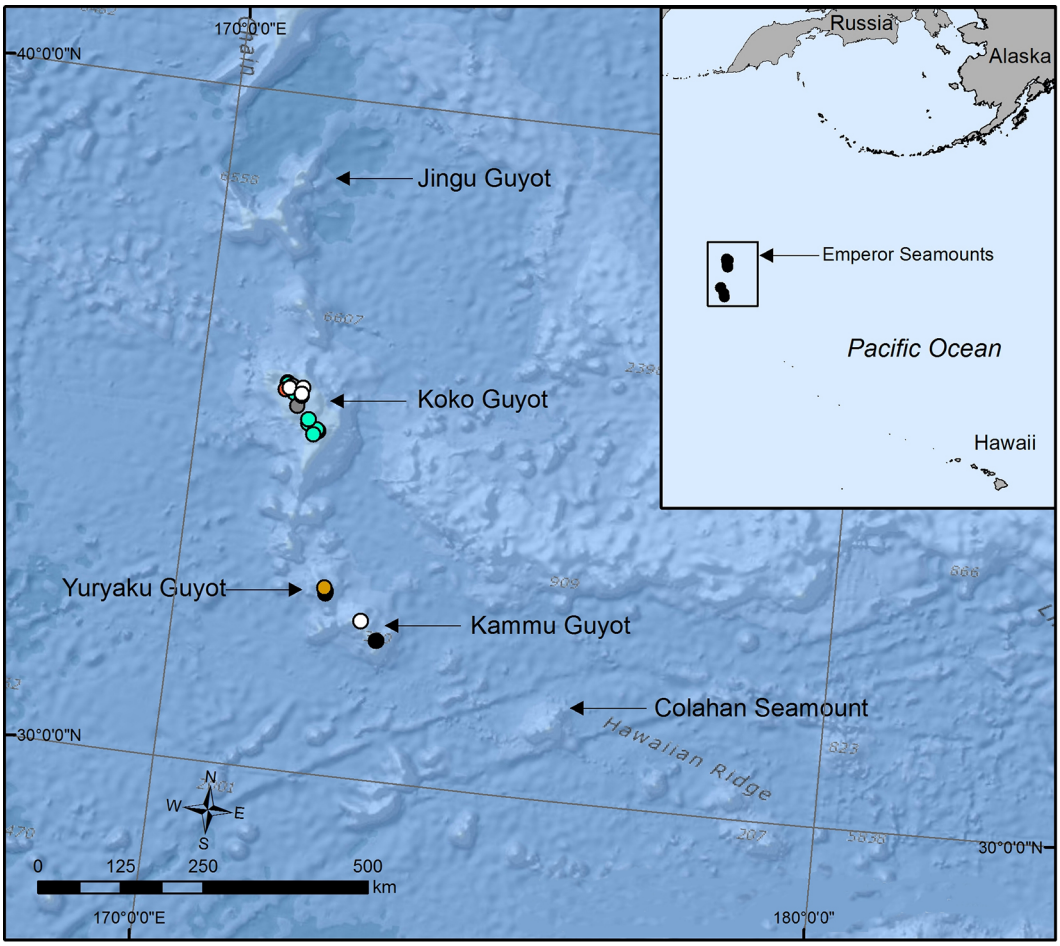

FIGURE 1. Map of the Emperor Seamounts in the North Pacific Ocean showing the location of six species of primnoid corals collected during this study. Taxa are as follows: *Callogorgia imperialis*, n. sp. (green circles), *Callogorgia formosa* (gray circles), *Faniella tuberculata* (black circles), *Candidella helminthophora* (brown circles), *Narella vermifera* (orange circle), and *Thouarella taylorae*, n. sp. (white circles).

Korea, and voucher fragments and scanning electron microscopy (SEM) stubs of most species are also deposited at the NMNH.

The morphological terminology used here follows that of Bayer et al. (1983). The scanning electron photomicrographs were taken by S.D.C. using a scanning electron microscope (Zeiss EVO MA15). Authorship of the two new species is attributed to the first author (Cairns) alone.

Abbreviations used in the text include the following:

BM	British Museum (Natural History), now the Natural History Museum, London
L:W	Length to width ratio of a sclerite
MZW	Museum of Natural History, Wrocław University, Poland
MABIK	National Marine Biodiversity Institute of Korea, Seocheon 33662, Republic of Korea
NMNH	National Museum of Natural History, Smithsonian
SEM	Scanning electron microscopy

USNM United States National Museum (now the NMNH, but acronym used for cataloging purposes)
ZMA Zöologische Museum, Amsterdam

RESULTS

SYSTEMATIC TREATMENT

Subclass Octocorallia
Order Alcyonacea
Suborder Calcaxonia
Family Primnoidae Milne Edwards, 1857
Genus *Callogorgia* Gray, 1858

Callogorgia Gray, 1858:286.—Bayer, 1982:119–123 (key to Indo-Pacific species).—Cairns and Bayer, 2009:40, fig. 12*A–D* (more complete synonymy).—Cairns, 2016:58.

TYPE SPECIES: *Gorgonia verticillata* Pallas, 1766, by monotypy.

DIAGNOSIS: Colonies uniplanar, pinnately or dichotomously branched. Polyps cylindrical to clavate, arranged in whorls of up to 12, all polyps facing upward. Polyps covered with eight longitudinal rows of body wall scales, the number of scales per row decreasing from ab- to adaxial polyp side. Body wall scales granular, smooth, pitted, or covered with tall ridges. Inner side of opercular scales covered with serrated multiple keels.

REMARKS: Including the new species described herein there are 27 valid species in the genus. A key to the Indo-Pacific *Callogorgia* is in preparation.

DISTRIBUTION: Indo-Pacific, North Atlantic, 37–2,472 m.

Callogorgia imperialis Cairns, **n. sp.**
Figures 2*A*, 3*A–D*, 4*A–I*

Caligorgia elegans: Kinoshita, 1908:40–42, pl. 3, figs. 17–18; pl. 6, fig. 48.

MATERIAL EXAMINED (TYPES): Holotype: *Oyang* 2015-96-138-1, MABIK CN00076574, branch fragments, SEM stubs 2359–2363, USNM 1422524. Paratypes: *Oyang* 2014-96-13-2, colony, MABIK CN00076352, branch fragments USNM 1422525; *Oyang* 2014-96-152-5, colony, MABIK CN00076508, branch fragment, USNM 1422521; *Oyang* 2014-96-153-1, colony, MABIK CN00076513, branch fragment, USNM 1422510; *Oyang* 2014-96-153-5, colony, MABIK CN00076514, branch fragment, USNM 1422518; *Oyang* 2014-96-158-2, colony, MABIK CN00079269, branch fragment, USNM 1422513; *Oyang* 2014-96-181-5, colony, MABIK CN00076544, branch fragment, USNM 14225217; *Oyang* 2015-96-4-1, colony, MABIK CN00076567, branch fragment, USNM 1422520; *Oyang* 2016-96-37-1, colony, MABIK CN00076578, fragments, USNM 1422519; *Oryong* 2014-501-13-1, branch fragment, MABIK CN00076125, fragments, USNM 1422522; *Oryong* 2014-501-131-3, branch fragments, MABIK CN00076288, fragments, USNM 1422523.

TYPE LOCALITY: *Oyang* 2015-96-138-1: 35.6217° N, 171.3167° E (Kōkō Guyot, Emperor Seamounts), 347 m.

DISTRIBUTION: Emperor Seamounts (Kōkō Guyot), 284–380 m. Elsewhere: Sagami Bay, Japan (depth unknown).

DESCRIPTION: Colonies are uniplanar and taller than wide, the largest specimen (the holotype, Figure 2*A*) measuring 42 cm in height and 22 cm in width, having a broken basal branch diameter of 7.2 mm. Branching is irregularly dichotomous (not pinnate) and the branches are rather stiff, the axis being longitudinally ridged. The polyps are arranged in whorls of 6 or 7 (Figure 3*B*) on distal branches (8 or 9 on proximal stems); 5 to 6 whorls occur per cm branch length; the whorl diameter ranges from 2.8 to 3.5 mm. The polyps are 1.5–1.9 mm in length, curved, and slightly clavate (Figures 3*A*, *C*). The color of the colony is light orange.

There are eight longitudinal rows of body wall scales, decreasing in number from the ab- to adaxial polyp side; the body wall sclerite formula is 12–16: 6–10: 2–5: 2–3. Most body wall scales are wider than taller, slightly curved to accommodate the curvature of the polyp, and rather thick (e.g., about 0.08 mm). The abaxial body wall scales (Figure 4*A*) range from 0.33 to 0.36 mm in width, the outer laterals (Figure 4*B*) 0.37–0.42 mm, and the inner laterals (Figure 4*C*) 0.14–0.16 mm. The abaxial and outer laterals often have a

FIGURE 2. Colony images of: *A*, *Callogorgia imperialis*, holotype; *B*, *Callogorgia formosa*, *Oryong* 2014-501-33-1; *C*, *Fanellia tuberculata*, *Oyang* 2014-96-37-6; *D*, *Candidella helminthophora*, *Oryong* 2014-501-110-6; *E*, *Narella vermifera*, *Oyang* 2016-96-20-1; *F*, *Thouarella taylorae*, holotype.

serrate distal edge. The adaxial body wall scales (Figure 4*D*) are squarish, ranging from 0.19 to 0.21 mm on a side, and thinner, although even smaller adaxials occur lower on the polyp. Proximal to the adaxial scales the polyp is naked (Figure 3*D*). At the proximal margin of the polyp, where the polyp scales transition to the coenenchymal scales, there may be 2 wide (up to 0.6 mm wide) infrabasal-type scales (Figures 3*C*, 4*E*), or this region may be covered with polygonal scales similar to those of the coenenchyme. The outer face of the body wall scales is fairly smooth, covered with very small (5 μm in diameter) granules. The opercular scales (Figure 4*F*) range in length from 0.23 to 0.49 mm (L:W = 2.1–2.2), decreasing in length from the ab- to adaxial polyp side, forming a low opercu-

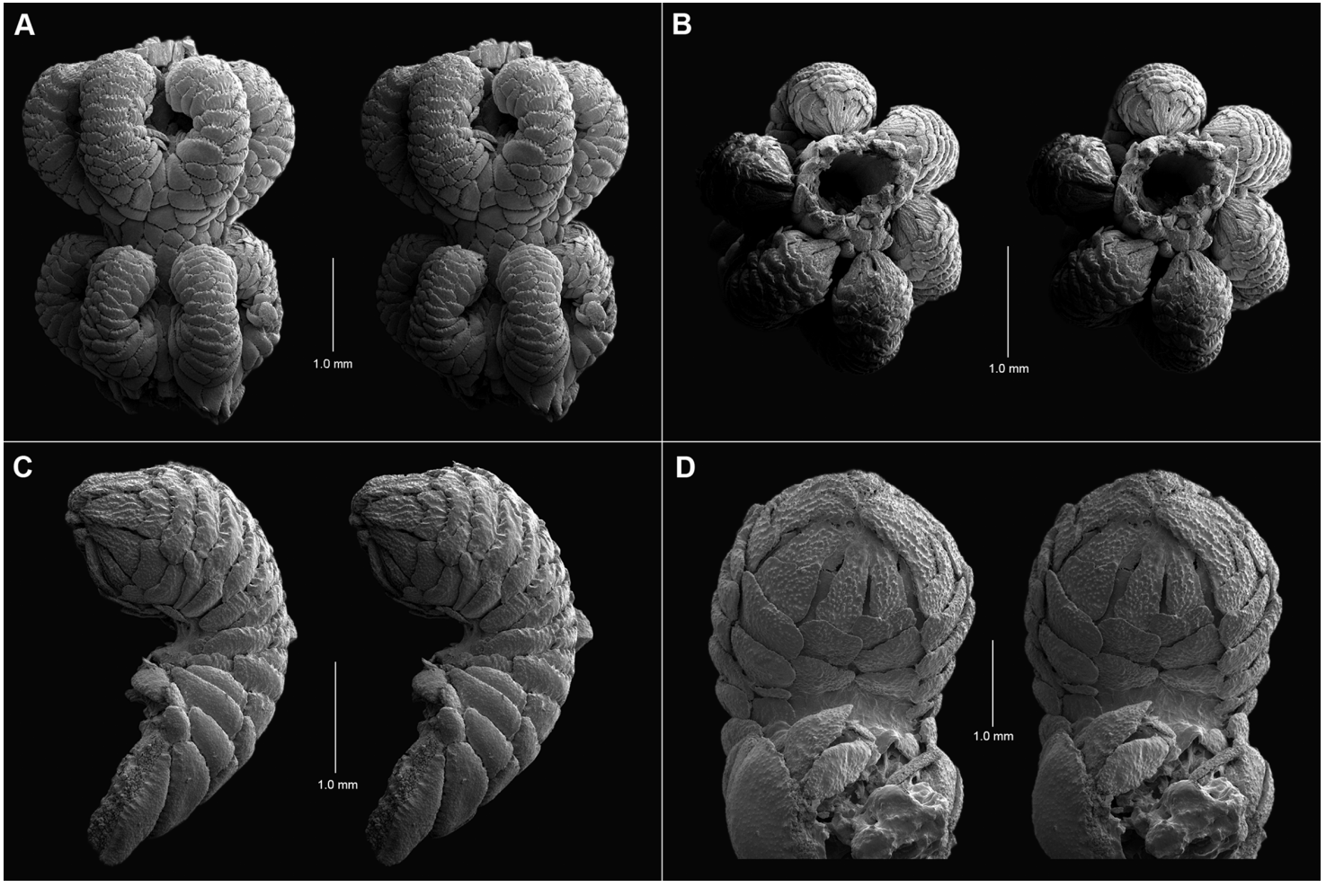

FIGURE 3. Stereo views of the holotype of *Callogorgia imperialis: A*, lateral view of two polyp whorls; *B*, apical view of a polyp whorl; *C*, lateral view of a polyp; *D*, adaxial-oral view of a polyp.

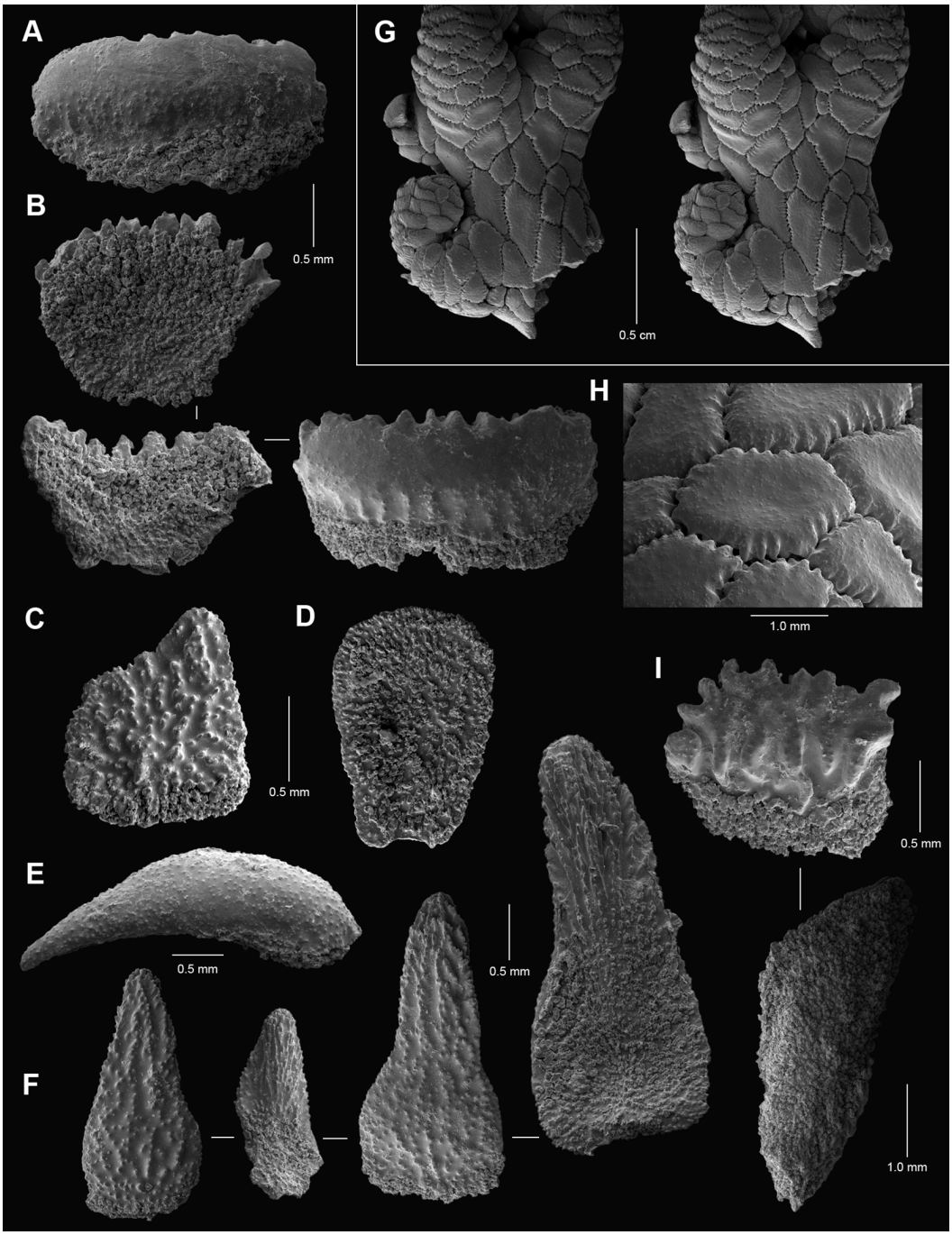

FIGURE 4. Holotype of *Callogorgia imperialis: A*, outer surface of an abaxial body wall scale; *B*, outer lateral body wall scales; *C*, outer surface of an inner lateral body wall scale; *D*, inner surface of an adaxial body wall scale; *E*, curved infrabasal scale; *F*, opercular scales; *G*, stereo view of coenenchymal scales in situ and a juvenile polyp; *H*, coenenchymal scales in situ; *I*, thick coenenchymal scales.

lum. They are lanceolate in shape with a blunt tip. Their outer surface is covered with low granules, loosely arranged in several rows distally; their inner surface is covered with tubercles proximally and distally bears serrated ridges.

The coenenchymal scales are polygonal (Figure 4*I*) and quite thick (up to 0.12 mm), fitting together in a closely adjacent mosaic (tessellate) pattern (Figures 4*G–H*). These scales range from 0.35 to 1.02 mm in greater length, which is aligned with the branch axis. These scales are flat to slightly concave and essentially smooth (bearing tiny granules about 5 μm in diameter) and have serrate edges, such that the projecting points of one scale often interdigitate with the recessed region of an adjacent scale, locking them in position. Below the coenenchymals is a thin layer of small (35–45 μm in diameter) tuberculate spheroids.

COMPARISONS: Using the keys of Kükenthal (1919, 1924) and Bayer (1982), this species keys closest to *C. elegans* (Gray, 1870), but as explained in Remarks that species has been incorrectly diagnosed since its description. *Callogorgia imperialis* is unique among the Indo-Pacific species by having a high number of abaxial body wall scales and tessellate coenosteal scales. It appears to be the species Kinoshita (1908) described as "? *Caligorgia elegans*."

ETYMOLOGY: Named *imperialis* (Latin for "of the empire" or "emperor"), an allusion to its type locality on the Emperor Seamounts.

REMARKS: As mentioned earlier, *C. imperialis* keys closest to *C. elegans* (Gray, 1870) in the classic keys of Kükenthal (1919) and Bayer (1982), but that species is poorly known. The seven-word original description and two illustrations of *C. elegans* (Gray, 1870) of a specimen from Formosa (= Taiwan) do not help to distinguish it from other *Callogorgia* with dichotomous branching. Studer's (1878) reference to *C. elegans* simply transferred the species from *Callicella* to *Calligorgia*. Wright and Studer (1889) synonymized it with *C. flabellum* (Ehrenberg, 1834), but as Versluys (1906) and Bayer (1982) later showed, *C. flabellum* has pinnate branching, and *C. elegans* is dichotomous. Without having additional material or seeing the type, Versluys (1906) doubted the synonymy with *C. flabellum* but suggested that the type be re-examined. Kinoshita (1908) provisionally reported a specimen from Japan as *C. elegans;* that specimen has a flabellate, dichotomously branched corallum, a sclerite formula of 12–13:7:3:1–3, four to six polyps per whorl, a polyp length of 1.0–1.1 mm, and 8–8.5 whorls per cm. From this description, Kükenthal (1919, 1924), and later Bayer (1982), defined and provided keys to *C. elegans* based on this characterization. Unfortunately, the Japanese specimen is not *C. elegans*, as indicated by the unpublished SEM (Figures 5, 6*A–D*) and notes of the dry BM holotype (BM 1965-12-15-006 and 008), both made by F. M. Bayer, who showed this species to have a sclerite formula of 7–8:2+1:0:1, four polyps per whorl, a polyp length of 0.78–0.93 mm, and about nine polyps per cm. (The 2+1 convention indicates that the outer lateral sclerites are disjunct). Kinoshita's *C. elegans*, however, does seem to be the same as *C. imperialis*, as described herein. Using the key provided by Bayer (1982) and Kükenthal (1919, 1924), *C. elegans* would key closest to *C. indica* Versluys *in* Thomson and Henderson (1906), known only from the Andaman Islands at 82–490 m. They both have a similar sclerite formula and polyp size, differing only in that *C. indica* has only two or three polyps per whorl and a more delicate colony than that of *C. elegans*.

ECOLOGICAL REMARKS: Several colonies of *C. imperialis* hosted one or more large ophiuroids, Family Asteroschematidae and likely *Asteroschema* sp. (Gordon Hendler, Los Angeles County Museum of Natural History, pers. comm.) when collected. The brittle stars are quite large, up to 24 cm in total length (arm tip to arm tip), and apparently use the corals as elevated feeding or spawning platforms.

Callogorgia formosa (Kükenthal, 1907)
Figure 2*B*

Caligorgia formosa Kükenthal, 1907:208–209; 1919:366–369, text figs. 155–159; pl. 30, fig. 1; pl. 40, fig. 47.

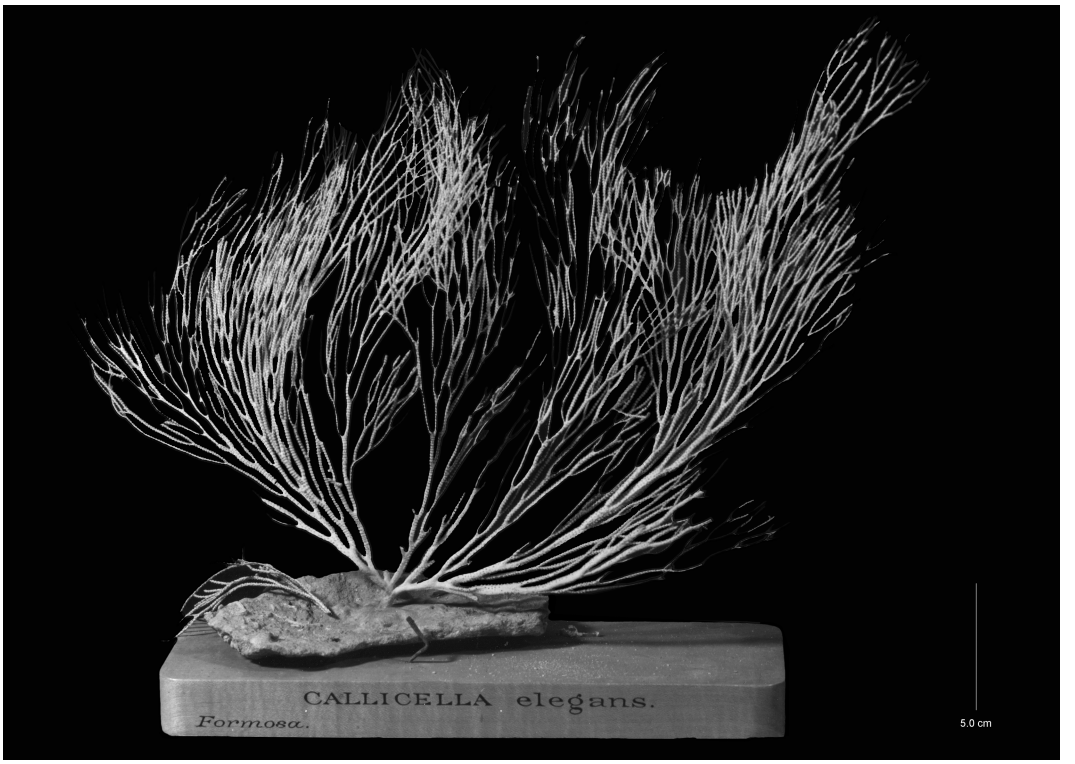

FIGURE 5. Holotype of *Callogorgia elegans*, BM 1965-12-15-006.

Callogorgia formosa: Bayer, 1982:130–134, figs. 9–10.—Cairns, 2010:427–429, figs. 1*E*, 12*A;* 2016:61–65, figs. 31*A*, 32, 33.

MATERIAL EXAMINED: *Oryong* 2014-501-58-3, fragments, MABIK CN00076181, 2 branch fragments, USNM 1422534; *Oryong* 2014-501-33-1, fragments, MABIK CN00079275, 2 branch fragments, USNM 1422535.

TYPES AND TYPE LOCALITY: Syntype deposited as MZW 25. Type locality: Southwest of Great Nicobar Islands, Indian Ocean, 362 m.

DISTRIBUTION: Emperor Seamounts: Kōkō Guyot, 280–289 m. Elsewhere: Off Great Nicobar, Nicobar Islands, northern New Zealand, Hawaiian Islands, 296–750 m.

DIAGNOSIS: Colony uniplanar, usually consisting of one straight main branch from which pairs of undivided branchlets diverge from opposite sides of the main branch (opposite pinnate), the undivided branchlets up to 15 cm in length (Figure 2*B*). Polyps arranged in whorls of 3 to 5; polyps slightly clavate, 1.4–1.7 mm in length. Body wall sclerite formula: 8–12: 7–9: 2–5: 1–3; the proximal adaxial polyp side is unprotected. Body wall scales rectangular with a coarse serrate distal margin. Opercular scales unique in that both outer and distal inner surfaces covered with coarse blunt spines, producing a thick, blunt apex. Coenenchymal scales elongate and granular.

REMARKS: Of the 27 species in the genus, *C. formosa* is the only one to have opposite pinnate branching and is thus probably the most easily recognized species in the genus. It has been more than adequately described and figured at least four times (see synonymy) and thus is not redescribed herein.

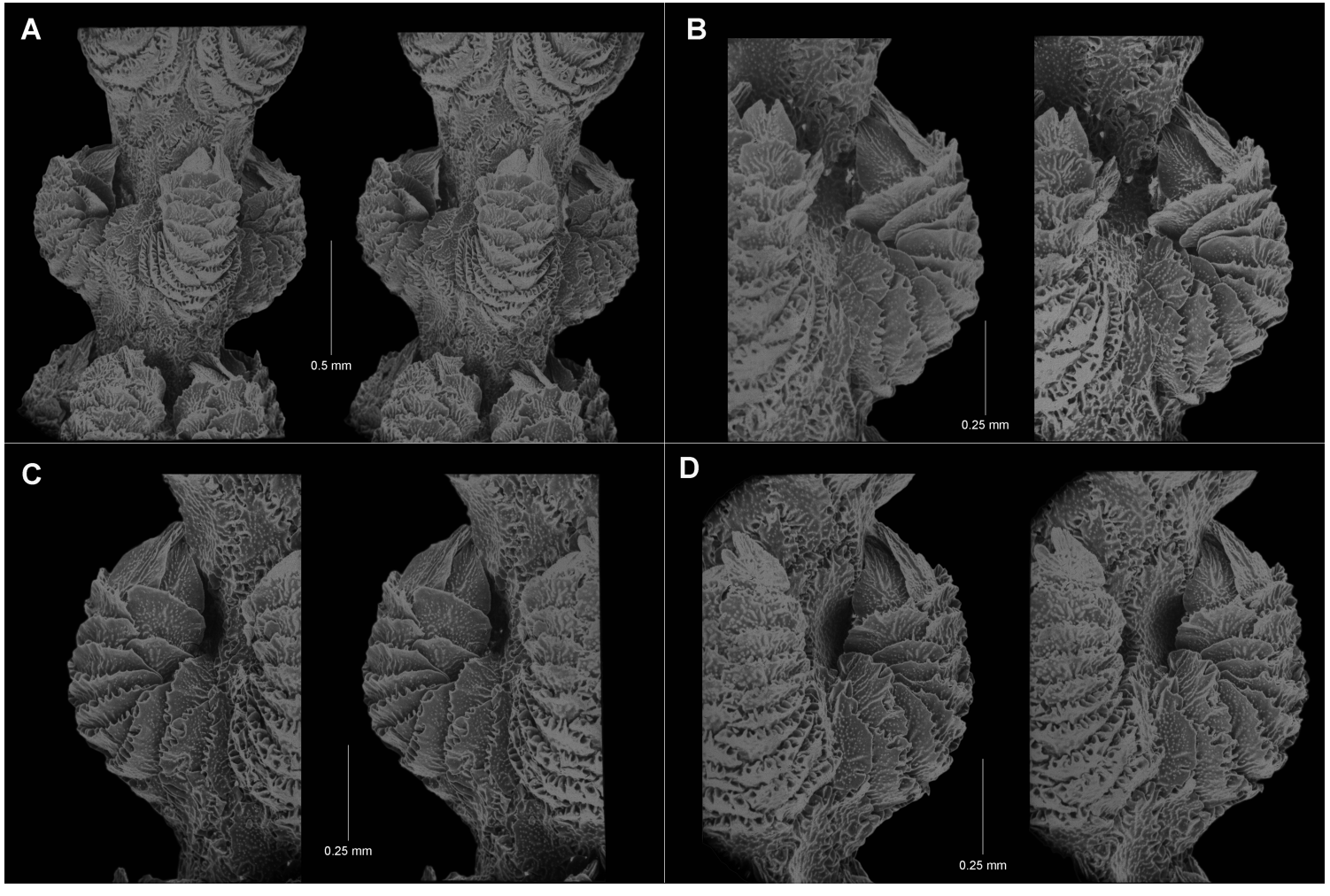

FIGURE 6. Stereo views of the holotype of *Callogorgia elegans*, BM 1965-12-15-006. *A*, lateral view of a whorl of polyps; *B–D*, lateral views of individual polyps.

Genus *Fanellia* Gray, 1870

Fanellia Gray, 1870:46.—Bayer, 1982:134–135 (key to species).—Bayer and Stefani, 1989:470–471 (key to species).—Cairns and Bayer, 2009:40–41, fig. 12*E–M*.—Cairns, 2016:72–73.

TYPE SPECIES: *Primnoa compressa* Verrill, 1865, by monotypy.

DIAGNOSIS: Colonies uniplanar, branches alternate-pinnate or dichotomously arranged. Polyps often clavate, arranged in pairs or whorls of up to 16, all polyps facing upward. Polyps arranged in 4 to 8 longitudinal rows of body wall scales, the number of scales in each row decreasing from ab- to adaxial side. Outer surface of body wall and coenenchymal scales covered with closely spaced, complex, granular tubercles, sometimes fusing into low, flat-topped radial ridges. Inner face of operculars bears a keel composed of multiple ridges. Coenenchymal scales or plates thick, and imbricate or tessellate in arrangement.

REMARKS: Nine species are known in the genus, most of them keyed by Bayer and Stefani (1989). The genus is primarily differentiated from *Callogorgia* by its unique tuberculate surface sculpturing; however, based on molecular sequencing evidence, Taylor and Rogers (2015) suggested that *Fanellia* is probably synonymous with *Callogorgia*.

DISTRIBUTION: Western and Central Pacific, from New Zealand to Alaska, 82–1,341 m.

Fanellia tuberculata (Versluys, 1906)
Figure 2*C*

Caligorgia tuberculata Versluys, 1906:80–81, text-figs. 95–96.
Fanellia tuberculata: Bayer, 1982:144–154, figs. 18–26.—Bayer and Stefani, 1989:471.—Cairns, 2010:433–434, table 3; Taylor and Rogers, 2015:fig. 1.—Cairns, 2016:73–74, figs. 31*E*, 40, 41, table 4.

MATERIAL EXAMINED: *Oyang* 2014-96-15-1, colony, MABIK CN00076354, branch fragment, USNM 1422507; *Oyang* 2014-96-20-1, colony, MABIK CN00079270, branch fragment, USNM 1422508; *Oyang* 2014-96-37-6, colony, MABIK CN00076378, branch fragment, USNM 1422506; *Oyang* 2014-96-39-3, colony, MABIK CN00076383, branch fragment, USNM 1422505; *Oyang* 2014-96-40-3, colony, MABIK CN00076389, branch fragment, USNM 1422503.

TYPES AND TYPE LOCALITY: Holotype: formerly ZMA Coel. 2286, now at Centre for Biodiversity Naturalis, Leiden. Type locality: 5.717° N, 119.667° E (Sulu Sea), 522 m.

DISTRIBUTION: Emperor Seamounts: Kammu, Yūryaku, and Kōkō Guyots, 343–480 m. Elsewhere: northern New Zealand and Kermadec Ridge, Sulu Sea, Bikini, Japan, Hawaiian Islands, 128–522 m.

DIAGNOSIS: Colony uniplanar and alternate-pinnate in branching (Figure 2*C*), the terminal branchlets rarely more than 4 cm in length. Polyps arranged in pairs or whorls of 3, often lacking from the terminal cm of each branchlet; polyps 0.9–1.4 mm in length. Body wall scale formula: 4–9: 1–3: 0–3: 1–2; the short adaxial side of the polyp is unprotected. Body wall scales rectangular, with a straight distal edge (not pointed). Coenenchymal scales (plates) thick, trapezoidal to rectangular, and arranged in a tessellate pattern.

COMPARISONS: *Fanellia tuberculata* is compared to other species using tabular keys (Cairns 2010, 2016) and dichotomous keys (Bayer 1982, Bayer and Stefani 1989) and is fully described and illustrated by Bayer (1982) and Cairns (2016), and thus only a diagnosis is provided herein.

Genus *Candidella* Bayer, 1954

Candidella Bayer, 1954:296 (nom. nov.).—Cairns and Bayer, 2004:476–477; 2009:46, fig. 16*H–N* (synonymy and discussion).—Cairns, 2009:440; 2016:102.

TYPE SPECIES: *Primnoa imbricata* Johnson, 1862, by monotypy.

DIAGNOSIS: Colonies unbranched (flagelliform) or uniplanar, with dichotomous branching. Polyps arranged in whorls, usually standing perpendicular to branch. Each polyp ringed distally with 4 large marginal scales, which form a cowl around operculum; body wall scales much smaller, occurring in 2 to 4

submarginal tiers. Opercular scales with an inner keel. Coenenchymal scales elliptical and highly concave.

REMARKS: Four species are known in the genus, discussed and figured by Cairns (2009) and Cairns and Bayer (2009).

DISTRIBUTION: Amphi-Atlantic, Fiji, Hawaiian Islands, New Zealand, Emperor Seamounts, 378–2,165 m.

Candidella helminthophora (Nutting, 1908)
Figure 2*D*

Stenella helminthophora Nutting, 1908:575–576, pl. 44, figs. 6–9; pl. 47, fig. 5.
Candidella helminthophora: Grigg and Bayer, 1976:171 (listed).—Cairns, 2009:440–443, pl. 1*A*, *H*, 19–20 (complete synonymy); 2016:102–104, figs. 46*G*, 60–62.

MATERIAL EXAMINED: *Oyang* 2014-96-20-2, colony, MABIK CN00079271, 2 branch fragments, USNM 1422541; *Oryong* 2014-501-F-110-6, colony, MABIK CN00079272, 2 branch fragments, USNM 1422542.

TYPES AND TYPE LOCALITY: The holotype is deposited at the NMNH (USNM 23385). Type locality: 23.786° N, 166.415° W (off French Frigate Shoals, Hawaiian Islands), 722–726 m.

DISTRIBUTION: Emperor Seamounts (Yūryaku and Kōkō Guyots), 300–470 m. Elsewhere: Southern Kermadec Ridge to North Cape, and Kermadec Ridge, New Zealand, throughout Hawaiian Islands, 417–1,801 m.

DIAGNOSIS: Colonies uniplanar, equally and dichotomously branched (Figure 2*D*). Polyps occur in whorls of 2–4, individual polyps strongly flared and up to 3.8 mm in length, standing perpendicular to branch. Of the 4 marginal scales, the 2 abaxial marginals are wider; 4 submarginals occur below marginals. Below submarginals the body wall scales are irregular but usually consist of at least 2 more tiers. Two tall basal scales firmly attach polyp to coenenchymal scales, sometimes becoming greatly enlarged and reflexed in shape, forming a tube for a commensal polynoid polychaete, *Gorgoniapolynoe muzikae*. Opercular scales triangular, each bearing a prominent keel on their inner side. Coenenchymal scales elliptical to irregular in shape, having a flat to slightly concave outer surface.

REMARKS: This species has been fully described and figured recently (Cairns 2009, 2016), and thus only a diagnosis is given here. It is distinguished from congenerics by Cairns (2009).

Genus *Narella* Gray, 1870

Narella Gray, 1870:49.—Cairns and Bayer, 2003:618–619; 2007:84–86 (list of species); 2009:43, fig. 14*A–G*.—Cairns and Baco, 2007:392–393.—Cairns, 2012:14.—Taylor and Rogers, 2015:190 (list of species).

TYPE SPECIES: *Primnoa regularis* Duchassaing & Michelotti, 1860, by monotypy.

DIAGNOSIS: Colonies dichotomously or pinnately branched, or unbranched. Polyps arranged in whorls, the polyps always facing downward. Polyps covered by 3 pairs of large body wall scales (basal, medial, and buccal); smaller adaxial body wall scales may be present, although proximal portion of adaxial polyp usually naked. Opercular scales usually prominently keeled. Coenenchymal scales often quite thick (plates) and ridged, arranged in an imbricate or tessellate (mosaic) fashion.

REMARKS: *Narella* is one of the most species-rich among the 43 primnoid genera, containing 41 valid species (Cairns 2012, Taylor and Rogers 2015). More extensive discussions of the genus may be found in Cairns and Bayer (2009) and Cairns (2012).

DISTRIBUTION: All ocean basins, 128–4,594 m (Cairns 2012).

Narella vermifera Cairns & Bayer, 2007
Figure 2*E*

Narella vermifera Cairns & Bayer, 2007:98–99, figs. 1*E*, 8*A–D*, 9*A–H*.

MATERIAL EXAMINED: *Oyang* 2016-96-20-1, 1 colony, MABIK CN00076585, branch fragment, USNM 1422530.

TYPES AND TYPE LOCALITY: The types are deposited at the NMNH. Type locality: 23° 02′ N, 162° 05′ W (off Ka‘ula Rock, near

Ni'ihau), northwest Hawaiian Islands, 275–527 m.

DISTRIBUTION: Emperor Seamounts: Kōkō Guyot, 296 m. Elsewhere: Northwestern Hawaiian Islands (off Ni'ihau and Nīhoa), 271–527 m.

DIAGNOSIS: Colonies uniplanar and dichotomously branched, up to 17 cm in height and 19 cm in width, with a basal axis diameter of 5.8 mm (specimen reported herein, Figure 2*E*). Polyps arranged in whorls of 3 to 5; 5 whorls per cm branch length; whorl diameter about 3.9 mm. Polyps 1.8–2.0 mm in length. Basal scales have a rounded dorsolateral edge and often have greatly enlarged, recurved outer edges that form a tube for a commensal polynoid polychaete of the genus *Gorgoniapolynoe*. Medial scales quite short; both basal and buccal pairs of scales form complete but unfused rings. Coenenchymal scales thick, flat, and polygonal in shape, arranged in a mosaic pattern.

REMARKS: This is the first report of this species subsequent to its original description. Its characteristics were tabulated by Cairns and Bayer (2007: table 2), who also compared it to *N. biannulata* (Kinoshita, 1907), a similar species known from off Japan.

Genus *Thouarella* Gray, 1870

Thouarella Gray, 1870:45.—Cairns and Bayer, 2009:33–34 (more complete synonymy).—Cairns, 2011:4–5.—Taylor et al., 2013:20–21 (revision of genus, including complete synonymy and discussion).

TYPE SPECIES: *Primnoa antarctica* Valenciennes, 1846, by monotypy.

DIAGNOSIS: Branching of colonies as bottlebrush, uniplanar pinnate, or dichotomous, the main branch itself sparsely divided. Polyps isolated (i.e., occurring on all sides of branch). Group 1 sensu Taylor et al. (2013), or arranged in pairs and/or whorls (Group 2 sensu Taylor et al. 2013). Each polyp covered with 6 or 8 longitudinal rows of body wall scales, those of the adaxial side reduced in size and number. Marginal scales often arranged in 2 circlets that alternate with one another, the inner face of each marginal bearing a simple or ornate longitudinal keel. Opercular scales usually keeled as well.

REMARKS: The genus *Thouarella* was comprehensively revised by Taylor et al. (2013). They included 25 species in the genus, which were divided into two groups (see Diagnosis). Two species have been described since (Cairns 2011) and one herein, resulting in 28 species in the genus, making it one of the more species-rich among the primnoids. The species key in Taylor et al. (2013) makes it relatively easy to identify the species, which, until then, had been a difficult process.

DISTRIBUTION: Worldwide from the Aleutian Islands to Antarctica, 11–2,100 m.

Thouarella taylorae Cairns, **n. sp.**

Figures 2*F*, 7*A–D*, 8*A–E*

MATERIAL EXAMINED: Types.

TYPES AND TYPE LOCALITY: Holotype: *Oryong* 2014-501-178-2, colony, MABIK CN00076337, several branch fragments, USNM 1422540. Paratypes: *Oryong* 2014-501-93-1, colony fragment, MABIK CN00079274, branch fragment, USNM 1422536; *Oryong* 2014-501-94-2, colony fragment, MABIK CN00076228, 2 branch fragments, USNM 1422539; *Oryong* 2014-501-110-1, 1 colony, MABIK CN00079273, polyps, USNM 1422538; *Oyang* 2014-96-15-2, colony fragment, MABIK CN00076355, branch fragment, USNM 1422537. Type locality: 34° 33.3′ N, 171° 13.7′ E, 297 m.

DISTRIBUTION: Emperor Seamounts: Kammu and Kōkō Guyots, 280–372 m.

DESCRIPTION: The colonies are essentially uniplanar, consisting of relatively few main branches from which long (up to 8 cm in length) branchlets originate in an irregularly pinnate manner, although some branchlets diverge slightly out of the plane, producing a slightly bushy aspect but not considered to be bottlebrush branching (Figure 2*F*). The holotype is 17 cm in height and 2 mm in basal axis diameter. The axis is bronze and finely longitudinally striate.

The white polyps occur individually on the main branches and in pairs and whorls of 3 or 4 on the branchlets, paired polyps most com-

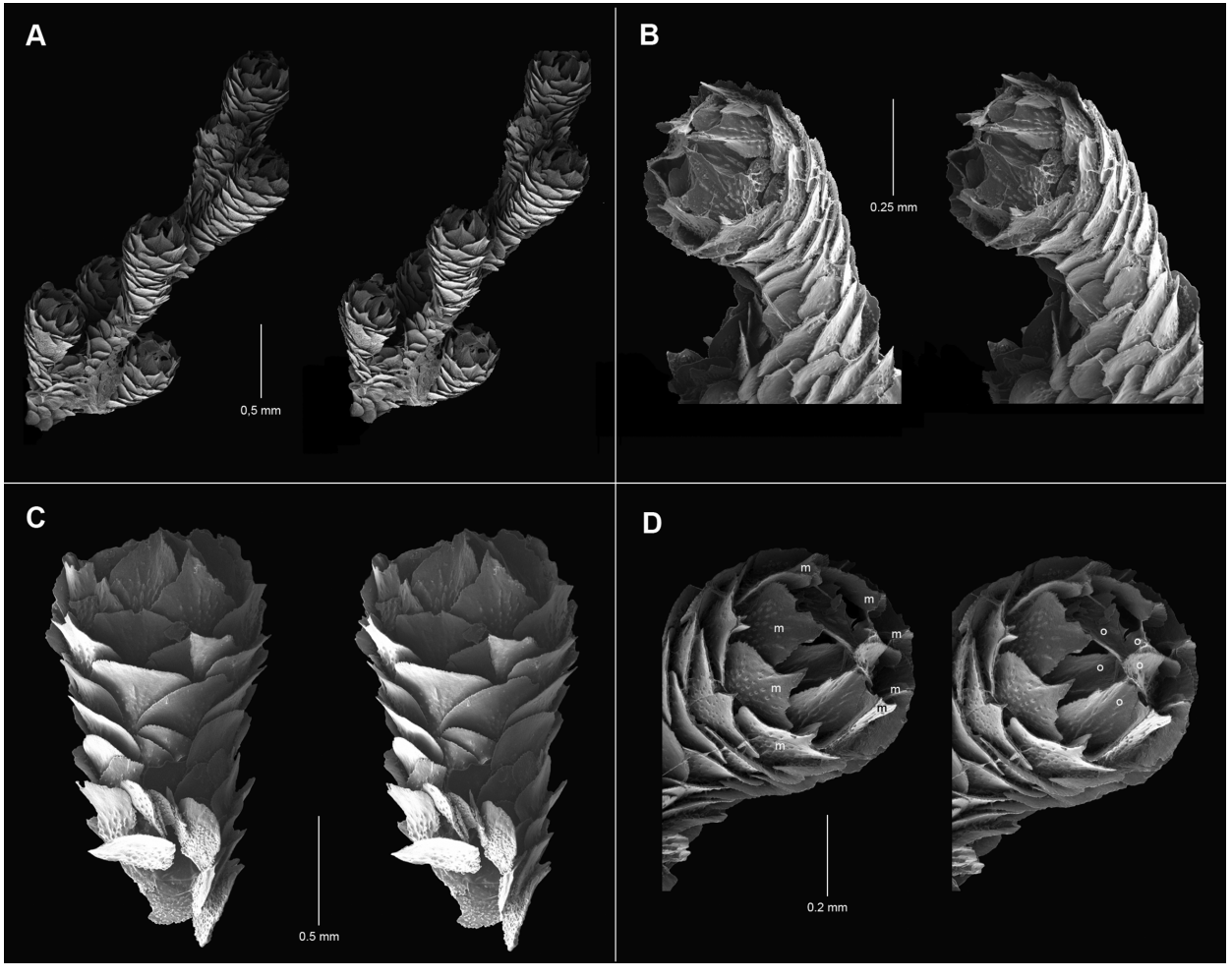

FIGURE 7. Stereo views of the holotype of *Thouarella taylorae: A*, distal polyps arranged in whorls of three and pairs; *B*, lateral view of a polyp; *C*, adaxial view of a polyp; *D*, opercular view of a polyp (o, 5 opercular scales; m, the 8 marginal scales).

mon at branchlet tips (Figure 7*A*), the whorls more developed proximally. The polyps are 0.8–1.1 mm in length and slightly flared distally, curved upward along the branchlet axis (Figures 7*B–C*); about 10 pairs of whorls occur per cm branchlet length.

Each polyp is covered with 8 longitudinal rows of body wall scales having the body wall sclerite formula of: 8–9:4–7:4–5:3–5. The adaxial body wall scales (Figure 7*C*) are slightly fewer and smaller than the others but still cover the entire adaxial side. The marginal scales (Figures 7*D*, 8*A*) are quite broad (up to 0.3 mm, L:W = 0.75–1.1), slightly curved to fit the circumference of the polyp, and arranged in an inner and outer overlapping quartet; all marginals are the same size and shape. The sculpturing of their outer and inner surfaces is similar to that of the opercularis. Their medial keel folds over and fits into the concavity on the outer side of the adjacent opercular scale. Some, but usually not all, of the 8 submarginals also have keeled inner surfaces. Otherwise the body wall scales (Figure 8*B*) are elliptical, fairly flat, up to 0.25 mm in width, granular above and tuberculate below, and lack keels. The opercular scales (Figures 7D, 8C) also occur in two quartets of 4, but alternate in size and shape. The opercularis of the outer quartet are lanceolate, up to 0.28 mm in length, and have an L:W of 1.6–2.2. The operculars of the inner quartet, which are usually overshadowed by the larger quartet and thus not visible, are only up to 0.21 mm in length and much more slender (L:W = 2.5–3.1). All opercular scales have a highly concave outer surface that is covered with granules and short radiating ridges, whereas their inner faces are tuberculate basally and prominently keeled distally. The coenenchymal scales (Figures 8*D–E*) are elongate elliptical, about 0.11–0.15 mm in width and 0.25 mm in length, but otherwise similar to the body wall scales.

COMPARISONS: *Thouarella taylorae* belongs to "species group 2" sensu Taylor et al. (2013), a group of 9 of the 28 known species in this genus characterized by having their polyps arranged in pairs and/or whorls. Only three species in this group have pinnate branching, as does *T. taylorae*: *T. tydemani* Versluys, 1906; *T. laxa* Versluys, 1906; and *T. moseleyi* Wright & Studer, 1889. *Thouarella taylorae* can be distinguished from both *T. tydemani* and *T. laxa* by having pointed (not spinose) marginal scales (and thus a much lower L:W), smaller polyps (those of the other two species are up to 1.5 mm in length), and more abaxial body wall scales (those of the other two have only four to six abaxial body wall scales per row). *Thouarella taylorae* differs from *T. moseleyi* in having longer branchlets, shorter polyps, whorled polyps (only pairs occur in *T. moseleyi*), and more body wall scales in its abaxial rows.

ETYMOLOGY: This species is named in honor of Michelle Taylor, who published a seminal paper consisting of a revision of all species of the genus *Thouarella* (Taylor et al. 2013).

ECOLOGICAL REMARKS: At the one site on Kammu Guyot where specimen 2014-96-15-2 was collected, approximately six additional specimens were collected, possibly indicating that this species is found in patches.

DISCUSSION

Of the six primnoid species reported herein, two (*Callogorgia imperialis* and *Thouarella taylorae*) are thus far known only from the Emperor Seamounts, although a broader distribution off the Hawaiian Islands is expected; one (*Narella vermifera*) is known elsewhere only in the Hawaiian Islands, this record being the first subsequent record since its description; and the remaining three species (*Callogorgia formosa*, *Fanellia tuberculata*, and *Candidella helminthophora*) are known from throughout the western Pacific, including the Hawaiian Islands. Thus, four of the six species are known from the Hawaiian Islands, and it is expected that the remaining two will eventually be found there as well. Twenty-eight primnoid species are known from the Hawaiian Islands (Cairns 2010), a much more heavily collected and studied faunistic region, and it is expected that the number of primnoids from the Emperor Seamounts will increase, including some of these Hawaiian species, as more collecting is done. The key to the genera of Hawaiian primnoids given by Cairns

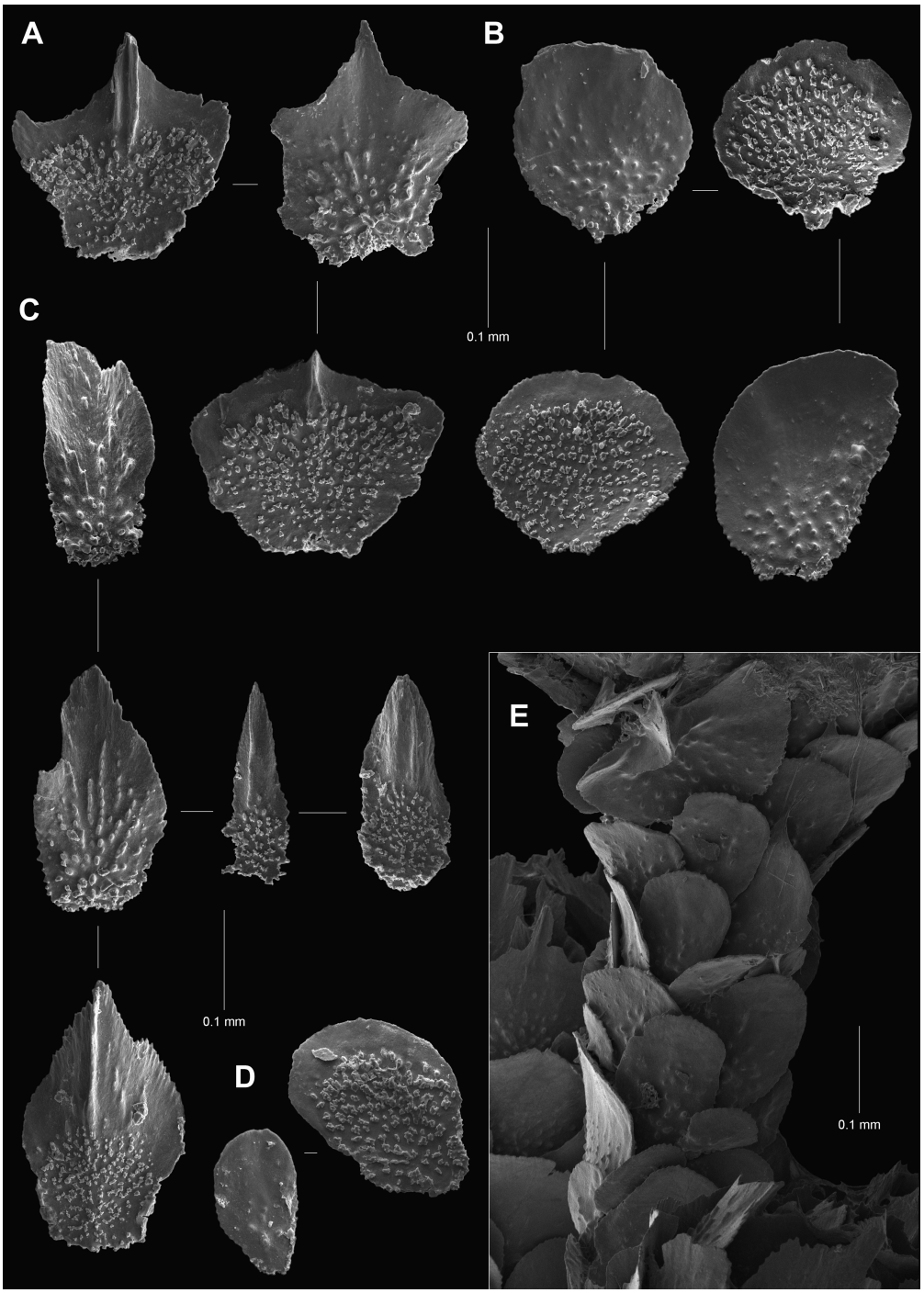

Figure 8. Holotype of *Thouarella taylorae: A*, marginal body wall scales; *B*, body wall scales; *C*, opercular scales; *D*, coenenchymal scales; *E*, coenenchymal scales in situ.

TABLE 1

Station Data for the 26 Primnoid Specimens Collected during This Study

Specimen No.	Date	Latitude (N)	Longitude (E)	Depth (m)
2015-96-138-1	10 May 2015	35.6217°	171.3167°	347
2014-96-13-2	14 March 2014	35.0550°	171.7100°	380
2014-96-152-5	21 May 2014	34.9617°	171.8700°	343
2014-96-153-1	21 May 2014	34.9567°	171.8200°	348
2014-96-153-5	21 May 2014	34.9567°	171.8200°	348
2014-96-158-2	23 May 2014	34.9817°	171.8550°	344
2014-96-181-5	31 May 2014	35.5533°	171.3850°	364
2015-96-4-1	8 April 2015	34.9050°	171.8100°	328
2016-96-37-1	24 March 2016	35.6000°	171.3333°	284
2014-501-13-1	26 March 2014	35.1117°	171.7000°	296
2014-501-131-3	25 May 2014	35.4817°	171.4350°	285
2014-501-58-3	25 April 2014	35.5800°	171.3967°	280
2014-501-33-1	11 April 2014	35.2900°	171.5083°	289
2014-96-15-1	15 March 2014	32.2733°	172.8650°	370
2014-96-20-1	17 March 2014	32.6967°	172.2567°	470
2014-96-37-6	28 March 2014	32.6383°	172.2850°	480
2014-96-39-3	29 March 2014	32.6150°	172.2833°	~450
2014-96-40-3	31 March 2014	32.0100°	173.1300°	343
2014-96-20-2	17 March 2014	32.6967°	172.2567°	470
2014-501-110-6	15 May 2014	35.4533°	171.5617°	300
2016-96-20-1	24 March 2016	35.5167°	171.3000°	296
2014-501-178-2	15 June 2014	35.4800°	171.5583°	297
2014-501-110-1	15 May 2014	35.4533°	171.5617°	300
2014-501-93-1	9 May 2014	35.5467°	171.3617°	280
2014-501-94-2	9 May 2014	35.5667°	171.5650°	372
2014-96-15-2	15 March 2014	32.2733°	172.8650°	370

(2010) also serves to identify the genera from the Emperor Seamounts.

The Aleutian Islands and the seamounts of the Gulf of Alaska, only a slightly greater distance to the north than the Hawaiian Islands are to the southeast, also have a rich primnoid fauna [e.g., 19 species off the Aleutians (Cairns 2011) and five different species from the deep seamounts in the Gulf of Alaska (Cairns and Baco 2007)]. However, no species are held in common between the Emperor Seamounts and this more northerly region, a finding recently reported by Miyamoto et al. (2017).

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Literature Cited

Bayer, F. M. 1954. New names for two genera of Octocorallia. J. Wash. Acad. Sci. 44:296.

———. 1982. Some new and old species of the primnoid genus *Callogorgia* Gray, with a revalidation of the related genus *Fanellia* Gray (Coelenterata: Anthozoa). Proc. Biol. Soc. Wash. 95:116–160.

Bayer, F. M., M. Grasshoff, and J. Verseveldt, eds. 1983. Illustrated trilingual glossary of morphological and anatomical terms applied to Octocorallia. E. J. Brill, Leiden.

Bayer, F. M., and J. Stefani. 1989. Primnoidae (Gorgonacea) de Nouvelle-Calédonie. Bull. Mus. Natl. Hist. Nat., Paris (4) 10:449–518.

Cairns, S. D. 2009. Review of Octocorallia (Cnidaria: Anthozoa) from Hawai'i and adjacent seamounts. Part 2. Genera *Paracalyptrophora* Kinoshita, 1908; *Candidella* Bayer, 1954; and *Calyptrophora* Gray, 1866. Pac. Sci. 63:413–448.

———. 2010. Review of Octocorallia (Cnidaria: Anthozoa) from Hawai'i and adjacent seamounts. Part 3: The genera *Thouarella*, *Plumarella*, *Callogorgia*, *Fanellia*, and *Parastenella*. Pac. Sci. 64:413–440.

———. 2011. A revision of the Primnoidae (Octocorallia: Alcyonacea) from the Aleutian Islands and Bering Sea. Smithson. Contrib. Zool. 634:1–55.

———. 2012. New Zealand Primnoidae (Anthozoa: Alcyonacea) Part 1. Genera *Narella*, *Narelloides*, *Metanarella*, *Calyptrophora*, and *Helicoprimnoa*. NIWA Biodiv. Mem. 126:1–71.

———. 2016. The marine fauna of New Zealand: Primnoid octocorals (Anthozoa, Alcyonacea)—Part 2. *Primnoella*, *Callozostron*, *Metafannyella*, *Callogorgia*, *Fanellia* and other genera. NIWA Biodiv. Mem. 129:1–131.

Cairns, S. D., and A. Baco. 2007. Review of five new Alaskan species of the deep-water octocoral *Narella* (Octocorallia: Primnoidae). Syst. Biodiv. 5:391–407.

Cairns, S. D., and F. M. Bayer. 2003. Studies on western Atlantic Octocorallia (Coelenterata: Anthozoa). Part 3: The genus *Narella* Gray, 1870. Proc. Biol. Soc. Wash. 116:617–648.

———. 2004. Studies on western Atlantic Octocorallia (Coelenterata: Anthozoa). Part 5: The genera *Plumarella* Gray, 1870; *Acanthoprimnoa*, n. gen.; and *Candidella* Bayer, 1954. Proc. Biol. Soc. Wash 117:447–487.

———. 2007. A review of the Octocorallia (Cnidaria: Anthozoa) from Hawai'i and adjacent seamounts: The genus *Narella* Gray, 1870. Pac. Sci. 62:83–115.

———. 2009. A generic revision and phylogenetic analysis of the Primnoidae (Cnidaria: Octocorallia). Smithson. Contrib. Zool. 629:1–79.

Duchassaing, F. P., and J. Michelotti. 1860. Mémoire sur les coralliaires des Antilles. Mem. Accad. Sci. Torino (2) 19:279–365 [reprint paged 1–89].

Durán Muñoz, P., M. Sayago-Gil, F. J. Murillo, J. L. Del Río, L. J. López-Abellán, M. Sucau, and R. Sarralde. 2012. Actions taken by fishing nations towards identification and protection of vulnerable marine ecosystems in the high seas: The Spanish case (Atlantic Ocean). Mar. Pol. 36:536–543.

Ehrenberg, C. G. 1834. Beiträge zur physiologischen Kenntniss der Corallenthiere im allgemeinen und besonders des Rothen Meeres, nebst einem Versuch zur physiologischen Systematik derselben. Physik.-Math. Abhand. König. Akad. Wissen. Berlin (1832) 1:225–380.

FAO (Food and Agriculture Organization of the United Nations). 2009. Report of the technical consultation on international guidelines for the management of deep-sea fisheries in the high seas. Rome, 4–8 February and 25–29 August 2008. FAO Fish. Aquacult. Rep. 881.

Gray, J. E. 1858. Synopsis of the families and genera of axiferous zoophytes or barked corals. Proc. Zool. Soc. Lond. for 1857: 278–294.

———. 1870. Catalogue of the lithophytes or stony corals in the collection of the British Museum. British Museum, London.

Grigg, R. W., and F. M. Bayer. 1976. Present knowledge of the systematics and zoogeography of the order Gorgonacea in Hawaii. Pac. Sci. 30:167–175.

Johnson, J. Y. 1862. Descriptions of two new corals from Madeira, belonging to the genera *Primnoa* and *Mopsea*. Proc. Zool. Soc. Lond. for 1862: 245–246.

Kinoshita, K. 1907. Vorläufige Mitteilung über einige neue japanische Primnoidkorallen. Annot. Zool. Jpn. 6:229–237.

———. 1908. Primnoidae from Japan. J. Coll. Sci., Imp. Univ., Tokyo 23:1–74.

Kükenthal, W. 1907. Gorgoniden der Deutschen Tiefsee-Expedition. Zool. Anz. 31:202–212.

———. 1919. Gorgonaria. Wiss. Ergeb. Deut. Tiefsee-Exped. Dampfer "*Valdivia*," 1898–1899, 13:1–946.

———. 1924. Coelenterata: Gorgonaria. Das Tierreich 47. Walter de Gruyter & Co., Berlin.

Milne Edwards, H. 1857. Histoire des Coralliaires ou Polyps Proprement dits. Vol. 1. Librairie Encyclopédique de Roret, Paris.

Miyamoto, M., M. Kiyota, T. Hayashibara, M. Nonaka, Y. Imahara, and H. Tachikawa. 2017. Megafaunal composition of cold-water corals and other deep-sea benthos in the southern Emperor Seamounts area, North Pacific Ocean. Galaxea, J. Coral Reef Stud. 19:19–30.

Nutting, C. C. 1908. Descriptions of the Alcyonaria collected by the U. S. Bureau of Fisheries Steamer *Albatross* in the vicinity of the Hawaiian Islands in 1902. Proc. U.S. Natl. Mus. 34:543–601.

Pallas, P. S. 1766. Elenchus Zoophytorum. P. van Cleef, Hague Comitum.

Studer, T. 1878. Ubersicht der Steinkorallen aus der Familie der Madreporaria aporosa, *Eupsammina*, und *Turbinaria*, welche auf der Reise S. M. S. *Gazelle* um die Erde gesammelt wurden. Monatsschr. König. Preuss. Akad. Wiss. Berlin, 1877: 625–654.

Taylor, M. L., S. D. Cairns, D. Agnew, and A. D. Rogers. 2013. A revision of the genus *Thouarella* Gray, 1870 (Octocorallia: Primnoidae), including an illustrated dichotomous key, a new species description, and comments on *Plumarella* Gray, 1870 and *Dasystenella* Versluys, 1906. Zootaxa 3602:1–105.

Taylor, M. L., and A. D. Rogers. 2015. Evolutionary dynamics of a common sub-Antarctic octocoral family. Mol. Phylogenet. Evol. 84:185–204.

Thomson, J. A., and M. A. Henderson. 1906. An account of the alcyonarians collected by the Royal Indian Marine Survey Ship Investigator in the Indian Ocean, Part 1. The Alcyonarians of the deep sea. Indian Museum, Calcutta.

United Nations General Assembly. 2007. Sustainable fisheries, including through the 1995 Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation of Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, and related instruments. 4–8 February and 25–29 August 2008, UNGA Resolution 61/105. Rome.

Valenciennes, A. 1846. Zoophytes. *In*: A. Du Petit-Thouars, ed. Voyage autour du monde sur la fregate Venus, pendant les annees 1836–1839. Atlas de Zoologie, pls. 1–15. Ministre de la Marine, Paris.

Verrill, A. E. 1865. Synopsis of the polyps and corals of the North Pacific Exploring Expedition. Proc. Essex Inst., Salem 4:181–196.

Versluys, J. 1906. Die Gorgoniden der *Siboga*-Expedition. II. Die Primnoidae. *Siboga*-Exped. 13a:1–187.

Wright, E. P., and T. Studer. 1889. Report on the Alcyonaria collected by H.M.S. *Challenger* during the years 1873–76. Rep. Sci. Res. Voy. H.M.S. *Challenger* during the years 1873–76, Zool. 31:1–314.