ResearchGate

See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/344420272

Anthopleura mariae sp. nov. (Cnidaria: Actiniaria: Actiniidae), a New Species of Sea Anemone from the Mexican Pacific

Article *in* Pacific Science · September 2020

DOI: 10.2984/74.2.5

CITATION
1

READS
179

4 authors:

Aurora Vassallo
Universidad Nacional Autónoma de México
4 PUBLICATIONS **14** CITATIONS

SEE PROFILE

Ricardo González-Muñoz
Instituto de Investigaciones Marinas y Costeras (IIMyC) - Universida…
41 PUBLICATIONS **193** CITATIONS

SEE PROFILE

Fabián H Acuña
Universidad Nacional de Mar del Plata
86 PUBLICATIONS **675** CITATIONS

SEE PROFILE

Gerardo Rivas
Universidad Nacional Autónoma de México
56 PUBLICATIONS **348** CITATIONS

SEE PROFILE

Some of the authors of this publication are also working on these related projects:

Project

Epicontinental amphipods from Mexico, with emphasis in Hyalella genus View project

Project

Sea anemones (Cnidaria: Actiniaria, Ceriantharia, Corallimorpharia, Zoanthidea) from Venezuela View project

All content following this page was uploaded by Aurora Vassallo on 16 June 2022.

The user has requested enhancement of the downloaded file.

BioOne COMPLETE

Anthopleura mariae sp. nov. (Cnidaria: Actiniaria: Actiniidae), a New Species of Sea Anemone from the Mexican Pacific

Authors: Vassallo-Avalos, Aurora, González-Muñoz, Ricardo, Acuña, Fabián H., and Rivas, Gerardo

Source: Pacific Science, 74(2) : 159-170

Published By: University of Hawai'i Press

URL: https://doi.org/10.2984/74.2.5

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

Downloaded From: https://bioone.org/journals/Pacific-Science on 29 Sep 2020
Terms of Use: https://bioone.org/terms-of-use Access provided by Universidad Nacional Autonoma de Mexico (UNAM)

Anthopleura mariae sp. nov. (Cnidaria: Actiniaria: Actiniidae), A New Species of Sea Anemone From the Mexican Pacific[1]

Aurora Vassallo-Avalos,[2,3] *Ricardo González-Muñoz,*[4,6] *Fabián H. Acuña,*[4,5] *and Gerardo Rivas*[3]

Abstract: *Anthopleura mariae* sp. nov. is a new species of sea anemone (Actiniaria: Actiniidae) from the rocky intertidal of Punta Morro, Baja California, and Punta Eugenia Baja California Sur, México. This species is characterized by a column with verrucae arranged in longitudinal rows from margin to limbus with a red spot atop each verruca, as well as the presence of more than two siphonoglyphs and the lack of directive mesenteries. Differences between *Anthopleura mariae* sp. nov. with other species of the genus are discussed. This is the sixth species of *Anthopleura* documented for the Mexican Pacific.

Keywords: Anthozoa, Hexacorallia, Actiniaria, Pacific Coast, México, invertebrates

The genus *Anthopleura* Duchassaing de Fonbressin and Michelotti, 1860 is one of the most well-known genera of sea anemones classified within the family Actiniidae Rafinesque, 1815, which can be commonly found in both temperate and tropical rocky intertidal habitats (Daly 2004*a*, Daly et al. 2017, Spano and Häussermann 2017). Members of *Anthopleura* are recognized by the occurrence of both acrorhagi and adhesive hollow structures called verrucae in their columns (Stephenson 1935, Carlgren 1949, Daly and den Hartog 2004, Daly et al. 2017). However, the presence of these anatomical features is not exclusive to *Anthopleura*, since either only one or both can also be present in other genera within the superfamily Actinioidea (Daly et al. 2017). *Anthopleura* is paraphyletic with respect to Actinioidea, which can be explained in part by the recent discovery that both acrorhagi and verrucae are plesiomorphic characters (Daly et al. 2017). Although the phylogeny of *Anthopleura*, and the homology of acrorhagi and verrucae across Actinioidea is still unclear (Daly et al. 2017), these two anatomical features are traditionally used to distinguish members of this genus from other genera within Actiniidae.

There are currently 47 known species within the genus *Anthopleura* (Daly and Fautin 2019*a*), five of them have been previously reported in the Northeast Pacific coast: *A. artemisia* (Pickering in Dana 1846), *A. dowii* Verrill, 1869, *A. elegantissima* (Brandt, 1835), *A. sola* Pearse and Francis 2000 and *A. xanthogrammica* (Brandt, 1835) (Carlgren 1951, Hand 1955, Gotshall and Laurent 1979, Brusca 1980, McFadden et al. 1997, Pearse and Francis 2000, Geller and Walton 2001, Daly 2004*a*, Hendrickx et al. 2005, Kerstitch

[1]Manuscript accepted 21 April 2020.
[2]Posgrado en Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, Instituto de Ciencias del Mar y Limnología, Ciudad Universitaria, Ciudad de México, México.
[3]Laboratorio de Zoología Acuática, Dpto. Biología Comparada, Facultad de Ciencias, Universidad Nacional Autónoma de México, Ciudad Universitaria, Ciudad de México, México.
[4]Laboratorio de Biología de Cnidarios, Instituto de Investigaciones Marinas y Costeras (IIMyC), CONICET – Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Mar del Plata, Funes 3250, 7600 Mar del Plata, Argentina.
[5]Estación Científica Coiba (Coiba-AIP), Clayton, Panamá, República de Panamá.
[6]Corresponding author (e-mail: ricordea.gonzalez@gmail.com).

Pacific Science (2020), vol. 74, no. 2:159–170
doi:10.2984/74.2.5
© 2020 by University of Hawai'i Press.
All rights reserved.

Downloaded From: https://bioone.org/journals/Pacific-Science on 29 Sep 2020
Terms of Use: https://bioone.org/terms-of-use Access provided by Universidad Nacional Autonoma de Mexico (UNAM)

and Bertsch 2007, Barragán et al. 2019, Daly and Fautin 2019*b*, 2019*c*).

In the present study, a new species of sea anemone is described from specimens collected in the intertidal of Punta Morro, Baja California, and Punta Eugenia, Baja California Sur, México. The taxonomic features of *A. mariae* sp. nov. resemble in some aspects *A. nigrescens* (Verrill, 1928) and *A. buddemeieri* Fautin 2005. However, *A. mariae* sp. nov. presents differences that are discussed below, as well as the distinctions with other species of *Anthopleura* reported for the region.

MATERIAL AND METHODS

Nine specimens were collected in the rocky intertidal zone of the west coast of Baja California Peninsula. Specimens of *A. mariae* sp. nov. were found in two locations sampled along the coast: Punta Morro, Baja California, México (31° 51.7354′ N, 116° 40.0452′ W) and Punta Eugenia, Baja California Sur, México (27° 51.3144′ N, 115° 4.3481′ W) (Figure 1). Collections were made by hand, using a chisel and a hammer. Collected specimens were transferred to the laboratory and maintained in an aquarium to photograph their color while alive. Specimens were relaxed in 7% $MgCl_2$ seawater solution, subsequently fixed in 10% seawater formalin, and stored in 70% ethanol (Häussermann 2004). Body measurements are from preserved specimens. Cnidae capsules were identified in squash preparations of tissue from tentacles, marginal projections, actinopharynx, column, and filaments (Häussermann 2004), and examined in a light microscope (1,000× oil immersion). The length and width of at least 20 undischarged capsules of each type of cnidae detected by each tissue were measured in four specimens. We follow the cnidae terminology implemented by Sanamyan et al. (2012) and Gusmão et al. (2018, 2019), which combines the classification of Weill (1934), modified by Carlgren (1940) and thus differentiating basitrichs from microbasic *b*-mastigophores, with that of Schmidt (1969, 1972, 1974), which captures the underlying

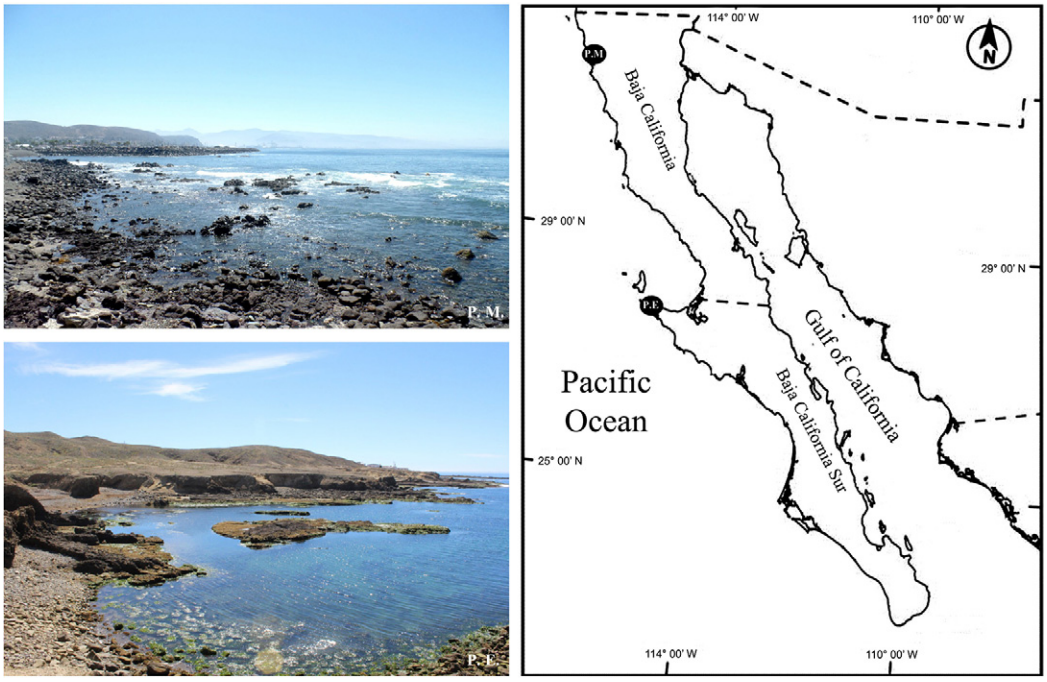

FIGURE 1. Map of the Baja California Peninsula. Black circles indicate Punta Morro, Baja California (P.M.) and Punta Eugenia, Baja California Sur (P.E.). Modified from Cupul-Magaña et al. (2017)

Downloaded From: https://bioone.org/journals/Pacific-Science on 29 Sep 2020
Terms of Use: https://bioone.org/terms-of-use Access provided by Universidad Nacional Autonoma de Mexico (UNAM)

variation seen in rhabdoids. To observe the internal morphology, histological serial sections were made (10–12 μm thick) following paraffin embedding and stained with Hematoxylin-Eosin (Estrada et al. 1982). Holotype and voucher specimens were deposited in the Colección de Invertebrados Acuáticos de la Facultad de Ciencias de la Universidad Nacional Autónoma de México (registration code: IAFCUNAM), and one paratype in the American Museum of Natural History (AMNH). The taxonomic treatment follows the systematic arrangement proposed by Rodríguez et al. (2014).

RESULTS

Suborder Enthemonae Rodríguez and Daly, 2014 in Rodríguez et al. (2014)
Superfamily Actinioidea Rafinesque, 1815
Family Actiniidae Rafinesque, 1815
Genus *Anthopleura* Duchassaing de Fonbressin and Michelotti, 1860

Anthopleura mariae sp. nov.
(Figures 2–3, Table 1)

Material Examined

Holotype: one specimen (IAFCUNAM-AN-0126), Punta Morro, Baja California, México, (31° 51.7354′ N, 116° 40.0452′ W), 0.5 m depth, 14 March 2017, colls. A. Vassallo-Avalos and C. Conejeros-Vargas. Paratypes: two specimens (IAFCUNAM-AN-0048), Punta Eugenia, Baja California Sur, México, (27° 51.3144′ N, 115° 4.3481′ W), 0.5 m depth, 21 June 2016, colls. A. Vassallo-Avalos and C. Conejeros-Vargas; three specimens (IAFCUNAM-AN-0103), Punta Eugenia, Baja California Sur, México (27° 51.3144′ N, 115° 4.3481′ W), 0.5 m depth, 9 March 2017, colls. A. Vassallo-Avalos and C. Conejeros-Vargas; three specimens (IAFCUNAM-AN-0127; AMNH_IZC-361335), Punta Morro, Baja California, México (31° 51.7354′ N, 116° 40.0452′ W), 0.5 m depth, 14 March 2017, colls. A. Vassallo-Avalos and C. Conejeros-Vargas. Voucher of longitudinal and cross histological sections from one specimen (IAFCUNAM-AN-0126-H), with the same sampling data as the holotype, and two specimens (IAFCUNAM-AN-0048-H; IAFCUNAM-AN-0103-H) with the same data as the paratypes, respectively.

Diagnosis

Actiniidae with a cylindrical column, brownish, grayish, or olive green, with endocoelic adhesive verrucae arranged in longitudinal rows from margin to limbus, each verruca with a red spot atop. More than two siphonoglyphs (up to five), and directive mesenteries absent. Tentacles arranged in four to five cycles (48–96 in number). Limbus with pink to whitish lines. Marginal projections with acrorhagi (containing holotrichs, basitrichs and spirocysts) on oral surface. Marginal sphincter circumscribed, more or less pinnate.

Description

External anatomy — Oral disc flat, smooth, 5–11 mm in diameter, brownish or grayish lilac, with radial marks brown to beige, ranging from tentacular bases towards mouth, mostly on endocoels of first two cycles (Figure 2*A*); mouth small, rounded. Tentacles 3–5 mm in length, arranged in four to five cycles (48–96 in number), conical, smooth, contractile, inner cycles slightly longer than outer ones, beige or grayish lilac, without marks (Figure 2*A*, *B*, *D*). Fosse well marked. Column cylindrical, 3–16 mm in diameter and 4–20 mm in height, brownish, grayish or olive green, with 32–46 endocoelic longitudinal rows of adhesive verrucae from margin to limbus, with a red spot atop each verruca; verrucae simple, cup-shape, more prominent distally than proximally (Figure 2*B*–*E*). Limbus with pink or lilac flashes and whitish marks on endocoelic spaces (Figure 2*B*, *D*). Margin with endocoelic marginal projections (25–56 in number) with acrorhagi (containing holotrichs, basitrichs, and spirocysts) on oral face; acrorhagi pale orange or beige while alive, whitish in preservation (Figure 2*C* and *D*). Pedal disc well-developed, 4–15 mm in diameter, slightly wider than column, pale pink to beige.

Downloaded From: https://bioone.org/journals/Pacific-Science on 29 Sep 2020
Terms of Use: https://bioone.org/terms-of-use Access provided by Universidad Nacional Autonoma de Mexico (UNAM)

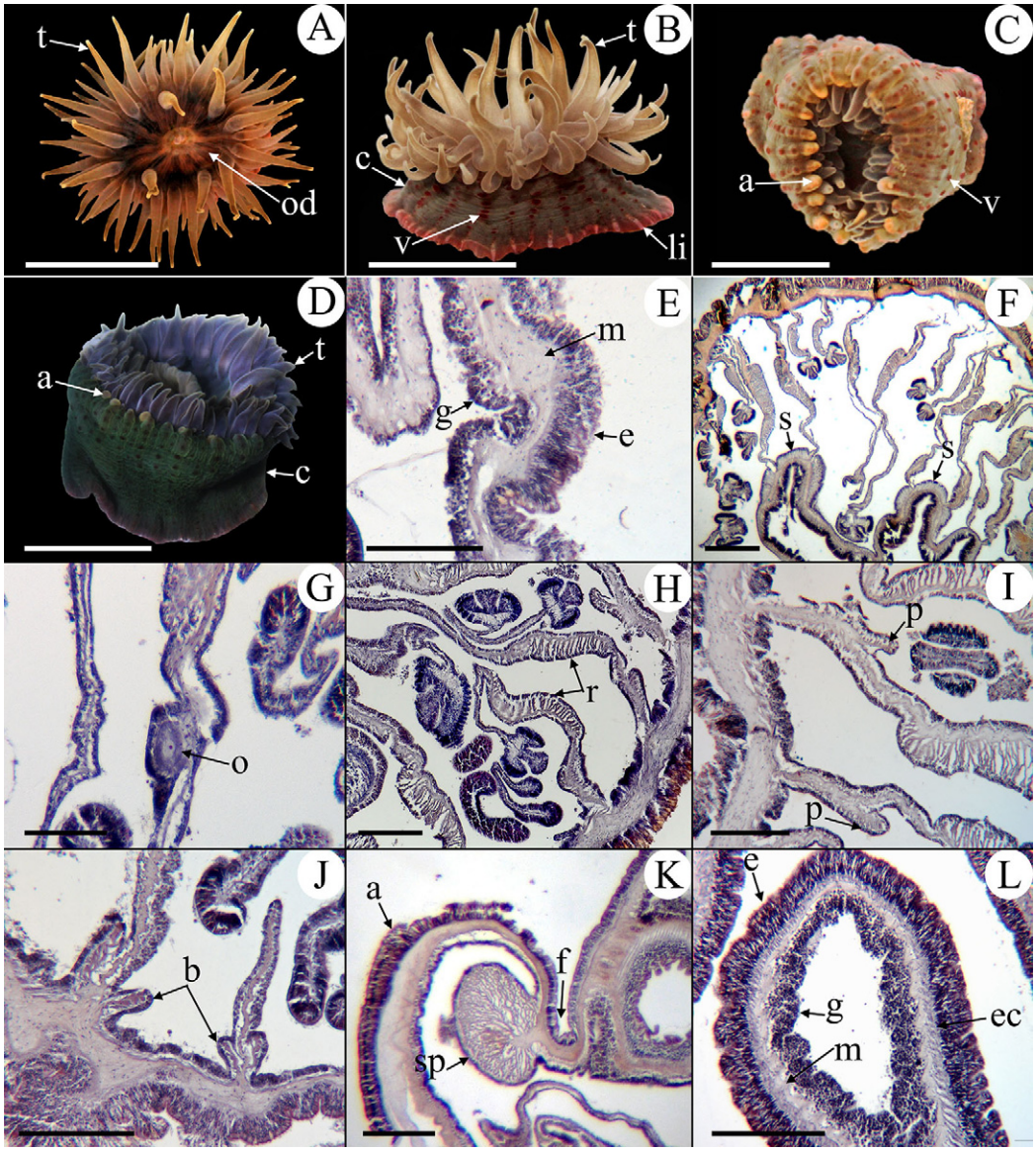

FIGURE 2. *Anthopleura mariae* sp. nov. *A*) oral view showing oral disc and tentacles, *B*) lateral view showing verrucae arrangement, *C*) oral view showing marginal projections with acrorhagi, *D*) lateral view showing the tentacles and verrucae arrangement, *E*) longitudinal section through distal column showing verrucae, *F*) cross section through distal column showing mesenterial and siphonoglyphs arrangement, *G*) cross section through column, detail of a oocysts, *H*) cross section through column, detail of retractor muscles, *I*) cross section through column, detail of the parietobasilar muscles, *J*) longitudinal section through pedal disc, detail of the basilar muscles, *K*) longitudinal section through margin showing the sphincter muscle, *L*) cross section through tentacle, detail on the ectodermal muscles. Abbreviations. - a: acrorhagi, b: basilar muscle, c: column, e: epidermis, ec: ectodermic muscles, f: fosse, g: gastrodermis, li: limbus, m: mesoglea, o: oocyst, od: oral disc, p: parietobasilar muscle, r: retractor muscle, s: siphonoglyph, sp: sphincter muscle, t: tentacle, v: verrucae. Scale bar. A–D = 10 mm; E–L = 200 μm.

Downloaded From: https://bioone.org/journals/Pacific-Science on 29 Sep 2020
Terms of Use: https://bioone.org/terms-of-use Access provided by Universidad Nacional Autonoma de Mexico (UNAM)

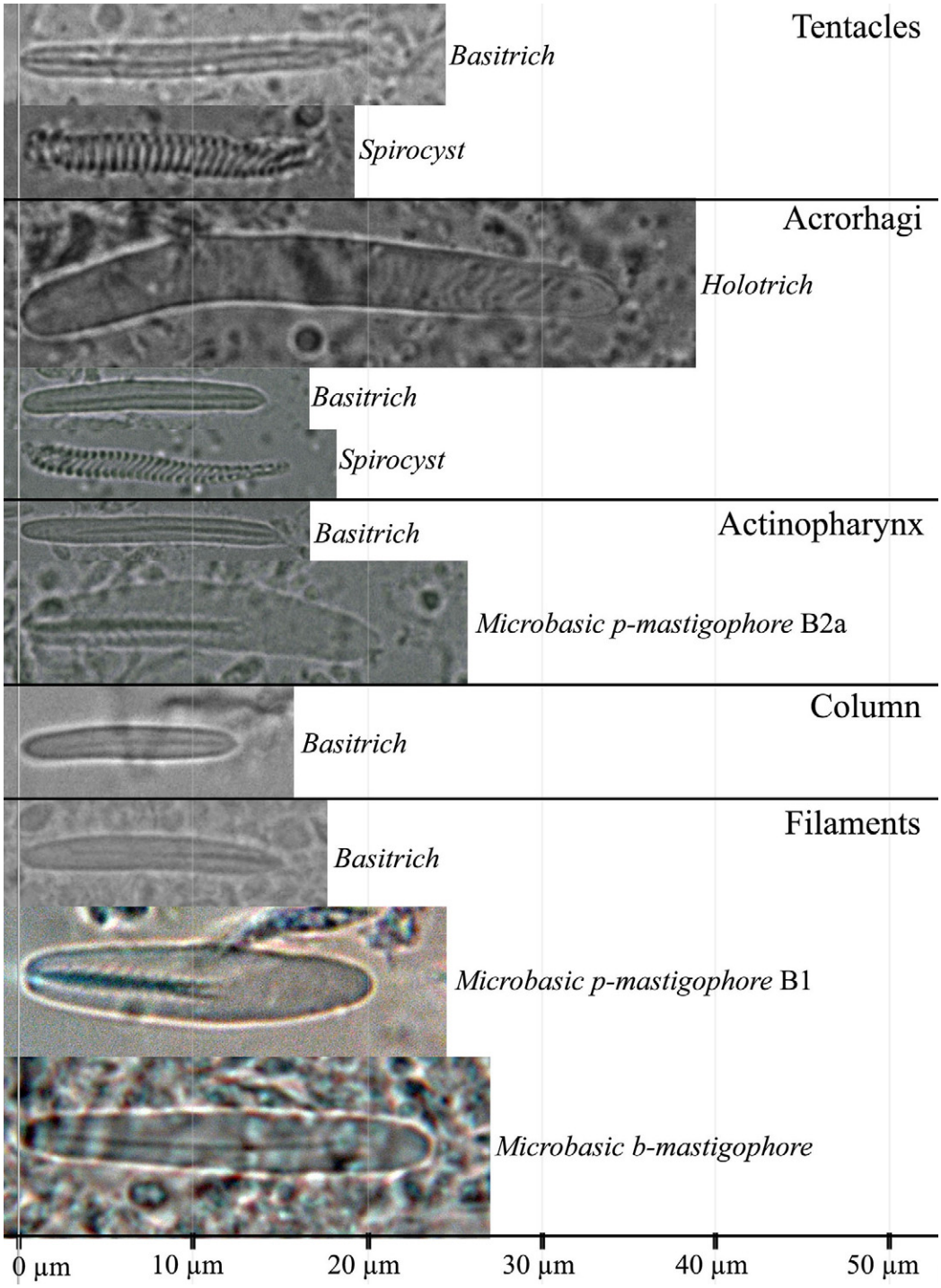

FIGURE 3. Cnidae from *Anthopleura mariae* sp. nov.

Downloaded From: https://bioone.org/journals/Pacific-Science on 29 Sep 2020
Terms of Use: https://bioone.org/terms-of-use Access provided by Universidad Nacional Autonoma de Mexico (UNAM)

TABLE 1

Capsule Sizes and Distribution of Cnidae of *Anthopleura mariae* sp. nov.

Tissue	Cnidae	Length (μm)	m_l	Width (μm)	m_w	N	n
Tentacle	Basitrich	18.0–30.0	22.88	1.8–3.0	2.13	4/4	100
	Spirocyst	15.0–37.0	24.43	2.0–3.5	2.71	4/4	100
Acrorhagi	Holotrich	32.0–53.0	43.06	3.0–6.0	4.37	4/4	100
	Basitrich	9.0–22.0	16.28	2.0–4.0	2.36	4/4	100
	Spirocyst	15.0–35.0	25.60	2.0–4.0	2.75	4/4	100
Actinopharynx	Basitrich	10.0–33.0	24.54	2.0–4.0	2.76	4/4	100
	Microbasic *p*–mastigophore B2a	20.0–31.0	24.93	3.5–6.0	4.66	4/4	100
Column	Basitrich	9.0–19.5	17.00	2.0–3.0	2.20	4/4	100
Mesenterial filament	Basitrich	10.0–16.70	12.28	1.50–2.50	2.0	4/4	100
	Microbasic *p*–mastigophore B1	19.0–29.0	23.50	3.5–6.0	4.85	4/4	100
	Microbasic *b*–mastigophore	20.0–35.0	26.33	2.5–6.0	3.64	4/4	100

m_l and m_w are the means, N is the proportion of specimens examined with the respective type of cnidae present, and n is the number of capsules measured.

Internal anatomy — Mesenteries arranged in three to four cycles (24–48 pairs): mesenteries of first and some of second cycles perfect, rest imperfect; same number of mesenteries distally and proximally. Directive mesenteries absent; more than two siphonoglyphs (up to five in the specimens examined) attached to regular pairs of mesenteries (Figure 2*F*). Gametogenic tissue in the strongest mesenteries of the first three cycles; gonochoric (?): only oocysts (160–254 μm in diameter) observed in specimens examined (Figure 2*G*). Retractor muscles well-developed, diffused (Figure 2*H*); parietobasilar muscles well-developed with a short mesogleal pennon (Figure 2*I*). Basilar muscles well-developed (Figure 2*J*). Endodermal marginal sphincter muscle strong, circumscribed, more or less pinnate (Figure 2*K*). Longitudinal muscles of tentacles ectodermal (Figure 2*L*).

Cnidom — Basitrichs, spirocysts, holotrichs, microbasic *p*-mastigophores B1 and B2a, and microbasic *b*-mastigophores. See Table 1 and Figure 3 for size and distribution of cnidae.

Natural history — *Anthopleura mariae* sp. nov. lives under rocks, both between cracks and attached to smooth surfaces, in the intertidal zone. It easily detaches from convex surfaces. Zooxanthellate.

Known distribution — Punta Morro, Baja California, and Punta Eugenia, Baja California Sur, México.

Etymology — *Anthopleura mariae* sp. nov. is named after María S. Avalos, mother of the first author.

DISCUSSION

Distinguishing A. mariae sp. nov. from A. nigrescens

Anthopleura mariae sp. nov. resembles the species *A. nigrescens* in the lack of directive mesenteries and the presence of more than two siphonoglyphs (Dunn 1974). However, the column of *A. nigrescens* is dark gray-brown or black, sometimes with the verrucae lighter than rest of the column (Dunn 1974, Fautin et al. 2007, 2009, Acuña et al. 2012). *Anthopleura nigrescens* has brownish gray to orange tentacles, often with transversal or longitudinal white-yellow splotches on its oral face (Dunn 1974, Fautin et al. 2007, 2009, Acuña et al. 2012), while those of *A. mariae* sp.

Downloaded From: https://bioone.org/journals/Pacific-Science on 29 Sep 2020
Terms of Use: https://bioone.org/terms-of-use Access provided by Universidad Nacional Autonoma de Mexico (UNAM)

Downloaded From: https://bioone.org/journals/Pacific-Science on 29 Sep 2020
Terms of Use: https://bioone.org/terms-of-use Access provided by Universidad Nacional Autonoma de Mexico (UNAM)

TABLE 2

Comparison of the Capsule Sizes (Length × Width) and Distribution of Cnidae between *A. mariae* sp. nov. and *A. nigrescens*. Sizes in micrometers (m)

Tissue	Cnidae Type	*A. mariae* sp. nov.	*A. nigrescens*				
			Dunn (1974)	England (1987)			
				Holotype_Hawaii	Paratype_Hawaii	Hawaii_1	Hawaii_2
Tentacle	Spirocyst	15.0–37.0 × 2.0–3.5	10.3–28.2 × 1.9–3.8	24.0 × 3.0	14.1–26.4 × 1.8–3.0	14.4–28.8 × 1.8–2.4	14.4–27.4 × 1.8–3.0
	Basitrich	–	–	–	–	12.0–14.4 × 1.2	12.0–13.2 × 1.8
	Basitrich	18.0–30.0 × 1.8–3.0	16.0–21.6 × 1.7–2.8	18.0–21.6 × 1.2–1.8	15.6–20.4 × 1.8–2.4	18.0–24.0 × 3.0–4.0	18.0–24.0 × 1.8
Acrorhagi	Spirocyst	15.0–35.0 × 2.0–4.0	14.1–28.2 × 1.9–3.6	26.4–2.4	–	–	–
	Basitrich	9.0–22.0 × 2.0–4.0	–	9.6–13.2 × 1.8	12.0–20.4 × 1.8	9.6–13.2 × 1.2	8.4–19.2 × 1.8
	Holotrich	32.0–53.0 × 3.0–6.0	27.3–43.2 × 2.8–4.7	33.6–54.0 × 3.6–5.4	–	33.6–54.0 × 3.6–5.4	43.2–54.0 × 3.6–4.8
	Heterotrich	–	–	30.0–42.0 × 3.0–3.6	–	31.2–42.0 × 3.0–3.6	30.0–42.0 × 3.0–3.6
Column	Basitrich	9.0–19.5 × 2.0–3.0	11.3–16.0 × 1.7–2.4	9.6–20.4 × 2.4–3.0	–	–	–
	Basitrich	–	16.5–22.6 × 2.4–3.8	–	–	9.6–24.0 × 1.8–3.0	13.2–24.0 × 2.4–3.0
	Heterotrich	–	–	–	–	16.8–24.0 × 3.0–4.0	19.2–21.6 × 3.6
Actinopharynx	Basitrich	10.0–33.0 × 2.4–4.0	20.7–27.3 × 1.9–2.8	10.8–16.2 × 1.8	9.6–12.0 × 1.8	10.8–16.8 × 1.8	10.8–13.2 × 1.8
	Basitrich	–	–	18.0–25.2 × 2.4–3.0	21.6–26.4 × 2.5–3.0	18.0–25.2 × 2.4–3.0	21.6–28.8 × 2.4–3.0
	M. p–mastigophore B2a	20.0–31.0 × 3.5–6.0	–	19.0–20.0 × 3.6	19.2–24.0 × 3.0–3.6	19.0–20.4 × 3.6	19.2–3.6
Mesenterial filament	Basitrich	10.0–16.7 × 1.5–2.5	13.2–18.7 × 1.7–2.6	13.2–16.9 × 2.4	10.8–18.0 × 1.8	13.2–16.2 × 2.4	14.4–18.0 × 1.8
	M. b–mastigophore	20.0–35.0 × 2.5–6.0	20.7–29.1 × 2.4–3.8	22.8–31.2 × 3.6–4.8	27.6–31.2 × 3.6–4.2	22.8–31.2 × 3.4–4.8	24.0–31.2 × 3.6–4.2
	M. p–mastigophore B1	19.0–29.0 × 3.5–6.0	15.0–18.8 × 2.8–4.7	18.2–23.4 × 3.0–4.0	18.0–21.6 × 3.6	14.4–2.4	9.6–15.6 × 2.4–3.0
	M. p–mastigophore B1	–	–	–	–	15.6–19.2 × 3.0–3.6	16.8–20.4 × 3.0–3.6

nov. are beige or grayish lilac, and without marks. Moreover, *A. mariae* sp. nov. harbor zooxanthellae, while these are absent in *A. nigrescens* (Dunn 1974, Fautin et al. 2009). The known distribution of *A. nigrescens* includes Hawaii, Hong Kong, India, Japan, Korea, the Marshall and the Galapagos Islands, and the Pacific coast of Costa Rica (Acuña et al. 2012), which is located approximately 3,600 km apart from the location of *A. mariae* sp. nov. In addition, although the cnidae size ranges of *A. mariae* sp. nov. partially overlap with those of *A. nigrescens* (Dunn 1974, England 1987), several types of cnidae are larger in the former, such as the spirocysts from tentacles and acrorhagi, basitrichs from tentacles and actinopharynx, microbasic *p*-mastigophores B2a (reported as *p*-mastigophores by England (1987)) from actinopharynx, and microbasic *b*-mastigophores (reported as basitrichs by Dunn (1974) and England (1987)), and microbasic *p*-mastigophores B1 (reported as *p*-mastigophores by Dunn (1974) and England (1987)) from filaments (Table 2). Furthermore, *A. mariae* sp. nov. presents only one size category of basitrichs in the tentacles and column, and one of microbasic *p*-mastigophore B1 in the filaments, while two categories of each type of these cnidae have been reported for *A. nigrescens* by Dunn (1974) and England (1987), respectively. England (1987) also reported the presence of heterotrichs in the acrorhagi and column of *A. nigrescens*, and Acuña et al. (2012) found microbasic *p*-mastigophores in the column of this species, both absent in *A. mariae* sp. nov. (Table 2).

Distinguishing A. mariae *sp. nov. from Other Species of* Anthopleura *from the Northeast Pacific*

Anthopleura mariae sp. nov. is distinguished from the other five species of the genus from the Northeast Pacific mainly by its column coloration pattern, with a red spot atop of each verruca and by the lack of directive mesenteries. In addition, in *A. mariae* sp. nov., as well as in *A. dowii*, *A. elegantissima* and *A. sola*, the verrucae are arranged in longitudinal rows from the margin to the limbus (Hand 1955, Pearse and Francis 2000, Daly 2004*b*, Barragán et al. 2019). However, the verrucae do not extend to the limbus in *A. artemisia* (Hand 1955) and are not obviously arranged in rows in *A. xanthogrammica* (Hand 1955). Asexual reproduction by longitudinal fission only occurs in *A. artemisia*, *A. dowii*, and *A. elegantissima* (Hand 1955, Daly 2004*b*), but not in *A. sola* and *A. xanthogrammica* (Hand 1955, Pearse and Francis 2000); the presence of more than two siphonoglyphs suggests that *A. mariae* sp. nov. could be capable of asexual reproduction. *Anthopleura elegantissima*, *A. sola*, *A. xanthogrammica* and *A. mariae* sp. nov. harbor zooxanthellae (Hand 1955, Pearse and Francis 2000), while these are absent in *A. artemisia* (Hand 1955) and are not reported for *A. dowii*. The acrorhagi of all these species, except *A. dowii*, have holotrichs, basitrichs and spirocysts (Hand 1955, Pearse and Francis 2000), while those of *A. dowii* only include holotrichs and basitrichs (Daly 2004*b*, Barragán et al. 2019).

Some characteristics to distinguish among the species of *Anthopleura* of the Northeast Pacific region, as well as from *A. nigrescens*, are compared in Table 3, including the number of tentacular cycles, column coloration, arrangement of the verrucae, and distribution of gametogenic tissue, among others.

Other Species of Anthopleura *Resembling* A. mariae *sp. nov.*

Anthopleura mariae sp. nov. resembles *A. buddemeieri* Fautin 2005, *A. krebsi* Duchassaing and Michelotti, 1860, and *A. balli* (Cocks, 1851) in the column coloration pattern with red spots atop each verruca (Daly and den Hartog 2004, Fautin 2005, Daly and Picton 2012). Unlike *A. mariae* sp. nov., *A. buddemeieri* presents a diffuse marginal sphincter and lacks zooxanthellae. Moreover, *A. buddemeieri* is native of the tropical western Pacific, found it on the north and south coasts of New Guinea and in Fiji (Fautin 2005). The species *A. krebsi* has three to four cycles of tentacles (24–48 in number), only has holotrichs and basitrichs in the acrorhagi, and it is distributed in the Gulf of México and the Caribbean Sea, Bermuda, and Brazil (Daly and den Hartog 2004). *Anthopleura ballii* has a

Downloaded From: https://bioone.org/journals/Pacific-Science on 29 Sep 2020
Terms of Use: https://bioone.org/terms-of-use Access provided by Universidad Nacional Autonoma de Mexico (UNAM)

Downloaded From: https://bioone.org/journals/Pacific-Science on 29 Sep 2020
Terms of Use: https://bioone.org/terms-of-use Access provided by Universidad Nacional Autonoma de Mexico (UNAM)

TABLE 3

Comparison of the Diagnostic Features of *A. mariae* sp. nov. with *A. nigrescens* and Other Species of *Anthopleura* from the Northeast Pacific

Species	Number of Tentacular Cycles	Column Color	Verrucae Arrangement	Marginal Sphincter	Retractor Muscles	Cnidae of Acrorhagi	Gametogenic Tissue	Asexual Reproduction	Zooxanthellae
Anthopleura nigrescens	4–5	Dark gray–brown or black	In rows, to limbus	Circumscript, pinnate	Diffuse to restricted	Basitrichs, holotrichs (and heterotrichs), spirocysts	All the strongest mesenteries	Longitudinal fission	Absent
Anthopleura artemisia	5	Black, gray or brown distally, white or pink proximally	In rows, not extending to limbus	Circumscript, pinnate	Diffuse to restricted	Basitrichs, holotrichs and spirocysts	First three cycles fertile, including directives	Longitudinal fission	Absent
Anthopleura dowii	5–6	Olive or brownish green	In rows, to limbus	Circumscript, pedunculated	Restricted	Holotrichs and basitrichs	First four cycles fertile, including directives	Longitudinal fission	No info
Anthopleura elegantissima	5–6	Dark to bright green	In rows, to limbus	Circumscript, pinnate	Diffuse to restricted	Basitrichs, holotrichs and spirocysts	First four cycles fertile, including directives	Longitudinal fission	Present
Anthopleura sola	5–6	Greenish	In rows, to limbus	Circumscript, pinnate	Diffuse to restricted	Basitrichs, holotrichs and spirocysts	First four cycles fertile, including directives	No asexual reproduction	Present
Anthopleura xanthogrammica	6	Green or dark greenish–brown, paler at limbus	Not obviously arranged in rows	Circumscript, pinnate	Diffuse to restricted	Basitrichs, holotrichs and spirocysts	First four cycles fertile, including directives	No asexual reproduction	Present
Anthopleura mariae sp. nov.	4–5	Brownish, grayish or olive green, with a red spots	In rows, to limbus	Circumscript, more or less pinnate	Diffuse to restricted	Basitrichs, holotrichs and spirocysts	First two cycles fertile, except the directives	No evidence of asexual reproduction	Present

trumpet shape column, a diffuse marginal sphincter muscle, has only holotrichs and basitrichs in the acrorhagi (Stephenson 1935, Daly and Picton 2012), and it is distributed in the south-west Europe and in the Mediterranean (Manuel 1981).

At least eleven species of *Anthopleura* have been reported with more than two siphonoglyphs: *A. anjunae* den Hartog and Vennam 1993, *A. artemisia* (Pickering in Dana, 1846), *A. biscayensis* (Fischer, 1874), *A. buddemeieri*, *A. dalyae* González-Muñoz, Garese, and Acuña, 2019, *A. dixoniana* (Haddon and Shackleton, 1893), *A. elegantissima*, *A. minima* (Stuckey and Walton, 1910), *A. nigrescens*, *A. thallia* (Gosse, 1854), and *A. waridi* (Carlgren, 1900) (Parry 1951, Hand 1955, England 1987, den Hartog and Vennam 1993, Fautin 2005, Daly and Picton 2012, González-Muñoz et al. 2019). However, the lack of directive mesenteries has only been reported in *A. nigrescens*. This species can be easily distinguished from *A. mariae* sp. nov. by the coloration pattern of its column and tentacles (see above).

The two localities where *A. mariae* sp. nov. were found are included in the Californian biogeographic province, which is influenced by cold currents that run from north to south on the Northeast Pacific coast (Ayón and Hendrickx 2009, Briggs and Bowen 2012). Therefore, we consider that *A. mariae* sp. nov. could be characteristic of temperate to cold waters, as well as *A. artemisia* and *A. sola*.

ACKNOWLEDGEMENTS

This work was partially funded by grants from project DGAPA-UNAM-PAPIIT IN 224217 and IN218414. Aurora Vassallo was supported by a Master's degree fellowship from the Consejo Nacional de Ciencia y Tecnología (CONACYT) in the Postgraduate Program of Ciencias del Mar y Limnología, UNAM. We thank to MS. Carlos Conejeros, BS. Mauricio Carmona, Dr. Rogelio Aguilar, MS. Alma Islas and MS. Omar Lagunas from the Universidad Nacional Autónoma de México (UNAM) for assistance in the field. Thanks also due to Dr. Rosario Ortiz, Dr. Patricia Rivas and MS. Maricela Vicencio (UNAM) for assistance in histological techniques. Special thanks to Dr. Estefanía Rodríguez for her help in managing the deposit of a specimen at the American Museum of Natural History (AMNH).

Literature Cited

Acuña, F. H., J. Alvarado, A. Garese, and J. Cortés. 2012. First record of the sea anemone *Anthopleura nigrescens* (Cnidaria, Actiniaria, Actiniidae) on the Pacific coast of Central America. Mar. Biodivers. Rec. 5:1–3.

Ayón, P. M., and M. E. Hendrickx. 2009. A review of the *Dardanus sinistripes* (Stimpson, 1859) (Decapoda, Anomura, Diogenidae) species with the description of five new species from the Mexican Pacific. Zootaxa 2323:1–71.

Barragán, Y., C. Sánchez, and E. Rodríguez. 2019. First inventory of sea anemones (Cnidaria: Actiniaria) from La Paz Bay, southern Gulf of California (Mexico). Zootaxa 4559:501–549.

Briggs, J. C., and B. W. Bowen. 2012. A realignment of marine biogeographic provinces with particular reference to fish distributions. J. Biogeogr. 39:12–30.

Brusca, R. C. 1980. Common intertidal invertebrates of the Gulf of California. The University of Arizona Press, Tucson, Arizona.

Carlgren, O. 1940. A contribution to the knowledge of the structure and distribution of the cnidae in the Anthozoa. K. Fysiogr. Sällsk. Handl. 3:3–62.

Carlgren, O. 1949. A survey of the Ptychodactiaria, Corallimorpharia and Actiniaria. K. Sven. Vetenskapsakad Handl. (4th series) 1:1–121.

Carlgren, O. 1951. The actinian fauna of the Gulf of California. Smithson. Proc. U. S. Natl. Mus. 101:415–449.

Cupul-Magaña, L. A., R. Guardado-France, E. Gil-Silva, J. Ledesma-Vázquez, G. E. Ávila-Serrano, O. E. González-Yajimoich, and A. Chee-Barragán. 2017. Interacción océano-tierra en la generación de sedimentos de playas y dunas. Ciencia y Sociedad 20:85.

Downloaded From: https://bioone.org/journals/Pacific-Science on 29 Sep 2020
Terms of Use: https://bioone.org/terms-of-use Access provided by Universidad Nacional Autonoma de Mexico (UNAM)

Daly, M. 2004*a*. Phylogeny and biogeography of *Anthopleura* in the North Atlantic Ocean. Hydrobiologia 530/531:241–248.

———. 2004*b*. Anatomy and taxonomy of three species of sea anemones (Cnidaria: Anthozoa: Actiniidae) from the Gulf of California, including *Isoaulactinia hespervolita* Daly, n. sp. Pac. Sci. 3:377–390.

Daly, M., L. M. Crowley, P. Larson, E. Rodríguez, E. Heestand Saucier, and D. G. Fautin. 2017. *Anthopleura* and the phylogeny of Actinioidea (Cnidaria: Anthozoa: Actiniaria). Org. Divers. Evol. 17:545–564.

Daly, M., and D. G. Fautin. 2019*a*. World list of Actiniaria. Actiniaria. World Register of Marine Species. [http://www.marinespecies.org/aphia.php?p=taxdetailsandid=1360] Reviewed: 6 March 2019.

———. 2019*b*. World list of Actiniaria. *Anthopleura artemisia* (Pickering in Dana, 1846). World Register of Marine Species. [http://www.marinespecies.org/aphia.php?p=taxdetails&id=283337 on 2019-08-14] Reviewed: 14 August 2019.

———. 2019*c*. World list of Actiniaria. *Anthopleura xanthogrammica* (Brandt, 1835). World Register of Marine Species. [http://www.marinespecies.org/aphia.php?p=taxdetails&id=283377 on 2019-08-14] Reviewed: 14 August 2019.

Daly, M., and J. C. den Hartog. 2004. Taxonomy, circumscription, and usage in *Anthopleura* (Cnidaria: Anthozoa: Actiniaria) from the Gulf of Mexico and Caribbean. Bull. Mar. Sci. 74(2):401–421.

Daly, M., and Picton, B. 2012. Description of the sea anemone *Anthopleura thallia* (Gosse, 1854). Biology and Environment: P. Roy. Irish Acad., 235–240.

Dunn, D. F. 1974. Redescription of *Anthopleura nigrescens* (Coelenterata, Actiniaria) from Hawaii. Pac. Sci. 28:377–382.

England, K. W. 1987. Actiniaria from the Red Sea and Tropical Indo-Pacific. Bull. Br. Mus. Nat. Hist. 53:205–292.

Estrada, E., L. Peralta, and P. Rivas. 1982. Manual de técnicas histológicas. AGT Editor, Distrito Federal, México.

Fautin, D. G. 2005. Three species of intertidal sea anemones (Anthozoa: Actiniidae) from the Tropical Pacific: description of *Anthopleura buddemeieri*, n. sp., with remarks on *Anthopleura asiatica* and *Gyractis sesere*. Pac. Sci. 3:379–391.

Fautin, D. G., C. P. Hickman, M. Daly, and T. Molodtsova. 2007. Shallow-water sea anemones (Cnidaria: Anthozoa: Actiniaria) and tube anemones (Cnidaria: Anthozoa: Ceriantharia) of the Galapagos Islands. Pac. Sci. 61:549–573.

Fautin, D. G., S. H. Tan, and R. Tan. 2009. Sea anemones (Cnidaria: Actiniaria) of Singapore: abundant and well-known shallow-water species. Raffles Bull. Zool. 22:121–143.

Geller, J. B., and E. D. Walton. 2001. Breaking up and getting together: evolution of symbiosis and cloning by fission in sea anemones (genus *Anthopleura*). Evolution 55:1781–1794.

González-Muñoz, R., A. Garese, and F. H. Acuña. 2019. *Anthopleura dalyae* sp. nov. (Cnidaria: Actiniaria), a new species of sea anemone from the southern Gulf of Mexico. Mar. Biodivers. 49:683–690.

Gotshall, W. D., and L. L. Laurent. 1979. Pacific coast subtidal marine invertebrates. A fishwatchers guide. Sea Challengers, Monterey, California.

Gusmão, L. C., A. Grajales, and E. Rodríguez. 2018. Sea anemones through X-rays: visualization of two species of Diadumene (Cnidaria, Actiniaria) using micro-CT. Am. Mus. Novit. 3907:1–45.

Gusmão, L. C., E. Rodríguez, and M. Daly. 2019. Description of *Calliactis tigris* sp. nov.: reconciling taxonomy and phylogeny in hermit-crab symbiotic anemones (Cnidaria: Actiniaria: Hormathiidae). Org. Divers. Evol. https://doi.org/10.1007/s13127-019-00414-2

Hand, C. 1955. The sea anemones of central California part II. The Endomyarian and Mesomyarian anemones. Wasmann J. Biology 13:37–99.

Hartog, J. C. den, and J. Vennam. 1993. Some Actiniaria (Cnidaria: Anthozoa) from the west coast of India. Zool. Med. Leiden 67 (42):601–637.

Häussermann, V. 2004. Identification and taxonomy of soft-bodied hexacorals

Downloaded From: https://bioone.org/journals/Pacific-Science on 29 Sep 2020
Terms of Use: https://bioone.org/terms-of-use Access provided by Universidad Nacional Autonoma de Mexico (UNAM)

exemplified by Chilean sea anemones; including guidelines for sampling, preservation and examination. J. Mar. Biol. Assoc. U. K. 84:931–936.

Hendrickx, M. E., R. C. Brusca, and L. T. Findley. 2005. Listado y Distribución de la macrofauna del Golfo de California, México. Parte 1. Invertebrados. Arizona-Sonora Desert Museum, Tucson, Arizona.

Kerstitch, A., and H. Bertsch. 2007. Sea of Cortez marine invertebrates. A guide for the Pacific Coast, México to Perú. Sea Challengers, Monterey, California.

Manuel, R. L. 1981. British Anthozoa. London: Academic Press. [Synopses of the British Fauna, New Series, no. 18.]

McFadden, C. S., R. K. Grosberg, B. B. Cameron, D. P. Karlton, and D. Secord. 1997. Genetic relationships within and between clonal and solitary forms of the sea anemone *Anthopleura elegantissima* revisited: evidence for the existence of two species. Mar. Biol. 128:127–139.

Parry, G. 1951. The actiniaria of New Zealand. A check-list of recorded and new species. A review of the literature and a key to the commoner forms. Part I. Records of the Canterbury Museum 6 (1):83–119.

Pearse, V., and L. Francis. 2000. *Anthopleura sola*, a new species, solitary sibling species to the aggregating se anemone, *A. elegantissima* (Cnidaria: Anthozoa: Actiniaria: Actiniidae). P. Biol. Soc. Wash. 113:596–608.

Rodríguez, E., M. S. Barbeitos, M. R. Brugler, L. M. Crowley, A. Grajales, L. Gusmão, V. Häussermann, A. Reft, and M. Daly. 2014. Hidden among sea anemones: the first comprehensive phylogenetic reconstruction of the order Actiniaria (Cnidaria, Anthozoa, Hexacorallia) reveals a novel group of hexacorals. PLoS One 9(5): e96998.

Sanamyan, N. P., K. E. Sanamyan, and K. R. Tabachnick. 2012. The first species of Actiniaria, *Spongiactis japonica* gen. n., sp. n. (Cnidaria: Anthozoa) and obligate symbiont of a glass sponge. Invertebr. Zool. 9:127–141.

Schmidt, H. 1969. Die Nesselkapseln der Aktinien und ihre differentialdiagnostische Bedeutung. Helg. Wiss. Meers. Bd. 19.S. 287–317.

Schmidt, H. 1972. Die Nesselkapseln der Anthozoen und ihre Bedeutung fur die phylogenetische Systematik. Helg. Wiss. Meers. 23:422–458.

Schmidt, H. 1974. On evolution in the Anthozoa. Proceedings of the Second International Coral Reef Symposium 1:533–560.

Spano, C., and V. Häussermann. 2017. *Anthopleura radians*, a new species of sea anemone (Cnidaria: Actiniaria: Actiniidae) from northern Chile, with comments on other species of the genus from the South Pacific Ocean. Biodiver. Nat. Hist. 3:1–11.

Stephenson, T. A. 1935. The British Sea Anemones. Vol. II. The Ray Society, London, 426 pp.

Weill, R. 1934. Contribution a l'étude des Cnidaires et de leurs nematocysts. Paris: Les Presses Universitaires de France. 701 p.

Downloaded From: https://bioone.org/journals/Pacific-Science on 29 Sep 2020
Terms of Use: https://bioone.org/terms-of-use Access provided by Universidad Nacional Autonoma de Mexico (UNAM)
View publication stats