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Anthopleura mariscali, a new species of sea anemone (Cnidaria: Anthozoa: Actiniaria) from the Galápagos Islands

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Abstract

Anthopleura mariscali, a new species of sea anemone (Actiniaria) known only from the intertidal zone of islands in the Galápagos Archipelago, is described and illustrated. The column of a member of *Anthopleura mariscali* is orange to pink, becoming darker distally, and has prominent endocoelic marginal projections, each of which bears an acrorhagus on the oral surface and several verrucae on the adoral surface. Distally, the projections are typically frosted with opaque white patches. Living firmly adherent to the substratum in cracks and crevices, the animal is inconspicuous in life.

Key words: Actiniidae, coelenterates, Pacific Ocean, taxonomy, Zoantharia

Introduction

The marine invertebrate fauna of the Galápagos Archipelago is characterized as a distinct faunal province that comprises elements of the Panamic and Indo-Pacific faunas and endemic species (e.g., Glynn & Wellington 1983; Kay 1991; Zullo 1991). The new species of sea anemone we describe—*Anthopleura mariscali*—appears to be one of the endemic species that comprise this fauna, as it is only known from Pinzón Island, Plaza Island Sur, and Santa Cruz Island in the Galápagos Archipelago.

None of the species having both acrorhagi and verrucae listed by Verrill (1869), McMurrich (1893, 1904), or Carlgren (1899, 1959) in their discussions of the actiniarian fauna of Central and South America have the opaque white patches on the distal column characteristic of *A. mariscali*. Field surveys in Chile have not uncovered any species resembling *A. mariscali* (Sebens & Paine 1979; V. Häussermann, pers. comm.). Similarly, no sea anemone described from the Indo-Pacific has the coloration or anatomy characteristic of *A. mariscali* (DGF, pers. obs., see also England 1987, 1992). However, because *A. mariscali* is small, and inhabits cracks and crevices, it may have been overlooked elsewhere, and may actually have a broader distribution than the Galápagos Islands.

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Materials and Methods

Specimens were observed in life by DGF in the intertidal zone on Pinzón Island and from the vicinity of the Charles Darwin Research Station on Santa Cruz Island. We also examined material collected by R. N. Mariscal in 1964, as part of the Galápagos International Science Project (GISP). Specimens were preserved in formalin and stored in 70% ethanol. Type and voucher specimens have been deposited at the California Academy of Sciences (CAS), the University of Kansas Natural History Museum (KUNHM), and the U. S. National Museum of Natural History (USNM).

Pedal disc width and column height were measured on both living and preserved material; for irregularly shaped specimens, greatest pedal disc width and greatest column height were recorded. Longitudinal and cross-sectional serial sections 6–10 μm thick were made from specimens dehydrated in ethanol and embedded in Paraplast (Fisher Scientific). Sections were stained in Heidenhain's Azan (Presnell & Schreibman 1997).

Small pieces (approximately 1 mm^2) of tentacle, column, marginal spherule, limbus, actinopharynx, and mesenterial filament tissue were squashed on a slide and examined at 1000X using differential interference microscopy; length and width of undischarged cnidae were measured using ScanPro measurement software (Jandel Scientific Software) and a Summa Sketch digitizing tablet (Summagraphics). The largest and smallest cnidae of a particular type were sought for each tissue sample (Hand 1955; England 1987). Cnidae nomenclature follows Mariscal (1974).

Description

Family ACTINIIDAE Rafinesque, 1815

Genus *Anthopleura* Duchassaing de Fonbressin & Michelotti, 1860

***Anthopleura mariscali* new species**
Figures 1–3

Material examined. Pacific Ocean, Galápagos Islands, Santa Cruz Island, Turtle Cove, 0°29’37” S, 90°19’41” W, intertidal, Coll. R. N. Mariscal, 14 February 1964, preserved in formalin, stored in 70% ethanol, KUNHM 1851, holotype. Paratypes collected at the same time and place: CAS 168009, KUNHM 1852, USNM 1019899. Pacific Ocean, Galápagos Islands, Santa Fe Island, 0°48’00” S, 90°02’13” W, intertidal, Coll. R. N. Mariscal, 5 February 1964, preserved in formalin, stored in 70% ethanol, KUNHM 1855. Pacific Ocean, Galápagos Islands, Plaza Island Sur, West End, 0°34’46” S, 90°10’03” W, intertidal, Coll. R. N. Mariscal, 8 February 1964, preserved in formalin, stored in 70% ethanol, CAS 168010, KUNHM 1856. Pacific Ocean, Galápagos Islands, Plaza Island Sur, North Side,

0°34’51” S, 90°09’47” W, intertidal, Coll. R. N. Mariscal, 8 February 1964, preserved in formalin, stored in 70% ethanol, KUNHM 1859. Pacific Ocean, Galápagos Islands, Santa Cruz Island, north-east, 0°35’18” S, 90°10’28” W, intertidal, Coll. R. N. Mariscal, 10 February 1964, preserved in formalin, stored in 70% ethanol, KUNHM 1853. Pacific Ocean, Galápagos Islands, Santa Cruz Island, north-east of Point Bowditch, 0°31’02” S, 90°28’29” W, intertidal, Coll. R. N. Mariscal, 19 February 1964, preserved in formalin, stored in 70% ethanol, KUNHM 1854, USNM 1019900.

Diagnosis. Actiniidae with endocoelic adhesive verrucae from margin to limbus. Margin with long, endocoelic, fingerlike projections, each with an acrorhagus on the oral surface and verrucae on the adoral surface (Figure 1). Column orange to pink, darker distally than proximally, some individuals with broad opaque white markings on the distal endocoelic spaces, giving the column a striped appearance (Figure 1A).

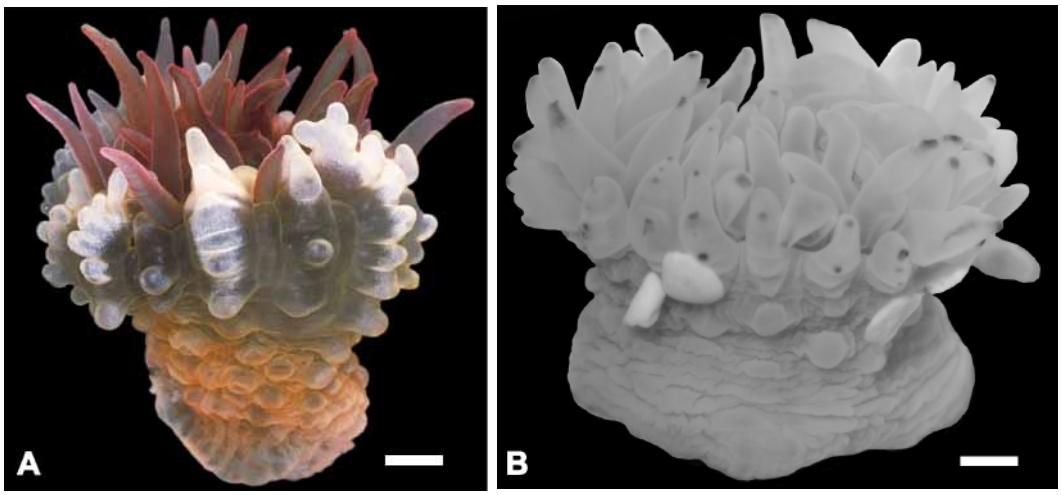

FIGURE 1. External morphology of *Anthopleura mariscali,* new species. Scale bar = 0.5 mm. A. Partially contracted live specimen. Note striped appearance of distal column and well-expanded marginal projections with verrucae. Photograph by C. P. Hickman, Jr. B. Holotype. Note spots of dark pigment on tips of some tentacles and marginal projections.

Column. Column approximately twice as wide in diameter distally as proximally in live specimens; column typically 7 mm long, oral disc diameter of 15 mm, pedal disc diameter approximately 7 mm. In preserved specimens, oral disc and pedal disc roughly same diameter, 4–11 mm (7 mm in holotype); column height 3–10 mm (6 mm in holotype). Contracted specimens often dome-shaped. Column covered from margin to just above limbus with simple, endocoelic, adhesive verrucae arrayed in regular longitudinal series (Figure 1); those of primary and secondary endocoels more numerous and extend further proximally compared to those of higher-order endocoels. Verrucae more prominent distally than proximally; same color as column; cup-shaped; to 0.5 mm in diameter (Figure 2D); hold stones and shell debris in life. Margin denticulate, with prominent endocoelic marginal projections, those of primary and secondary endocoels larger, more

prominent than others; each projection typically bears three or more large verrucae on its adoral surface and a single acrorhagus on its oral surface (Figure 2A). Most marginal projections of most specimens bear an acrorhagus, although acrorhagi not present on all marginal projections of all specimens, and a rare higher-order endocoel lacks a marginal projection.

Color orange-pink proximally, darker distally. Typically, each endocoelic space frosted distally with opaque white longitudinal stripe extending approximately one-quarter column length. Color of preserved specimens grayish-tan to peach, distal column typically darker than proximal column, frosting not visible. Acrorhagi opaque white. Tips of marginal projections in some preserved specimens spotted with dark pigment (Figure 1B).

Oral Disc and Tentacles. Inner tentacles longer than outer, typically held erect; outer tentacles point basally. In life, each tentacle tapers to blunt point, which is perforate (Figure 2B). Tentacles number 40–100, depending on size of animal (46 in holotype).

Oral disc brownish, mesenterial insertions visible as pale lines. Actinopharynx creamy white. Mouth typically same color as column, prominent, rounded, elevated on oral cone in center of disc. Tentacles paler than oral disc, some with reddish cast on oral surface; with longitudinal green stripe that may extend onto oral disc. In preservation, tentacles translucent gray brown, typically without markings, although tips and distalmost oral surface of tentacles of some specimens marked with dark pigment (Figure 1B).

Internal Anatomy. In specimens lacking regeneration scars, two siphonoglyphs, each of which attaches to a pair of directive mesenteries; in those with scars, directives or siphonoglyphs may be lacking or occur in greater numbers than in specimens without scars. Siphonoglyph prolonged aborally. Mesenteries hexamerously arranged, in three or four cycles; larger mesenteries perfect. Arrangement of mesenteries obscured in specimens that have regeneration scars. Gonochoric. All perfect mesenteries, except those attached to siphonoglyphs, fertile; imperfect mesenteries and those attached to siphonoglyphs sterile.

Marginal sphincter muscle strong, symmetrical, palmate, with many secondary branches (Figure 2C). Parietobasilar muscle diffuse, large, with narrow, short pennon (Figure 2E). Mesenterial lamella between retractor and parietal without folds or branches; no accessory muscles. Retractor muscles circumscribed, strong, almost reniform.

Cnidom. Spirocysts, basitrichs, holotrichs, microbasic *b*-mastigophores, microbasic *p*-mastigophores (Figure 3). See Table 1 for size and distribution.

Distribution. In cracks and crevices, high to low intertidal zone, Galápagos Archipelago, Pinzón Island, Plaza Island Sur, and Santa Cruz Island. Not seen subtidally. Likely clonal: many specimens have regeneration scars and anatomical irregularities, and individuals live in close physical proximity.

Etymology. *Anthopleura mariscali* is named for Dr. Richard N. Mariscal, in recognition of his numerous contributions to the study of cnidarians. Dr. Mariscal participated in the GISP, when he collected the specimens designated as the types of *Anthopleura mariscali*.

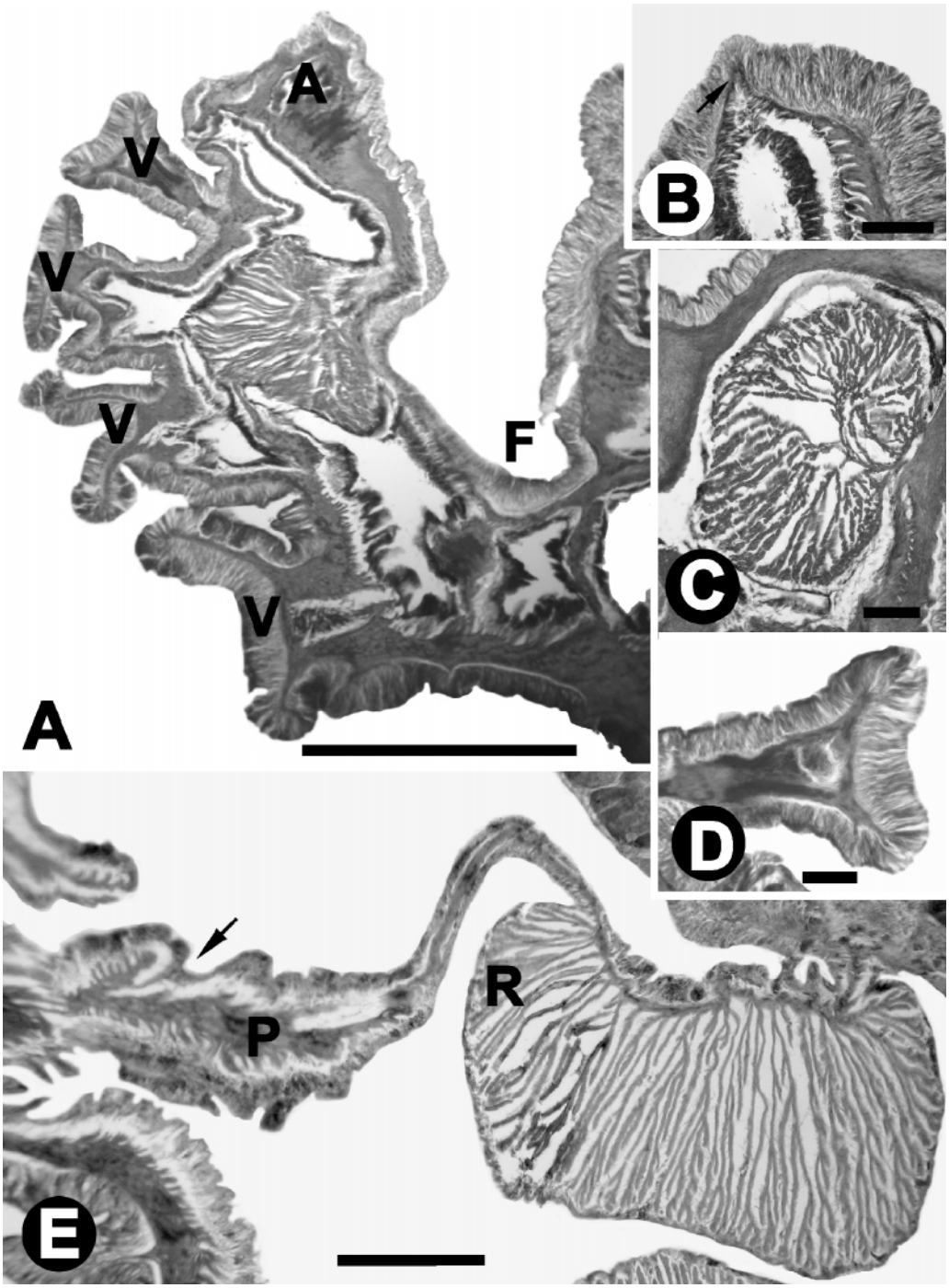

FIGURE 2. Internal anatomy and histology of *Anthopleura mariscali*, new species. A. Longitudinal section through a marginal projection. Each projection bears an acrorhagus (A) on the oral surface and several verrucae (V) on the adoral surface. F, fosse. Scale = 0.5 mm. B. Longitudinal section through tip of a tentacle, showing apical pore (arrow). Scale = 30 μm. C. Cross section of marginal sphincter muscle. Scale = 50 μm. D. Longitudinal section through a verruca. Scale = 60 μm. E. Cross section through mesentery proximal to actinopharynx, showing retractor muscle (R) and parietal muscle (P). Arrow indicates pennon of parietobasilar muscle. Scale = 90 μm.

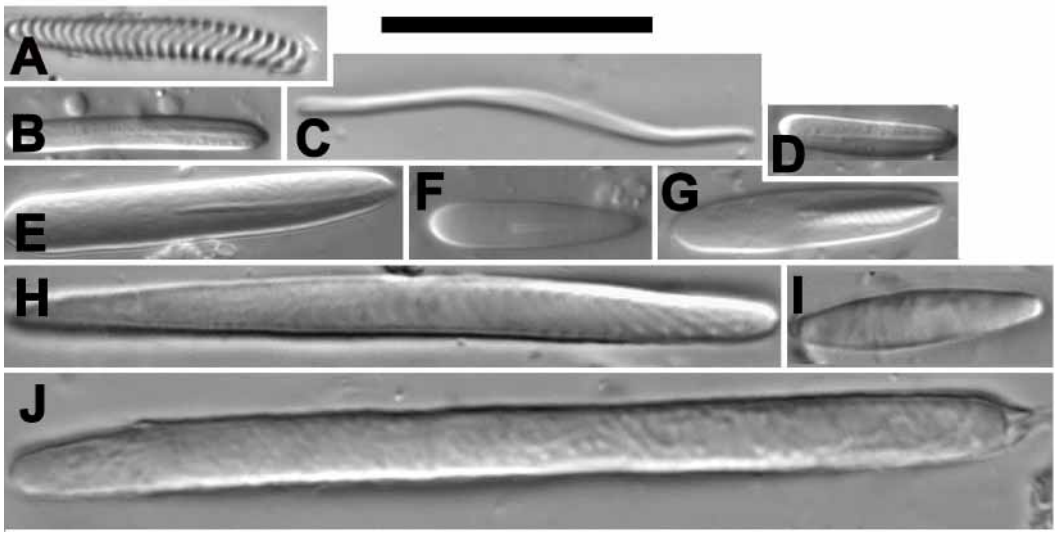

FIGURE 3. Representative cnidae from *Anthopleura mariscali*, new species. Scale bar = 20 μm; refer to Table 1 for size and distribution. A. Spirocyst. B. Basitrich. C. S-shaped basitrich. D. Small basitrich. E. Microbasic *b*-mastigophore I. F. Microbasic *b*-mastigophore II. G. Microbasic *p*-mastigophore. H. Holotrich I. I. Holotrich III. J. Holotrich II.

TABLE 1. Cnidae of *Anthopleura mariscali*. N is the proportion of examined individuals having a particular type of cnidae; n is the number of capsules measured. Values in parentheses are measurements of exceptionally large or small cnidae. Letters after each type refer to Figure 3. Measurements of cnidae from *Anthopleura nigrescens* are given for comparison. Measurements for *A. nigrescens* are a composite of those given by Dunn (1974) and England (1987). The measurements reported by Dunn differ in a few respects from those of England: Dunn did not discern two size classes of basitrichs in the tentacles or two types of holotrichs in the acrorhagi, and found no holotrichs in the column. However, the size range of the tentacular basitrichs reported by Dunn encompasses the two classes reported by England, the combined size range of the holotrichs measured by England is equivalent to that reported by Dunn, and Dunn recorded basitrichs of a size range consistent with the small holotrichs found by England.

Tissue	Type	N	n	Range, in μm	*A. nigrescens*
Tentacle	Spirocyst (A)	4/4	56	14.0–22.0 x 1.8–3.3	10.3–28.8 x 1.8–3.8
	Basitrich (B)	4/4	71	(8.9) 12.3–19.5 x (1.4) 1.7–3.1 (3.5)	12.0–14.4 x 1.2
	Basitrich				15.6–24.0 x 1.2–2.4
Acrorhagus	Holotrich I (H)	4/4	48	35.5–59.7 x 2.7–5.2	30–42 x 3–3.6
	Holotrich II (J)	4/4	43	(37.6) 42.2–68.1 x 4.6–9.1	33.6–54 x 3.6–5.4
Column	Basitrich (B)	4/4	44	10.2–17.8 x 1.6–3.1	9.6–24 x 1.8–3
	Holotrich III (I)	4/4	43	15.8–21.9 x 3.0–4.5	16.8–24 x 3–4
Actinopharynx	Basitrich (D)	3/3	41	9.3–18.5 x 1.4–2.8	10.8–16.8 x 1.8
	Basitrich (B)	3/3	36	20.1–27.9 x 2.3–3.5	18.0–25.2 x 2.4–3
	Microbasic *p*-mastigophore (G)	3/3	26	(14.4) 15.5–20.9 x 3.7–5.2	19.2–20.4 x 3.6
Filament	Small basitrich (D)	3/3	33	8.8–15.1 x 1.5–2.9	10.8–18 x 1.8–2.4
	Basitrich (B)	3/3	25	(13.4) 15.2–18.5 x (1.8) 2.4–3.2	
	S-shaped basitrich (C)	3/3	28	21.6–31.0 x 0.9–2.0	
	Microbasic *p*-mastigophore (G)	3/3	34	14.3–18.5 x 4.1–4.8	15.6–23.4 x 3.0–4.0
	Microbasic *b*-mastigophore I (E)	3/3	31	19.4–28.6 x (3.3) 3.6–5.0 (5.8)	22.8–31.2 x 3.6–4.8
	Microbasic *b*-mastigophore II (F)	3/3	28	13.3–18.2 x 2.0–3.6	9.6–15.6 x 2.4–3.1

Differential diagnosis. In the Galápagos, *Anthopleura mariscali* occurs in the same intertidal habitats as *A. nigrescens* (Verrill, 1928), a species widespread in the tropical Indo-Pacific (Dunn 1974, England 1987). These two species differ in habitat, color, anatomy, and cnidom. In the field, the two can be distinguished based on coloration: a member of *A. mariscali* has an orange to pink column that is darker distally and typically frosted with white at the margin, whereas a member of *A. nigrescens* is purple-black or deep green with pale verrucae, lacking frosted white markings distally. The two differ in habit as well; members of *A. mariscali* live in small cracks and crevices and adhere strongly to the substrate whereas members of *A. nigrescens* live less firmly attached on the surface of the substrate. The verrucae of *A. mariscali* are typically less adherent than those of *A. nigrescens*: when disturbed, a specimen of *A. mariscali* typically releases adherent gravel whereas one of *A. nigrescens* typically retains it. Preserved specimens of *A. mariscali* are typically paler than those of *A. nigrescens*, and the column often remains two-toned, with a gray distal half and a pale orange or tan proximal half. A preserved specimen of *A. nigrescens* is typically a uniform reddish-brown, becoming paler over time. These two species can also be distinguished based on cnidae size (Table 1), and by musculature: the retractor muscle of *A. mariscali* is more compact than that of *A. nigrescens*, and lacks a free flap (= pennon), and the sphincter muscle of *A. mariscali* is nearly symmetrical, rather than more developed on the adoral side as in *A. nigrescens*.

Other similar species. No described species of *Anthopleura* has the coloration pattern characteristic of *A. mariscali*, but in having opaque white patches on the distal column, *A. mariscali* recalls the common European species *Bunodactis verrucosa* (Pennant, 1777) and a population of the widespread species *Bunodosoma granulifera* (LeSueur, 1817) described from the Bahamas as *Bunodes taeniatus* McMurrich, 1899. However, the markings that create the stripes differ among these species: in *B. verrucosa*, the stripes result from the color of the verrucae themselves, rather than from streaks over both the verrucae and the column wall as in *A. mariscali* (MD pers. obs.). Drawings accompanying the description of *B. taeniatus* (Figure 4: McMurrich 1899) indicate that the lighter regions include several endocoelic spaces and the exocoels between them; in *A. mariscali*, each white streak covers a single endocoel.

In having a column that is darker distally than proximally, *A. mariscali* resembles *Actiniogeton spenceri* (Haddon & Duerden, 1896) and two species of *Anthopleura*: *A. varioarmata* Watzl, 1922 (see Carlgren 1952), a Panamic species, or *Anthopleura dixoniana* (Haddon & Shackleton, 1893), a species common in the Indo-Pacific. *Actiniogeton spenceri*, which is known only from southeast Australia, lacks holotrichs in the marginal structures (Carlgren 1938) and has a diffuse marginal sphincter (Haddon & Duerden 1896), unlike *A. mariscali* which has holotrichous acrorhagi and a strong, circumscribed marginal sphincter. *Anthopleura mariscali* differs from both *A. varioarmata* and *A. dixoniana* in the color of the column and in the size of the holotrichs of the acrorhagi: the acrorhagial holotrichs are larger in *A. mariscali* than in either *A. varioarmata* (see Belém & Monteiro,

1981) or *A. dixoniana* (see England 1987). The retractor muscle is more diffuse in *A. varioarmata* than in *A. mariscali*. Unlike *A. mariscali*, *A. dixoniana* is zooxanthellate, and has a maximum known tentacle number of 60 (England 1987).

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