A New *Distichopora* Species (Cnidaria: Stylasteridae) from the Mesophotic Zone of Palau

Stephen D. Cairns, and Daniela Pica

**Abstract:** Stylasterid corals are widely distributed in all oceans from the intertidal zone to the deep sea. They are habitat-forming species, reaching high densities and establishing a wide range of associations with other taxa. In the last decades, many new deep-water stylasterids have been described and the faunas of several regions of the globe have been revised; however, the tropical Pacific Ocean remains relatively understudied. In this paper, a new mesophotic species of *Distichopora, D. cryptostylus,* is described from the Republic of Palau, Caroline Islands. The new *Distichopora* is distinguished from congeners by its uniquely shaped coenosteal pores, a paucity of dactylostyles, and apical dactylotomes.

**Keywords:** stylasterids, Pacific Ocean, coral reef, taxonomy, *Distichopora*

Stylasterid corals, commonly known as “lace corals,” belong to the family Stylasteridae (Cnidaria, Hydrozoa), which is one of the two hydroid families having a hard, calcareous skeleton. Stylasterid colonies are polymorphic, characterized by having gastrozooids, dactylozooids, and gonophores. Coenosarcal canals usually permeate the entire skeleton linking together all these structures and forming a complex tridimensional canal network (Puco et al. 2011, 2012).

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2. Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution, Washington, DC 20560, USA.

3. Dipartimento di Scienze della Vita e dell’Ambiente, Università Politecnica delle Marche, Ancona, Italy.

4. Corresponding author (e-mail: daniela.pica@gmail.com).

Stylasterid corals are widely distributed in all the oceans, except for the Arctic region, at depths ranging from 0 to 2789 m, with a maximum concentration of species between 200 and 500 m (Cairns 2011). They are mainly known from deep water where they originated and diversified, and from where they colonized shallow waters (Lindner et al. 2008). To date, few species are found shallower than 40 m depth and only *Stylantheca papillosa* and an undescribed *Distichopora* species are reported from the intertidal zone (Fisher 1938, Pica et al. 2014). Due to their rigid, branched skeletons, they are considered habitat-forming species in deep water where they constitute important components of the so-called “cold water coral gardens” (Häussermann and Försterra 2007, Cairns 2011). They are also important in shallower waters where they reach high densities and establish a wide range of associations with other taxa (Zibrowius 1981, Goud and Hoeksema 2001, Pica et al. 2012, 2015, 2016, Tribollet et al. 2018).

During the last decades many new deep-water stylasterids have been described and the faunas of several regions of the globe have been revised (i.e., Cairns 1983, 1991, 2005, 2015, Zibrowius and Cairns 1992, Cairns and Lindner 2011, Cairns and Zibrowius 2013). Nevertheless, one area that remains poorly studied with respect to stylasterids fauna is the Pacific Ocean, and particularly the tropical...
areas. Several species were described during the eighteenth and the beginning of the nineteenth centuries (i.e., Dana 1848, Milne Edwards and Haime 1857, Moseley 1881, Hickson and England 1905), but for many of them the type locality or the depth were not reported. A revision of stylasterids in the Pacific Ocean was done by Boschma (1953), who analyzed all the literature records and recorded the presence of many species in the deep waters of several regions. However, the same author highlighted the absence of recorded stylasterids in many group of islands in the tropical Pacific, such as in the Republic of Palau, although he hypothesized that future research might prove their presence there (Boschma 1953). After this work, no taxonomic papers have been published on shallow-water stylasterids of the tropical Pacific Ocean. However, a few stylasterid records were noted in literature or field guides of the region (Wells 1954, Weber and Woodhead 1972, Veron 2000, Fenner and Miur 2008). The aims of the present paper are to formally record for the first time the presence of stylasterid corals in Palau Island and to describe a new species of Distichopora.

MATERIAL AND METHODS

The analyzed materials were obtained from the California Academy of Sciences (CAS) and the Smithsonian National Museum of Natural History (NMNH). The specimens were collected in Palau Island by Pat Colin in three different campaigns in 1998, 2001 and 2008. The morphology of the colonies was first observed using a stereomicroscope, and then selected coral branches were prepared for scanning electron microscopy (SEM) analysis (Cairns 1983). The samples were coated with gold-palladium and photographed with an SEM (Zeiss EVO MA15).

RESULTS

Systematic Account

Class Hydrozoa
Order Anthothecata
Suborder Filifera
Family Stylasteridae Gray 1847

Distichopora Lamarck 1816

Type Species: Millepora violacea Pallas 1766, by monotypy.

Diagnosis. (adapted from Cairns 2015) Colonies branching or flabellate, usually with blunt branch tips. Coenosteum reticulate-granular, reticulate-spinose, linear-imbricate, or lacking coenosteal strips; coenosteum of many colors. Gastropores aligned along branch edge usually within a sulcus, sometimes meandering on branch face. Gastropore row flanked usually on both sides by a row of horseshoe-shaped dactylopore spines, their dactylotomes oriented toward the gastropore row. Gastro- and dactylopores axial; dactylostomes usually absent and in one case a dactyloridge is present. Gastrostyles needle-shaped, elongate, often stabilized by transverse tabulae; a diffuse ring palisade is often present. Ampullae usually superficial and usually clustered.

Distribution. Eocene to recent: recent species are cosmopolitan, except for the eastern Atlantic, Arctic, and Antarctic, 0–1267 m (Cairns 2015).

Remarks. Including D. cryptostylus, 26 living species are found in the genus Distichopora (see Schuchert 2019), as well as two exclusively fossil species. In a family (i.e., Stylasteridae) in which 89% of its species are found deeper than 50 m (Cairns 2007), the genus Distichopora is atypical in that 8 of its 26 species (31%) are confined to shallow water. The species described herein is considered to be a mesophotic species.

Distichopora cryptostylus n. sp.

Figures 1–2

Type Material. Holotype: male colony (CAS 308408) and SEM stub 2643, 7° 16.51’ N, 134° 31.55’ E (Palau, 4 km east of Lighthouse Reef barrier reef, west sheltered side of reef), station Mutremidui, 122 m depth, coll. P. Colin, 4 September 2008, preserved in 70° alcohol.

Paratype: male colony (USNM 100167) and SEM stubs 2642, 2644–2645 (USNM), Palau, Short Drop Off, 137–153 m, coll. P. Colin, 16 August 1998, preserved dry. One branch, sex undetermined (USNM 1006516) *middle of
three Western Island, south of German Channel, Palau, Deepworker DSR, 213 m, coll. P. Colin, 26 March 2001, preserved 95° ethanol.

**Type Locality.** 7° 16.51' N, 134° 31.55' E, Palau, 122 m depth.

**Description.** The colonies are uniplanar (Figure 1A–C), with unequal dichotomous branching, and apparently broader than tall, the largest of the two colonies (the holotype) measuring 33 mm in height and 78 mm in width, with a basal branch diameter of 5.1 mm. Distal branches are blunt and somewhat rectangular in cross section, becoming more circular in cross section with greater size toward the base of the colony. Coralla are white and somewhat glistening. There are no coenosteal strips; rather the coenosteum is uniformly covered with short (up to 0.03 mm in height), squat, pointed spines, which also encircle or partially encircle the gastropores as a low circular rim (Figure 2A). The coenosteum is also covered with short (about 0.15 mm in height), discontinuous ridges that are often aligned with the dactylopores, and numerous uniformly distributed coenosteal pores (Figure 2A, B). The coenosteal pores (0.023–0.055 mm in diameter) are small hemispherical structures that often sit in a slight coenosteal depression (Figure 2C–E). Coenosteal pores also commonly occur in the gastropore sulcus (Figure 2A, F). Coralla are white.

The lateral pore rows are 0.75–1.1 mm wide, containing a broad, shallow sulcus in which the linearly arranged gastropores occur (Figure 2A, F). The gastropores are round in shape and variable in size, ranging from 0.18 to 0.42 mm in diameter (Figure 2F). Gastrostyles are rarely seen in unbroken or even broken branches, but do occur and are typically elongate (needle-shaped) and bear a fine supination (Figure 2G). The gastropore tubes contain a diffuse ring palisade composed of elongate blunt elements up to 0.1 mm in length and 0.030 mm in diameter (Figure 2G). Tabulae were not observed. The gastropores are flanked on either side by a row of thin-walled dactylopores, which are usually elliptical in cross section, the greater axis (up to 0.24 mm) oriented perpendicularly to the gastropore row and united to adjacent dactylopores by a tall (up to 0.23 mm) thin ridge (Figure 2A, E, F). Dactylopores are cylindrical with an apical pore (Figure 2A, E, F, H). Up to 23 dactylopores occur per cm, although they are usually more numerous on one side of the gastropore row than the other (Figure 2A, F). The two inner lateral faces of each dactylopore bear irregularly shaped elements up to 0.020 mm in height and 0.009 mm in diameter, similar to rudimentary dactylostyles (Figure 2H, I). The irregularly shaped male ampullae are clustered on both branch faces (Figure 2I), and are partially submerged in the coenosteum, their external diameter 0.55–0.65 mm, their internal diameter about 0.45 mm. Each ampulla appears to have multiple apical efferent pores, each found at the base of a shallow depression.
Figure 2. (A) Stereo views of a branch of the paratype showing the texture and the pore row; (B) stereo views of the texture showing coenosteal pores, spines, and ridges; (C) stereo views of the coenosteal pores and male ampullae; (D) detail of a coenosteal pore; (E) spines of the texture and two dactylopores on the ridge; (F) stereo views of the gastropores flanked on either side by dactylopores; (G) stereo views of the points of the gastrostyles and ring palisade; (H) dactylopore with rudimentary dactylostyles; (I) detail of rudimentary dactylostyles; (J) stereo views of the male ampulla. Scale bars: (A) 1 mm; (B) 100 μm; (C) 200 μm; (D) 40 μm; (E) 100 μm; (F) 400 μm; (G) 100 μm; (H) 30 μm; (I) 10 μm; (J) 200 μm.
about 0.25 mm in diameter, the efferent pore being 0.06–0.1 mm in diameter (Figure 2C).
Each efferent pore is encircled by numerous thin pillars about 0.022 mm in length that
project horizontally into the pore. Female
ampullae are unknown.

Comparisons. Distichopora cryptostylus differs from all other congeners (WoRMS
2019) in several characters: (1) its texture and
coenosteal pores are unique in shape; (2) its
dactylopores are unique in having apical
pores, not lateral dactylotomes; (3) it has very
few and inconspicuous gastrostyles; (4) it has
rudimentary dactylostyles; (5) although not
unique, it is one of only a few species that has a
ridge uniting its dactylospine spines. Among
the other described species, it is perhaps
closest in morphology to D. contorta de
Pourtalès 1878 (known only from off Cuba,
125–368 m, see Cairns 1986) in that both
species have linked dactylopore spines, a
ridged coenosteum, and similar-sized male
ampullae, but D. contorta differs in lacking the
unique characters mentioned above, in having
discrete coenosteal strips.

Etymology. From kryptos + stylos (Greek
for hidden style), in allusion to the rarity and
inconspicuous nature of the gastrostyles.

Distribution. Known only from the
Republic of Palau, western Pacific, 122–213 m.

Discussion
Stylasterid corals are considered habitat-
forming species (Häussermann and Försterra
2007, Cairns 2011), reaching in some areas
high density and establishing a wide range of
association with many organisms, enhancing
the biodiversity of areas where they grow
(Zibrowius 1981, Goud and Hoeksema
2018). Paradoxically the distribution and
the ecology of this group is poorly known and
and some regions unknown. The tropical
Pacific Ocean is one of these regions that
remains understudied with respect to stylas-
terid fauna. Many undescribed stylasterids are
found in several museums around the world
that represent an important reservoir of
information about biodiversity and species
distribution. Museum specimens collected in
the Republic of Palau led to the description
of a new species in this region Distichopora
cryptostylus. In the Archipelago, little pub-
lished information is available about stylas-
terid presence and distribution, and most
records come from non-taxonomic papers,
thus their species identification remain uncer-
tain (Wells 1954, Weber and Woodhead
In fact, many records and identification of
stylasterids from the tropical Pacific Ocean
need to be revised and confirmed.

Knowledge about biodiversity and distribu-
tion of the stylasterid species is funda-
mental to defining and understanding their
habitat and bathymetric range distribution,
understanding how and where these corals
could be influenced by climate change and
anthropogenic impacts, and for the identifica-
tion of priority areas for conservation.
Hydroids are considered as sentinel species
for monitoring climate change and environ-
mental stress (Di Camillo et al. 2008, Puce
As stylasterids are hydroids they could
potentially be used as environmental senti-
enls; however, the first step is to increase
knowledge about their biodiversity, distribu-
tion, and ecology.

Stylasterid corals are under CITES reg-
ulation as endangered species. Threats
include harvesting for souvenirs and jewelry
(Häussermann and Försterr 2007, Cairns
2011, Cairns and Zibrowius 2013) and
damage by diving activity (Miller et al.
2004). More information about their distribu-
tion and ecology is important to inform
conservation plans as for other corals (Roberts

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