New Distributional Records of Three Species of Euphylliidae (Cnidaria, Anthozoa, Hexacorallia, Scleractinia) from the Ryukyu Islands, Japan

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Three species of the family Euphylliidae (Cnidaria, Anthozoa, Hexacorallia, Scleractinia) have been formally recorded for the first time from the Ryukyu Islands, Japan, based on specimens. Their unique polyp morphology, such as the combination of extended tentacle, are considered to be useful for taxonomy at the species level in genus Fimbriaphyllia Veron and Pichon, 1980 and Euphyllia Dana, 1846. One reason that their distribution might have been overlooked is the insufficiency of environmental surveys, including turbid, sheltered, and upper mesophotic environments.

Key Words: Anthozoa, Scleractinia, Euphylliidae, Ryukyu Islands, Fimbriaphyllia, Catalaphyllia.

Introduction

The family Euphylliidae (Cnidaria, Anthozoa, Hexacorallia, Scleractinia) currently consists of eight genera (Luzon et al. 2018). Specimens of most of its species expand their fleshy soft body to protrude from the corallites when they are alive. In contrast to their unique polyp morphology, the skeletal features of the species within this family are not sufficiently varied to utilize for their taxonomy. Recently, a reconstruction of the classification based on molecular phylogenetic studies has been performed, and they proposed the resurrection of the genus Fimbriaphyllia Veron and Pichon, 1980 and Euphyllia Dana, 1846. One reason that their distribution might have been overlooked is the insufficiency of environmental surveys, including turbid, sheltered, and upper mesophotic environments.

Materials and Methods

The specimens were collected by hand or by using a hammer with a chisel by divers utilizing SCUBA after in situ photos were taken with digital cameras. The skeletal specimens were preserved by removing the tissues with bleach and drying. The measurement was performed using a vernier caliper with units of 0.1 mm. The specimens were deposited in the Kagoshima University Museum (KAUM), Coastal Branch of Natural History Museum and Institute, Chiba (CMNH), and the Smithsonian National Museum of Natural History (USNM).

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Results

Family **Euphylliidae** Alloiteau, 1952
Genus **Fimbriaphyllia** Veron and Pichon, 1980

**Fimbriaphyllia paraancora** (Veron, 1990)
[New Japanese name: Tsutsu-nagarehana-sango]  
(Figs 1A, D, 2A–D)

**Euphyllia paraancora** Veron, 1990: 159–162, figs 65–69, 90;

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**Fig. 1.** Underwater appearance of living corals.  
*A, in situ* photograph of the colonies of *Fimbriaphyllia paraancora* (KAUM-CN-10) on the left and *F. paradivisa* (KAUM-CN-11) at Tean, Amami-Oshima island, Kagoshima, Japan, on 21 December 2017;  
*B*, an aggregation of *F. paradivisa* approximately 3–5 m in diameter on the muddy bottom in the usually turbid inner bay at a depth 28 m, Henoko, Okinawajima island, Okinawa, Japan, on 25 November 2010;  
*C*, extended polyps of *F. paradivisa* showing branching tentacles with spherical ends;  
*D*, extended polyps of *F. paraancora* showing tentacles with anchor-shaped tips;  
*E*, *in situ* photograph of *Catalaphyllia jardinei* (KAUM-CN-14) at Tean, Amami-Oshima island, Kagoshima, Japan, on 21 December 2017;  
*F*, polyps of *C. jardinei* showing small bubble-shaped tentacles at the edge of the oral disc.
Wolstenholme et al. 1997: 389, table 2; Kenyon et al. 2011: 3, table 3; Hsieh et al. 2001: 316–317; Hoeksema and Waheed 2012: 299, fig. 2; Turak et al. 2012: 53–58; Waheed et al. 2015a: fig. 8c; Luzon et al. 2018: 1–11.

Specimens examined. KAUM-CN-100, a corallum of 81 mm height from the base, with three corallites of 14.4–34.2 mm greater calicular diameter (GCD), Tean, Oshima Strait, Setouchi, Amami-Oshima island, Kagoshima, Japan (28°9′38.98″N, 129°17′35.04″E), 32 m in depth, collected by Takuma Fujii on 21 December 2017; CMNH-ZG 09105, a corallum of 55 mm height, with seven corallites of 15.2–35.3 mm GCD, Tean, Oshima Strait, Setouchi, Amami-Oshima island, Kagoshima, Japan (28°9′39.00″N, 129°17′35.00″E), 35 m in depth, collected by Hiroyuki Tachikawa on 3 February 2018; CMNH-ZG 08523, a corallum of 154 mm height, with six corallites of 21.9–37.1 mm GCD, Wase, Sumiyo Bay, Amami, Amami-Oshima island, Kagoshima, Japan (28°17′36.04″N, 129°28′32.00″E), 9 m in depth.

Fig. 2. Corallum of Fimbriaphyllia species currently reported from the Ryukyu Islands, Japan, F. paraancora (A–D) and F. paradivisa (E–H). A, KAUM-CN-10, Tean, Amami-Oshima island, Kagoshima, Japan, depth of 32 m; B, CMNH-ZG09105, Tean, Amami-Oshima island, Kagoshima, Japan, depth of 35 m; C, CMNH-ZG 08523, Wase, Amami-Oshima island, Kagoshima, Japan, depth of 9 m; D, CMNH-ZG 07195, Ii-nanshi, Ogamijima island, Okinawa, Japan, depth of 10 m; E, KAUM-CN-11, Tean, Amami-Oshima island, Kagoshima, Japan, depth of 32 m; F, CMNH-ZG 09661, Tean, Amami-Oshima island, Kagoshima, Japan, depth of 32 m; G, KAUM-CN-12, Henoko, Okinawajima island, Okinawa, Japan, depth of 28 m; H, CMNH-ZG-09661, Henoko, Okinawajima island, Japan, depth of 28 m.
depth, collected by Hiroyuki Tachikawa on 11 September 2017; and CMNH-ZG 07195, a corallum of 108 mm height from base, with five corallites of 23.1–35.0 mm GCD, Ilnanshi, Miyakojima, Ogajima island, Okinawa, Japan (24°55′29.13″N, 125°18′20.48″E), 10 m in depth, collected by Hiroyuki Tachikawa on 7 July 2015.

**Morphology.** The morphological features of the soft body and the skeletal characteristics examined in this study agreed with the original description. Colony phaceloid with fleshy tentacles with anchor-shaped tips extend during day (Fig. 1A, D). Tubular corallum branching with weak costae, epitheca absent. Corallites greater diameter 14–37 mm in this study, up to four cycles of fine granulated septa without pali (Fig. 2A–D). Columella absent.

**Habitat and distribution.** Specimens collected in the current study were from hilly, muddy, and rubbly seafloor areas at depth greater than 30 m inside a bay (Tean) or on the undulating reef wall in comparatively turbid and sheltered coral reef areas at the mouth of a bay (Wase). This species was previously known from Bolinao (the Philippines) of the type locality, Motupore (Papua New Guinea) (Veron 1990), Penghu (Taiwan) (Hsieh et al. 2001), Kota Kinabalu (Malaysia) (Hoeksma and Weaheed 2012), Spratly Islands (Waheed et al. 2015a), Bali (Indonesia) (Turak et al. 2012), Northern Australia (Wolstenholme et al. 1997), and Guam (Randall and Myers 1983; Randall 2003). A photograph in a field guide to coral in Japan representing the features of this species showed the possibility of its distribution in Japan (Nishihira and Veron 1995); however, no information about the photograph was available. Yokochi et al. (2019) listed this species from Iriomotejima island, Japan without any vouchers. The specimens in this study formally represent the northernmost distributional record and the first record from Japan.

**Remarks.** The soft body of *F. parancora* resembles *F. an- cora* in its anchor-shaped tentacles (Fig. 1D), but it was easy to distinguish through its colony shape, as the latter forms a flabello-meandroid corallum (Fig. 2A–D). It is difficult to distinguish from other phaceloid species in the family Euphylliidae, such as *Euphyllia glabrescens* (Chamisso and Eysenhardt, 1821), *E. paraglabrescens* Veron, 1990, and *F. paradi- visa* by its skeletal features alone, with the exception of *Euphyllia baliensis* Turak, Devantier, and Erdman, 2012, which has a unique tetra or ocellar septal pattern and small cali- cular diameter. This species can be distinguished from the other species in the same genus by genetic sequencing as well (Luzon et al. 2018).

**Fimbriaphyllia paradivisa** (Veron, 1990)  
[New Japanese name: Tsutsu-koeda-nagarehana-sango]  
(Figs 1A–C, 2E–H)

*Euphyllia paradivisa* Veron, 1990: 157–159, figs 63, 64, 89;  
Kenyon et al. 2011: 3, table 3; Eyal et al. 2016: 91–100;  
Luzon et al. 2018: 1–11.  
Fimbriaphyllia paradivisa: Montgomery et al. 2019: 54, 158.

**Specimens examined.** KAUM-CN-11, a corallum of 95.1 mm height from the base, with five corallites of 18.1–29.4 mm and a dividing corallite of 46.1 mm GCD, Tean, Oshima Strait, Setouchi, Amami-Oshima island, Kagoshima, Japan (28°9′38.98″N, 129°17′35.04″E), 32 m in depth, collected by Takuma Fujii on 21 December 2017; CMNH-ZG 09104, a fragment of a corallum of 80 mm height, with two corallites of 38.6–41.1 mm GCD, 32 m in depth, the same site as KAUM-CN-11, originally a part of the colony of KAUM-11 and separated by Takuma Fujii on 21 December 2017 and collected by Hiroyuki Tachikawa on 3 Febru- ary 2018; KAUM-CN-12, a corallum of 140 mm height, with five oval corallites of 19.5–27.2 mm, two dividing corallites of 34.0–29.8, and a dead corallite of 30 mm GCD, Henoko, Oura Bay, Nago, Okinawajima island, Okinawa, Japan (26°31′50.85″N, 128°3′17.98″E), 28 m in depth, collected by Masaru Mizuyama on 16 September 2018; and CMNH-ZG 09661, a corallum of 101 mm height from the base, with five corallites of 21.0–27.8 mm GCD with a dividing corallite of 33.4 mm GCD, Henoko, Oura Bay, Nago, Okinawajima island, Okinawa, Japan (26°31′50.85″N, 128°3′17.98″E), 28 m in depth, collected by Masaru Mizuyama on 16 September 2018.

**Morphology.** The morphological features of both the soft body observed in situ and the skeletal characteristics examined in this study agree with the original description. Colony phaceloid, tentacles branching with spherical ends (Fig. 1A–C). Tubular corallum branching with weak costae, epitheca absent. Corallites greater diameter 14–30 mm in this study, up to four cycles of fine granulated septa without pali. Columella absent (Fig. 2E–H).

**Habitat and distribution.** Specimens collected by the current study were from hilly, muddy, and rubbly seafloor areas of depth greater than 30 m inside two bays of Okinawajima island and Amami-Oshima island, respectively (Henoko and Tean). This species was described from a depth of 8 m in Bolinao, Philippines, by Veron (1990), and, at present, is known from Lian (Philippines; Luzon et al. 2018), American Samoa (USA) (Montgomery et al. 2019), and Eilat (Israel) (Eyal et al. 2016). In Japan, in situ photographs of the large assemblage of presumed members of this species were posted in a book (Diving Team Snuck Snufkin 2015); however, no specimen-based record has been made thus far. Additionally, specimens from Okinawajima island were suggested by Eyal et al. (2016), but they are in a private collection, and the information is unavailable. The present study formally represents the new and northernmost distributional record of *F. paradivisa* from Japan based on the available specimens.

**Remarks.** The soft body of *F. paradivisa* resembles that of *F. divisa* in its branching tentacles with spherical ends (Fig. 1C), but it is easy to distinguish through its colony shape, as the latter forms a flabello-meandroid corallum (Fig. 2E–H). This species can also be distinguished from other species in the same genus by genetic sequencing (Luzon et al. 2018). Although this species was previously known only from a few locations, it is likely that immature colonies of *F. paradivisa* were confused with *F. divisa* and overlooked in some places. The species’ habit of forming assemblage at greater depths, such as mesophotic zones, might have been overlooked as
well, as suggested by Eyal et al. (2016).

Genus Catalaphyllia Wells, 1971
Catalaphyllia jardinei (Saville-Kent, 1893) (Figs 1E, F, 3, 4)

Pinctinia jardinei Savill-Kent, 1893: 158, pl. 4.
Catalaphyllia jardinei: Wells 1971: 368–370; Veron 2000: 82–83; Nomura and Mezaki 2015: 35, pl. 2.
Euphyllia sabiuraensis Eguchi, 1973: 82–83, pl. 1.
Cattalophyllia sabiuraensis: Eguchi and Miyawaki 1975: 54, pl. 6; Kushimoto Marine Park Center 1977: 3, 48.
Catalaphyllia sabiuraensis: Shirai 1977: 584.

Specimens examined. KAUM-CN-13, a fan-shaped corallum with a pointed base, corallum height of 126.4 mm, elongated calice of 209.3 × 26.8 mm calicular diameter, calice bifurcated and trifurcated at each end, Tean, Oshima Strait, Setouchi, Amami-Oshima island, Kagoshima, Japan (28°9′38.98″N, 129°17′35.04″E), 32 m in depth, collected by Takuma Fujii on 21 December 2018; and KAUM-CN-14, a fan-shaped corallum with a pointed base, 96.8 mm in height, elongated calice of 177.9 × 33.6 mm calicular diameter, Nishikomi, Oshima Strait, Setouchi, Amami-Oshima island, Kagoshima, Japan (28°14′28.86″N 129°10′6.33″E), 31 m in depth, collected by Takuma Fujii on 03 May 2019.

Comparative specimens examined. Photographs of the previously collected specimens are shown in Fig. 4. USNM 1259568, Horseshoe Cliffs, Onna, Okinawajima island, Okinawa, Japan, depth range 52–55 m, collected by Robert F. Bolland on 21 December 1988. USNM 94409, off Nago City, Nago, Okinawajima island, Okinawa, Japan, 27 m in depth, collected by Robert F. Bolland on 21 February 1992.

Morphology. The specimens collected at Amami-Oshima island show typical features of the current monotypic genus Catalaphyllia Wells, 1971, solid flabello-meandroid corallum with wide V-shaped valley moderately and linearly became hollow into the center, septa with a few teeth developed only in the inner margin (Fig. 3). The living polyp also shows the unique feature of the genus in thick fleshy oral disc which is expanded during the day and tubular to small

Fig. 3. Corallum of Catalaphyllia jardinei currently reported from Amami-Oshima island, Japan. A, side view of the corallite of KAUM-CN-14; B, view from the top side of the corallite and the calice of KAUM-CN-14; C, side view of the corallite of CMNH-ZG 09662; D, view from the top side of the corallite and the calice of CMNH-ZG 0966 showing three-forked branching of the calice.
bubble-shaped tentacles with a spherical tip at the edge (Fig. 1E, F).

**Habitat and distribution.** Specimens collected in the current study were from hilly, muddy, and rubbly seafloor areas at a depth greater than 30 m inside two different bays in the Oshima Strait (Tean and Nishikomi). *Catalaphyllia jardinei* was originally described from the Great Barrier Reef, Australia (Saville-Kent 1893), and is also known from the northern Great Barrier Reef (Veron and Pichon 1980), New Caledonia (Wells 1971), Malaysia (Waheed and Hoeksema 2014) and Indonesia (Best et al. 1989). In Japan, this species has been reported only in temperate (northern) localities such as Miyazaki (Fukami pers. comm.; Ministry of Environment, Japan 2017), Kumamoto, Kagoshima, Nagasaki (Ministry of Environment, Japan 2017), Kochi (Nomura and Mezaki 2015), and Wakayama (e.g., Eguchi 1973; Nomura and Hirabayashi 2018). Although the Ryukyu Islands have been considered as a distributional gap in the species (e.g., Nishihira and Veron 1995; Veron 2000), two specimens from the east shore of Okinawajima island, in

![Fig. 4. Specimens of *Catalaphyllia jardinei* preserved in the Smithsonian National Museum of Natural History (Photographs taken by Allison Becker) (USNM). A–B, corallite of USNM 1259568, collected at 52–55 m deep off Manza Horseshoe Cliffs, Onna, Okinawajima island, Okinawa, Japan, on 21 December 1988, by Robert F. Bolland; C–D, corallite of USNM 94409, collected at 27 m deep off Nago City, Nago, Okinawajima island, Okinawa, Japan, on 21 February 1992, by R. F. Bolland.](image-url)
the middle of the Ryukyu Islands, have been kept at USNM without publication (USNM 94409 and USNM 1259568; Fig. 4). Both specimens from Amami-Oshima island in the current study and the USNM specimens from Okinawajima island fill the distributional gaps of *C. jardinei* between the tropical Western Pacific region and temperate Japan. Sinnerger *et al.* (2019) observed *C. jardinei* at mesophotic region of Sesokojuima island, Okinawa.

**Remarks.** Two nominal species of *Catalaphyllia, C. sabius- rajenis* Eguchi, 1973, and *C. okinawaensis* Eguchi and Shirai, 1977, have been described from Japan. At present, these two species are considered to be junior synonyms of *C. jardinei* and *E. glabrescens*, respectively (Veron 1992). Currently, the genus *Catalaphyllia* is considered to be monospecific, with its sole member being *C. jardinei*. Because of its rarity, not much information about the genus has been reported in Japan, and a taxonomical reexamination including its phylogenetic position is necessary.

**Discussion**

Amami-Oshima island, the second-biggest island in the Ryukyu Islands, is located close to the northernmost area with developed coral reef. In addition, it is known as the area where the climate and fauna shift from tropic to temperate. Despite its biogeographic importance, the marine biodiversity of this area is currently poorly studied (e.g., Nakae *et al.* 2018). With regard to the zooxanthellate corals, no specimen-based distributional records have been made since Yabe and Sugiyama’s pioneering study in this area (e.g., Yabe *et al.* 1936; Yabe and Sugiyama 1941). Additionally, the major known habitats of the three euphylliid corals currently reported, such as turbid, sheltered, and mesophotic zones, have tended to be outside the research interests of coral surveys. One of the unique features of the geography of Amami-Oshima island is its many bays with a great depth range (< 30 m) originating from the Rias Coast. This might have caused coral assemblages to remain that are dominated by zooxanthellate corals, which are tolerant to low light intensity, such as those belonging to the genus *Leptoseris* (Fujii *et al.* 2018). Although it remains to be verified that the observed habitat and the morphological features of *F. para- ancora* in this study were comparatively different from the other two species (Veron 2000), the three euphylliid corals reported in the present study were found in comparatively sheltered environments. Further examination focused on turbid, sheltered environments or on the upper mesophotic zones will help us to more thoroughly understand the diversity and distributional patterns of not only the three euphylliid corals but also other zooxanthellate corals, such as mushroom corals occurring on sandy habitats (e.g., Gittenberger *et al.* 2015; Waheed *et al.* 2015b; Hoeksema and Suharsono 2019).

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