

SEA ANEMONES (CNIDARIA: ACTINIARIA) OF SINGAPORE: ABUNDANT AND WELL-KNOWN SHALLOW-WATER SPECIES

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ABSTRACT. – Sixteen species are recorded in this survey of common intertidal and shallow subtidal sea anemones (cnidarian order Actiniaria) in Singapore. Six have previously been reported from Singapore in the scientific literature; 10 are new records for Singapore. The 16 species belong to families Actiniidae, Actinodendridae, Aiptasiidae, Boloceroididae, Diadumenidae, Stichodactylidae, and Thalassianthidae. Most are widespread in the Indo-Pacific tropics; Singapore represents the westernmost occurrence of three of the species that have previously been known only from along the western rim of the Pacific Ocean. *Diadumene lineata* is a cosmopolitan, invasive species.

KEY WORDS. – Anthozoa, intertidal, littoral, Southeast Asia.

INTRODUCTION

We document 16 species of sea anemones (members of cnidarian order Actiniaria) from the intertidal and shallow subtidal regions of the Republic of Singapore. They do not represent all the species of anemones found in Singapore, but are those for which there are no unresolved taxonomic problems, and that are abundant or conspicuous. Six of these species have previously been recorded in the primary scientific literature from Singapore (summarized by Fautin, 2008); they are *Anthopleura dixoniana* (Haddon & Shackleton, 1893), *An. handi* Dunn, 1978, *Entacmaea quadricolor* (Rüppell & Leuckart, 1828), *Heteractis magnifica* (Quoy & Gaimard, 1833), *Paraipatasia radiata* (Stimpson, 1856), and *Stichodactyla gigantea* (Forsskål, 1775). Those recorded from Singapore for the first time are *Actinodendron arboreum* Quoy & Gaimard, in de Blainville, 1830; *Anthopleura buddemeieri* Fautin, 2005; *An. nigrescens* (Verrill, 1928); *Boloceroides mcmurrichi* (Kwietniewski, 1898); *Cryptodendrum adhaesivum* Klunzinger, 1877; *Diadumene lineata* (Verrill, 1869); *Heteractis crispa* (Hemprich & Ehrenberg in Ehrenberg,

1834); *Macrodactyla doreensis* (Quoy & Gaimard, 1833); *Stichodactyla haddoni* (Saville-Kent, 1893); and *S. tapetum* (Hemprich & Ehrenberg in Ehrenberg, 1834). We are currently studying about 20 other species, but have not seen representatives of some previously reported from Singapore.

Figure 1 and Table 1 display all Singapore localities at which we are aware each species occurs. In addition to 10 days of intensive fieldwork in 2007 and 10 days in 2009, the third author has conducted over 500 trips to explore and document Singapore's marine intertidal flora and fauna since 2003.

Most of the 16 species, which belong to seven families, are widespread in the Indo-Pacific tropics; the biogeography of these animals is discussed following the taxonomic treatments. Very little research on sea anemones in Singapore and near-by waters has been published in the primary scientific literature. The recently published second edition of the Singapore Red Data Book did not list even a single sea anemone species (Chou & Tan, 2008). One

major objective of this publication and its successors is to inventory these animals in Singapore and distinguish among them as a way of facilitating research on them. The **Remarks** section for each species account includes information on

how to distinguish among similar-looking species, and a key to distinguishing among the 16 species alive follows the taxonomic treatments.

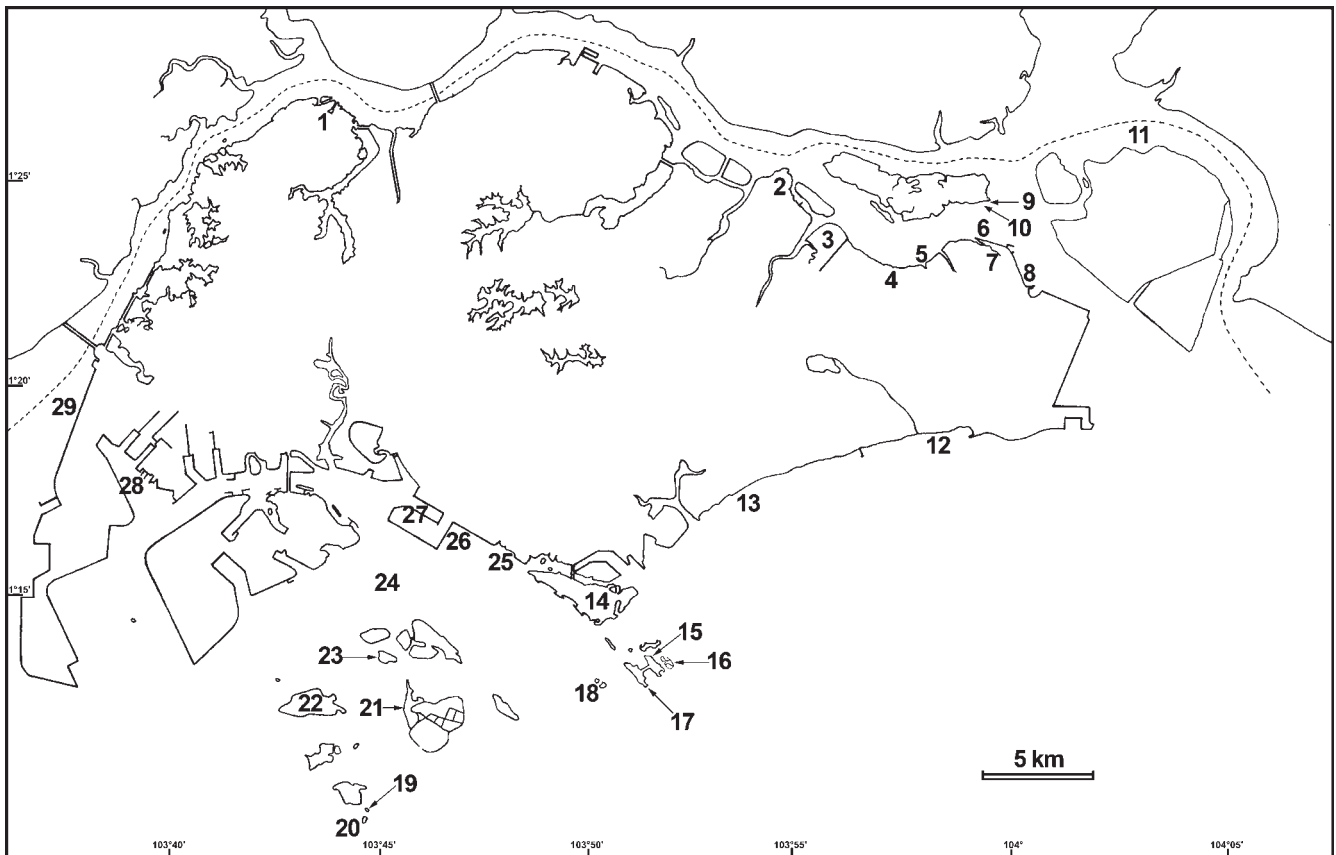


Fig. 1. Map of Singapore indicating the localities where sea anemones were obtained for this study: 1, Sungei Buloh Wetland Reserve ($1^{\circ}26'43.86''\text{N } 103^{\circ}43'36.24''\text{E}$); 2, Punggol Point ($1^{\circ}25'17.92''\text{N } 103^{\circ}54'38.26''\text{E}$); 3, Sungei Serangoon ($1^{\circ}23'49.29''\text{N } 103^{\circ}55'26.84''\text{E}$); 4, Pasir Ris ($1^{\circ}22'56.45''\text{N } 103^{\circ}57'3.88''\text{E}$); 5, Kampong (Kg.) Loyang ($1^{\circ}22'40.00''\text{N } 103^{\circ}57'34.00''\text{E}$); 6, Changi Point beaches ($1^{\circ}23'33.34''\text{N } 103^{\circ}59'20.94''\text{E}$); 7, Changi Creek ($1^{\circ}23'21.90''\text{N } 103^{\circ}59'30.77''\text{E}$); 8, Changi Ferry Terminal beach ($1^{\circ}22'26.03''\text{N } 104^{\circ}0'24.79''\text{E}$); 9, Chek Jawa (Pulau Ubin) ($1^{\circ}24'28.41''\text{N } 103^{\circ}59'28.82''\text{E}$); 10, Pulau Sekudu ($1^{\circ}24'19.00''\text{N } 103^{\circ}59'16.82''\text{E}$); 11, Beting Bronok (Trumbo Burong) ($1^{\circ}26'13.00''\text{N } 104^{\circ}02'58.00''\text{E}$); 12, Bedok ($1^{\circ}19'0.00''\text{N } 103^{\circ}58'0.00''\text{E}$); 13, Katong ($1^{\circ}17'47.40''\text{N } 103^{\circ}54'4.77''\text{E}$); 14, Sentosa ($1^{\circ}14'47.44''\text{N } 103^{\circ}49'55.64''\text{E}$); 15, Lazarus Island ($1^{\circ}13'27.87''\text{N } 103^{\circ}51'14.61''\text{E}$); 16, Kusu Island (Pulau Tembakul) ($1^{\circ}13'24.93''\text{N } 103^{\circ}51'39.22''\text{E}$); 17, St. John's Island ($1^{\circ}13'16.83''\text{N } 103^{\circ}50'55.35''\text{E}$); 18, Little Sister Island (Pulau Subar Darat) ($1^{\circ}12'58.09''\text{N } 103^{\circ}49'57.71''\text{E}$) and Big Sister Island (Pulau Subar Laut) ($1^{\circ}12'50.17''\text{N } 103^{\circ}50'5.23''\text{E}$); 19, Pulau Biola ($1^{\circ}09'51.86''\text{N } 103^{\circ}44'32.30''\text{E}$); 20, Raffles Lighthouse (Pulau Satumu) ($1^{\circ}09'36.13''\text{N } 103^{\circ}44'27.12''\text{E}$); 21, Pulau Semakau ($1^{\circ}12'27.97''\text{N } 103^{\circ}45'16.65''\text{E}$); 22, Pulau Sudong ($1^{\circ}12'29.69''\text{N } 103^{\circ}43'18.99''\text{E}$); 23, Pulau Hantu ($1^{\circ}13'34.95''\text{N } 103^{\circ}45'2.95''\text{E}$); 24, Cyrene Reef (Terumbu Pandan) ($1^{\circ}15'27.50''\text{N } 103^{\circ}45'19.02''\text{E}$); 25, Labrador Nature Reserve ($1^{\circ}16'0.40''\text{N } 103^{\circ}48'2.71''\text{E}$); 26, Buona Vista ($1^{\circ}16'42.65''\text{N } 103^{\circ}47'8.95''\text{E}$); 27, Pasir Panjang ($1^{\circ}17'15.62''\text{N } 103^{\circ}45'58.10''\text{E}$); 28, Jurong ($1^{\circ}17'59.10''\text{N } 103^{\circ}39'9.51''\text{E}$); 29, Tuas ($1^{\circ}19'33.03''\text{N } 103^{\circ}37'49.96''\text{E}$).

MATERIAL AND METHODS

All specimens examined in this work were from Singapore. For animals seen alive, members of most species achieving large size were photographed in situ; photographs were taken by Ria Tan between 2004 and 2007. Specimens requiring closer observation were collected. Collected specimens were studied in the laboratory, photographed (small ones through the microscope), preserved, and dissected. Histological sections were made of some; sections $8 \mu\text{m}$ thick were stained with haematoxylin and eosin (Humason, 1967).

Voucher specimens are in the Zoological Reference

Collection, Raffles Museum of Biodiversity Research, Department of Biological Sciences, National University of Singapore (ZRC) and the Division of Invertebrate Zoology, University of Kansas Natural History Museum, Lawrence, Kansas, USA (KUDIZ). We cite one record each from specimens in the Western Australian Museum (WAM), Perth, and Natural History Museum (NHM), London. We did not collect specimens of well-known species for which museum specimens exist; some literature citations included in each species treatment provide citations to those specimens. Occurrences not accompanied by specimen data or catalogue numbers were from sight or photographic records.

Table 1. Distribution of sea anemones found on the shores and off-shore islands of Singapore. The symbol “*” indicates previously published records, “x” indicates localities we have found the species but that were not previously published, and “†” indicates new records for Singapore.

Map location	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29								
<i>Actinodendron arboretum</i> †											x										x																
<i>Anthopleura buddemeieri</i> †																																					
<i>Anthopleura dixoniana</i>				*			*	x	x	x						x	x										*										
<i>Anthopleura handi</i>	x		x	*		x	x	x																													
<i>Anthopleura nigrescens</i> †						x																															
<i>Bolocerooides mcMurrichi</i> †						x		x	x	x																											
<i>Cryptodendrum adhaesivum</i> †																																					
<i>Diadumene lineata</i> †							x		x	x																											
<i>Entacmaea quadricolor</i>									x																												
<i>Heteractis crispata</i> †																																					
<i>Heteractis magnifica</i>																																					
<i>Macroductyla doreensis</i> †									x	x																											
<i>Paraipitastia radiata</i>									x	x																											
<i>Stichodactyla haddoni</i> †									x	x																											
<i>Stichodactyla gigantea</i>									x	x																											
<i>Stichodactyla tapetum</i> †																																					

The synonym list for each species contains reference to the first citation of the species by a particular name. For some species, some of the names are misapplications or misidentifications; we list them nonetheless because they are names that have been used for that species. We also list references that document occurrences in Singapore. For a complete list of references concerning taxonomy and occurrence of the species listed here, see Fautin (2008).

RESULTS

Boloceroidea Carlgren, 1924b

***Boloceroidea mcmurrichi* (Kwietniewski, 1898)**

(Fig. 2)

Bolocera mcmurrichi Kwietniewski, 1898: 387, 389, 394–395 (original description).

Boloceroidea McMurrichi – Carlgren, 1899b: 43–45.

Boloceroidea hermaphroditica Carlgren, 1900: 38–39 (original description).

Gonactinia sp. – Okada, 1926: 482–486.

Nectothelia lilae Verrill, 1928: 14 (original description).

Boloceroidea sp. – Carlgren, 1929: 530; Okada & Komori, 1932: 164–199.

?*Boloceractis gopalai* Panikkar, 1937: 76, 77–84, 86, 88 (original description).

Boloceroidea liliae – Carlgren, 1949: 40.

Boloceroidea mcmurrichi – Uchida, 1938b: 627–635.

Material examined. – Pasir Ris; Changi Point beaches (ZRC.CNI.0308); Changi Ferry Terminal beach (ZRC.CNI.0027–0030, KUDIZ 2914); Chek Jawa (Pulau Ubin); Pulau Sekudu (ZRC.CNI.0279, ZRC.CNI.0284, ZRC.CNI.0286); Beting Bronok; Pulau Semakau; Pulau Hantu; Cyrene Reef; Labrador Nature Reserve.

Live appearance/external anatomy. – See Fig. 2. Column very small relative to length of the abundant tentacles (commonly more than 400), so animal resembles a brown mop; mouth, which is on a cone, may be hidden by tentacles. Light brown animals typically have conspicuous bands along each tentacle; darker brown ones are less patterned. Six primary tentacles nearest mouth; a white band may cross mouth between the two directive tentacles, which are commonly lighter than others and nearer the mouth (Fig. 2). Some mesenterial insertions may be visible through oral disc as white lines. Base only lightly adherent.

Size. – Tentacle crown to 80 mm or more diameter, individual tentacles to 35 mm long for animals observed in Singapore.

Internal anatomy. – See Okada & Komori (1932), Uchida (1938b), England (1992).

Cnidaria. – Cnidom spirocysts, basitrichs, microbasic amastigophores. For details of distribution, size, and appearance, see England (1992).

Natural history. – Most animals lie unattached on the surface of the shore. Disturbance can provoke both swimming and shedding of tentacles by this zooxanthellate species (but does

not always do so). Swimming is by coordinated beating of the tentacles (Ross, 1974; Lawn & Ross, 1982). Contraction of a sphincter muscle at the base of a tentacle autotomizes it. Having muscle and nerve cells, a shed tentacle typically writhes; it can regenerate an entire anemone (e.g. Okada & Komori, 1932). Lost tentacles are regenerated, so an individual may have tentacles of various lengths, which differ in degree of regeneration. Asexual propagation is from buds on the outer tentacles, so small anemones in various stages of maturity may be attached to its parent, forming a sort of transient colony (Uchida, 1938b; Cutress, 1977).

Habitat. – Intertidal muddy sand shores.

Distribution. – First record for Singapore. Occurs at least from Indonesia through the tropical Pacific to the Hawaiian Islands, but perhaps from the tropical Indian Ocean and Red Sea (Fautin, 2008) (but see **Remarks**).

Remarks. – Occurrence seems to be episodic but data are insufficient to determine if animals appear at a particular time of year.

Few other species in the world, and none in Singapore, is similar. Tentacles of a burrowing species (to be dealt with in a subsequent publication) form a hemisphere at the surface, but the animal retracts into the sand when disturbed, whereas *B. mcmurrichi* is typically unattached to the substratum so can easily be lifted from it.

Many reports of this species are of smaller animals (such as in Papua New Guinea: Fautin, 1988), but Lawn & Ross (1982) found animals from the Hawaiian Islands ranging from 15 to 140 mm in crown diameter, so it is likely that reports of small and large anemones with a mop-like tentacle crown that swim and can shed their tentacles all refer to a single species.

Contrary to some others, England (1992) considered *B. mcmurrichi* and *B. hermaphroditica* as distinct species, with *B. gopalai*, described from India, possibly conspecific with the latter. England (1992: 55) therefore concluded “... it seems that *B. mcmurrichi* is confined to the Pacific region, whereas *B. hermaphroditica*, here considered a valid species, occurs from the Suez Canal through the Red Sea to the East African coast. It may also extend as far as India as *Boloceractis gopalai* Pannikar [sic] (1937: 76) could be conspecific with *B. hermaphroditica* ...” den Hartog wrote (1997a: 358) “Two species are currently recognized, *Boloceroidea mcmurrichi* (Central Indo-Pacific, including Indonesia) and *B. hermaphroditica* [sic] (Red Sea, east Africa), though on rather vague grounds (England 1992),” but in the same year, he (den Hartog, 1997b) reported *Boloceroidea* cf. *mcmurrichii* [sic] from eastern Africa.

We take this opportunity to correct a *lapsus* in Fautin (1988: 25), in which this species was referred to the genus *Bolocera*.



Fig. 2. *Bolocerooides mcMurrichi*: Chek Jawa (Pulau Ubin), not preserved. Photo: Ria Tan.

Actiniidae Rafinesque, 1815

***Anthopleura buddemeieri* Fautin, 2005**

(Fig. 3)

Anthopleura buddemeieri Fautin, 2005: 380–387 (original description).

Material examined. – St John’s Island (ZRC.CNI.0040, ZRC.CNI.0041).

Live appearance/external anatomy. – See Fig. 3. Column white proximally, darkening distally due to endodermal zooxanthellae; red spots entire length of column, those in distal part in the middle of adhesive verrucae, proximal ones more irregularly shaped, patterned; verrucae only in distal part. Each marginal protrusion with red dot on aboral side (which may be on a verruca), and pink spherule overhanging shallow fosse. Tentacles grey with red cast. Radial red stripes on pedal disc; mesenterial insertions visible through pedal disc as dark lines.

Size. – Typical individual 5 mm pedal disc diameter, 7 mm oral disc diameter, 12 mm long, tentacles to 7–8 mm long. Smallest about 2 mm diameter, long.

Internal anatomy. – See Fautin (2005).

Cnidae. – Cnidom spirocysts, basitrichs, holotrichs, microbasic *p*-mastigophores. For details of distribution, size, and appearance, see Fautin (2005).

Natural history. – Zooxanthellate.

Habitat. – Under rocks in very high intertidal zone.

Distribution. – First record for Singapore. Recorded from Australia (Queensland), Fiji, and Papua New Guinea (Fautin, 2008).

Remarks. – In having a light column with red spots on verrucae on the upper column and (in most) red streaks on the lower column, *Anthopleura buddemeieri* is superficially very similar to a species to be dealt with in a subsequent publication that lives on sand beaches. A tentacle of *An. buddemeieri* has a red cast and is unpatterned whereas one of the other species is colourless with transverse dark and light bands on the oral face. A marginal projection of *An. buddemeieri* has a pink acrorhagus overhanging the deep fosse whereas one of the other species is colourless with an opaque white cap and, in most individuals, a red spot at the end of each. The brilliant white ring at its margin when an individual of the other species is contracted is formed of the marginal projections. *Anthopleura buddemeieri* cannot be confused with any of the other three species of *Anthopleura* found in Singapore, all of which are darker in colour and lack red spots.

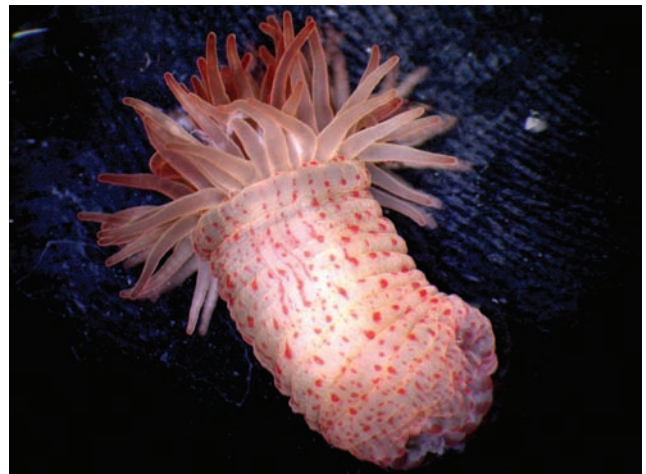


Fig. 3. *Anthopleura buddemeieri*: St John’s Island (ZRC.CNI.0040). Photo: S. H. Tan.

***Anthopleura dixoniana* (Haddon & Shackleton, 1893)**

(Fig. 4)

Actinioides Dixoniana Haddon & Shackleton, 1893: 117, 126 (original description).

Actinoides dixoniana – Carlgren, 1896: 174.

Actinoides Papuensis Haddon, 1898: 398, 415, 424, 425, 426–428 (original description).

Anthopleura dixoniana – Carlgren, 1949: 54.

Actiniogeton papuensis – Carlgren, 1949: 62.

Material examined. – Changi Creek (ZRC.CNI.0069, KUDIZ 2912); Changi Ferry Terminal beach (ZRC.CNI.0068); Chek Jawa (Pulau Ubin) (ZRC.CNI.0070, ZRC.CNI.0071); Pulau Sekudu (ZRC.CNI.0066); Sentosa; Lazarus Island; Kusu Island (ZRC.CNI.0067); St John’s Island; Labrador Nature Reserve.

Live appearance/external anatomy. – See Fig. 4. Column greenish or brownish near base, greyish toward margin with grey verrucae, unpatterned; mesenterial insertions may be visible as dark lines. Verrucae, which may hold debris, only in distal part, same colour as column or orangish; one at distalmost end of row occurs on marginal projection.

Acrorhagus on oral side of orange (commonly) or yellow or white (rarely) marginal projection. Oral disc flat or raised around mouth, brown with spots of green and yellow around the mouth and with cream or white patches scattered between mouth and base of tentacles so disc checkerboard-pattern (Fig. 4). To 60 slender, tapered tentacles; inner longer than outer; some inner ones commonly solid white on oral face, others resemble outer ones in being brownish with 2–4 white spots or bands along length. Out of water and contracted, animal appears uniformly dark and shiny. Actinopharynx may be white or radial lines of oral disc may run into it.

Size. – Column, oral disc, and pedal disc to 6 mm diameter, 8 mm long, but typically expanded length about twice diameter.

Internal anatomy. – See England (1987).

Cnidae. – Cnidom spirocysts, basitrichs, heterotrichs, holotrichs (termed atrichs by England, 1987), microbasic amastigophores, microbasic *p*-mastigophores. For details of distribution, size, and appearance, see England (1987).

Natural history. – Zooxanthellate. Usually packed so closely together that only oral disc can be seen in an expanded animal. When exposed at low tide, columns of contracted animals appear as shiny bumps on hard surfaces. Aggressive against specimens of *A. handi*.

Habitat. – England (1987: 241) described the occurrence of these animals in the field well: “In holes in rocks and stones; many specimens aggregating in a small area, but not close to each other; upper shore.”

Distribution. – Previously reported in Singapore from Pasir Panjang, Pungol [sic] Point, Pasir Ris, and Changi Creek by England (1987). Known also from Australia (Torres Straits), Hong Kong, and the Maldives (Gan, Addu Atoll) (Fautin, 2008).

Remarks. – *Anthopleura dixoniana* may be confused with three other species in Singapore. It obviously shares with both *An. handi* and *An. nigrescens* features of the genus such as verrucae and acrorhagi (there is no confusion with the fourth species of the genus recorded in Singapore, *An. buddemeieri*, which has a light column, pink acrorhagi, and a red spot in the centre of each verruca). 1) Both it and *An. handi* occur high in the intertidal, sometimes together (as in Changi Creek); large numbers of small individuals of *An. dixoniana* typically occur together whereas *An. handi* occurs less densely and a typical individual is larger; an individual of *An. dixoniana* is dark in colour and its verrucae are lighter than the column, whereas one of *An. handi* is dull grey-green, including its verrucae. 2) A typical individual of *An. nigrescens* is larger than one of *An. dixoniana*, but its column is darker in colour. The acrorhagi of *An. nigrescens* are white-tipped, unlike those of *An. dixoniana*, and its verrucae are much more conspicuous and occur more basally. 3) Both *An. dixoniana* and *Diadumene lineata* live

very high in the intertidal. When the tide is out, the very small and numerous animals of both species look dark and shiny; *D. lineata* is easily distinguished by being green with longitudinal white and orange or red lines, and an individual will readily emit its acontia when disturbed (*An. dixoniana* lacks acontia).



Fig. 4. *Anthopleura dixoniana*: Chek Jawa (Pulau Ubin), not preserved. Photo: Ria Tan.

Anthopleura handi Dunn, 1978

(Fig. 5)

Anthopleura handi Dunn, 1978: 54–63 (original description).

Material examined. – Sungei Buloh Wetland Reserve ZRC.CNI.0058, ZRC.CNI.0059, ZRC.CNI.0387, ZRC.CNI.0388), KUDIZ 2920); Sungei Serangoon (ZRC.CNI.0064, ZRC.CNI.0065; ZRC.CNI.0247); Pasir Ris (ZRC.CNI.0271–0274), Changi Point beaches (ZRC.CNI.0062); Changi Creek (ZRC.CNI.0061); Changi Ferry Terminal beach (ZRC.CNI.0060, ZRC.CNI.0063).

Live appearance/external anatomy. – See Fig. 5. Column dull grey-green (or lighter); inconspicuous verrucae, to which pieces of shell or gravel may adhere, only in distal part. Tentacles held out and up so typically dark oral disc easily seen. Area between mesenterial insertions may be white (pigment disappears with preservation); mouth may be raised on cone. Tentacles relatively long, colourless, with longitudinal dark stripes interrupted by narrow white cross-bars at irregular intervals. Most acrorhagi same colour as column but some white-tipped; when animal contracts, water may squirt from them.

Size. – Commonly 10–20 mm pedal disc diameter, but can attain diameter of 40 mm; in expansion, column considerably narrower than pedal disc and about 2–3 times as long. Longest tentacle somewhat longer than oral disc diameter.

Internal anatomy. – See Dunn (1978), England (1987).

Cnidae. – Cnidom spirocysts, basitrichs, holotrichs (termed atrichs by Dunn, 1978, England, 1987), microbasic

p-mastigophores, heterotrichs (not mentioned by Dunn, 1978), microbasic amastigophores (not mentioned by Dunn, 1978). For details of distribution, size, and appearance, see Dunn (1978), England (1987).

Natural history. – Azooxanthellate. Broods its young internally; for discussion of its reproductive biology in Malaysia, see Dunn (1983). Aggressive against specimens of *A. dixoniana*.

Habitat. – Attached to firm object such as mollusc shell, rock, or mangrove tree root, typically high in intertidal zone; firm object may be in sediment such as sand or mud.

Distribution. – Previously reported in Singapore from Pasir Ris by England (1987). Known also from Malaysia, Australia (Queensland) (Fautin, 2008).

Remarks. – *Anthopleura handi* may be confused with three other species in Singapore. It obviously shares with *An. dixoniana* and *An. nigrescens* features of the genus such as verrucae and acrorhagi (there is no confusion with the fourth species of the genus recorded in Singapore, *An. buddemeieri*, which has a light column, pink acrorhagi, and a red spot in the centre of each verruca). All also occur high in the intertidal zone. 1) *Anthopleura handi* and *An. dixoniana* may occur together (as in Changi Creek); *An. handi* occurs less densely than *An. dixoniana*, which is typically in large numbers; an individual of *An. handi* is generally larger and dull grey-green, including its verrucae, whereas one of *An. dixoniana* is dark in colour and its verrucae are lighter. 2) *Anthopleura handi* is also lighter in colour than *An. nigrescens* but the two are of similar size. Most acrorhagi of *An. handi* are not white-tipped, in contrast with those of *An. nigrescens*; the verrucae of *An. handi* are fewer and much less conspicuous. 3) A species to be dealt with in a subsequent publication that is longitudinally striped is typically considerably larger than *An. handi* and burrows in sand.

***Anthopleura nigrescens* (Verrill, 1928)**

(Fig. 6)

Tealiopsis nigrescens – Verrill, 1928: 26 (original description).

Cladactella obscura – Verrill, 1928: 24–25 (original description).

Anthopleura pacifica – Uchida, 1938a: 305–309 (original description).

Bunodactis nigrescens – Carlgren, 1949: 65.

Anthopleura nigrescens – Mathew, 1967: 41–43.

Material examined. – Changi Point beaches (ZRC.CNI.0074).

Live appearance/external anatomy. – See Fig. 6. Column black with vertical rows of light-coloured adhesive verrucae entire length, white-tipped acrorhagi. Tentacles tapered, blunt-tipped, slender in life; twice as many as acrorhagi; inner ones longer than outer; inner grey but oral face may have longitudinal dark stripe and white splotches at irregular intervals; outer ones typically colourless but oral face may have white splotches. Tentacles held out and up so oral disc



Fig. 5. *Anthopleura handi*: Sungei Serangoon, Lorong Halus (ZRC CNI.0247). Photo: S. H. Tan.

easily seen. Oral disc typically lighter colour than column; with dark radiating lines; space between lines may be light in life (light pigment disappears in preservation).

Size. – Pedal disc, oral disc, and length of expanded individual typically the same, 10–15 mm in life, but may be as much as 25 mm.

Internal anatomy. – See Dunn (1974), England (1987).

Cnidae. – Cnidom spirocysts, basitrichs, holotrichs (termed atrichs by Dunn, 1974), microbasic *p*-mastigophores, heterotrichs (not mentioned by Dunn, 1974), microbasic amastigophores (not mentioned by Dunn, 1974). For details of distribution, size, and appearance, see Dunn (1974), England (1987).

Natural history. – Azooxanthellate.

Habitat. – High intertidal zone to shallow subtidal attached to holes in rock or deal coral on sandy shores; in holes or cracks on rocky shores.

Distribution. – First record for Singapore. Recorded from Hawaii, Hong Kong, Australia (Queensland), and India (Fautin, 2008), may occur in Japan (England, 1992; Uchida and Soyama, 2001); known also from the Philippines (Fautin, pers. obs.).

Remarks. – *Anthopleura nigrescens* may be confused with two other species of *Anthopleura* in Singapore, *An. dixoniana* and *An. handi*, with which it obviously shares features of the genus such as verrucae and acrorhagi (there is no confusion with the fourth species of the genus recorded in Singapore, *An. buddemeieri*, which has a light column, pink acrorhagi, and a red spot in the centre of each verruca). 1) The column of both *An. nigrescens* and *An. dixoniana* is dark, but the



Fig. 6. *Anthopleura nigrescens*: Changi Point beaches (ZRC.CNI.0232). Photo: S. H. Tan.

latter typically occurs much higher in the intertidal zone and in large numbers; moreover, individuals of *An. dixoniana* are smaller. 2) An individual of *An. handi* can be similar in size to one of *An. nigrescens*, but its column is lighter in colour. The acrorhagi of *An. nigrescens* are white-tipped, unlike those of *An. dixoniana* and most of those of *An. handi*, and its verrucae are much more conspicuous and occur more basally than those of either of the others.

***Entacmaea quadricolor* (Leuckart, in Rüppell & Leuckart, 1828)**

(Fig. 7)

Actinia quadricolor Leuckart in Rüppell & Leuckart, 1828: 4–5 (original description).

Entacmaea quadricolor – Dunn, 1981: 3, 15–28, 39, 45, 56, 106–108.

Material examined. – Chek Jawa (Pulau Ubin); Kusu Island; Sisters Island; Pulau Semakau (ZRC.CNI.0312).

Live appearance/external anatomy. – See Fig. 7. Column usually hidden in hole in reef, so only tentacles visible. Each tentacle brownish (may have green sheen) with white band near terminus, commonly with red tip; tentacle usually inflated near end, with white band at equator. Column brownish to pinkish, smooth; oral disc broader than pedal disc so column flares.

Size. – Highly extensible: small individuals usually about as long as broad (as small as 50–100 mm), large individuals longer than broad (to 500 mm long).

Internal anatomy. – See Dunn (1981).

Cnidaria. – Cnidom spirocysts, basitrichs, microbasic *p*-mastigophores, heterotrichs (not mentioned by Dunn, 1981), microbasic amastigophores (not mentioned by Dunn, 1981). For details of distribution, size, and appearance, see Dunn (1981), England (1987).

Natural history. – Zooxanthellate. Host to 13 species of anemonefishes (Dunn, 1981; Fautin & Allen, 1992), of which three may occur in Singapore waters. However, fish are rarely found in Singapore anemones, and only *Amphiprion frenatus* has been observed; because elsewhere in nature, it is unusual to see anemones lacking anemonefish, it is likely they are removed by collectors in Singapore. Anemones lacking anemonefish are vulnerable to predation by butterflyfishes (e.g. Godwin & Fautin, 1992).

Habitat. – Small individuals live in shallow water, typically on the top of coral reefs, anchored in cracks; they form clusters, which are produced by longitudinal division of an initial individual. Large individuals are typically solitary, and live on reef slopes, anchored in holes, in deeper water than small ones.

Distribution. – Previously reported in Singapore from Pulau Hantu and Pulau Biola by England (1987). Widespread from Red Sea to western Pacific, southern Japan, Lord Howe Island (Dunn, 1981; Fautin & Allen, 1992; Fautin, 2008).

Remarks. – Many individuals of another species living in Singapore have tentacles that are bulbed at the end or just below the end like most of those of *E. quadricolor*. Individuals of that species, which will be dealt with in a subsequent publication, are much smaller than those of *E. quadricolor*.

England (1987) considered the genus *Entacmaea* to belong in family Stichodactylidae, an opinion with which we disagree because the presence of more than one tentacle per endocoel is rare, occurring in only some very large individuals, whereas in genera of family Stichodactylidae (*Heteractis* and *Stichodactyla*), multiple endocoelic tentacles are present in even the smallest individuals.

Probably due to its variable appearance and its broad geographical range, there are many, many synonyms for this species. See Dunn (1981) and Fautin (2008) for an inventory of them.

***Macroactyla doreensis* (Quoy & Gaimard, 1833)**
(Figs. 8, 9)

Actinia doreensis de Blainville, 1830: 293 (nomen nudum).

Actinia doreensis Quoy & Gaimard, 1833: 149–150 (original description).

Paractis Doreyensis – Milne Edwards, 1857: 252.
Cereactis doreyensis – Andres, 1883: 248–249.
Condylactis Gelam Haddon & Shackleton, 1893: 117, 123–124
 (original description).
Aulactinia Gelam – Haddon, 1898: 398, 442–443.
Anthopleura Gelam – Carlgren, 1949: 54.
non Radianthus Gelam – Allen, 1972: 122, 154, 168, 187, 200,
 252, i.
Macroactyla gelam – Mariscal, 1972: 330.
Radianthus gelam – Allen, 1973: 324.
Radianthus malu – Moyer, 1976: 13–14, 19.
Macroactyla doreensis – Dunn, 1981: 29–37, 57, 71, 106, 108.
Heteractis gelam – Cutress & Arneson, 1987: 54, 55, 57, 60.
Antheopsis doreensis – Uchida & Soyama, 2001: 92, 150, 155.

Material examined. – Chek Jawa (Pulau Ubin); Pulau Sekudu;
 Beting Bronok; Kusu Island; Sisters Island; Pulau Semakau (ZRC.
 CNI.0364); Cyrene Reef; Jurong (ZRC.CNI.0001); Tuas.

Live appearance/external anatomy. – See Figs. 8 and 9.
 Oral disc much broader than pedal disc so column flared;
 flared part of column darker than lower part (which may be
 spotted with orange or red), with distinctive eye-shaped
 white verrucae (Fig. 9). Tentacles relatively few (perhaps
 100–200), long, narrow and tapered; may be longitudinally
 striped and may coil corkscrew-like.

Size. – Oral disc to 500 mm diameter, but typically 100 mm;
 longest tentacles about same length as oral disc diameter.
 Column about as long as oral disc diameter; lower column
 and pedal disc about a quarter expanded oral disc diameter.

Internal anatomy. – See Dunn (1981).

Cnidae. – Cnidom spirocysts, basitrichs, microbasic
p-mastigophores. For details of distribution, size, and
 appearance, see Dunn (1981).

Natural history. – Zooxanthellate. Host to four species
 of anemonefishes (Dunn, 1981; Fautin & Allen, 1992)
 of which three may occur in Singapore waters. An error
 in the Appendix of Fautin & Allen (1992) was corrected
 by Ollerton et al. (2007): *M. doreensis* is listed as being
 in symbiosis with *Amphiprion chrysoaster*, whereas the
 species actually is *Am. chrysopterus*.

Habitat. – Soft sediment.

Distribution. – First record for Singapore. Known from
 Japan to Great Barrier Reef (Dunn, 1981; Fautin & Allen,
 1992; Fautin, 2008); also known from Western Australia
 (Dampier Peninsula) (WAM 830-88).

Remarks. – *Macroactyla doreensis* resembles in shape,
 size, and habitat *Heteractis crispata*. The eye-shaped,
 white verrucae of *M. doreensis* distinguish it, as do the fewer,
 longer tentacles. The texture of the column of *M. doreensis*
 is silky and thin, in contrast with that of *H. crispata*, which is
 tough and leathery.

Macroactyla doreensis is common in the aquarium trade.
 It had been thought to occur only in a narrow arc along the



Fig. 7. *Entacmaea quadricolor*: Sisters Island, not preserved. Photo: Ria Tan.



Fig. 8. *Macrodictyla doreensis* (partially expanded): Beting Bronok, not preserved. Photo: Ria Tan.



Fig. 9. *Macrodictyla doreensis* (contracted): Beting Bronok, not preserved. Photo: Ria Tan.

western Pacific, from southern Japan to the Great Barrier Reef (Dunn, 1981; Fautin & Allen, 1992); through the Singapore records and specimens in WAM, we now know it also occurs in the eastern Indian Ocean.

Actinodendridae Haddon, 1898

Actinodendron arboreum (Quoy & Gaimard, 1833)

(Fig. 10)

Actinodendron arborea Quoy & Gaimard in de Blainville, 1830: 287 (nomen nudum).

Actinia arborea Quoy & Gaimard, 1833: 153–154 (original description).

Actinodendron arboreum – de Blainville, 1834: 320.

Actinodendron alcyonoideum – Saville-Kent, 1893: 34, 146.

Acremodactyla ambonensis Kwietniewski, 1897: 19–23 (original description).

Actinodendron plumosum – Haddon, 1898: 399, 490–491.

Actinodendron ambonensis – Stephenson, 1922: 294.

Actinodendron ambonense – Carlgren, 1945: 15.

Material examined. – Beting Bronok; Kusu Island; Pulau Semakau (ZRC.CNI.0313).

Live appearance/external anatomy. – See Fig. 10. Typically only oral end seen because pillar-like column burrowed into soft sediment. Tentacles 48, complexly branched (Fig. 10) so animal resembles head of broccoli. Tentacles, oral disc, and column sand-coloured. Oral disc may have radiating white lines; column smooth, with many small dark splotches, some with crimson spots near base.

Size. – Oral disc diameter about same length as extended tentacles – to nearly 100 mm; column may be 120 mm long.

Internal anatomy. – See Kwietniewski (1898), who wrote about this species as *Acremodactyla ambonensis*.

Cnidae. – Cnidom spirocysts, microbasic *b*-mastigophores. For details of distribution and size, see Carlgren (1945), who referred to the microbasic *b*-mastigophores as basitrichs, and who studied specimens identified as *A. ambonense* and *A. plumosum*.

Natural history. – Zooxanthellate. Can retract quickly into soft sediment when disturbed. Can inflict painful sting on humans.

Habitat. – Soft sediment, usually sand.

Distribution. – First record for Singapore [a specimen collected by England in Singapore was recorded in the unpublished dissertation of Ardelean, 2003; this specimen, catalogue number NHM 1955.1540, was collected in sand near high water mark on “P. Hantu Br.,” and is presumably the animal referred to by England (1987) as *Actinodendron* sp. from Pulau Hantu]. Recorded from Marshall Islands, New Caledonia, Australia, Solomon Islands, New Guinea, Indonesia, Okinawa, Philippines (Fautin, 2008; some

records from unpublished dissertation of Ardelean, 2003), Japan (Uchida & Soyama, 2001).

Remarks. – The genus *Actinodendron* contains six valid species, all of which have complexly branched tentacles; family Actinodendridae contains two other genera with tentacles that are more simply branched.

Thalassianthidae

Cryptodendrum adhaesivum Milne Edwards, 1857

(Fig. 11)

Cryptodendrum adhäsivum Klunzinger, 1877: 86 (original description).

Stoichactis digitata Doumenc, 1973: 175, 194–198 (original description).

Material examined. – Sisters Island; Raffles Lighthouse (Pulau Satumu); Pulau Semakau; Pulau Hantu; Cyrene Reef (ZRC.CNI.0332).

Live appearance/external anatomy. – See Fig. 11. Commonly only broad oral disc visible. Short tentacles of two sorts cover nearly entire oral disc, which generally undulates rather than lying flat: short, spherical tentacles form wide rim near margin, whereas over central oral disc and at very edge of margin each tentacle has about five branches (resembling a hand). Typically central and marginal tentacles differ in colour (yellow and pink, or dark blue and light blue), but patches of central tentacles may differ in colour from others. See Dunn (1981) and Fautin & Allen (1992) for more details.

Size. – Oral disc can reach 200–300 mm diameter.

Internal anatomy. – See Dunn (1981).

Cnidae. – Cnidom spirocysts, basitrichs, microbasic *p*-mastigophores. For details of distribution, size, and appearance, see Dunn (1981).



Fig. 10. *Actinodendron arboreum*: Beting Bronok, not preserved. Photo: Ria Tan.

Natural history. – Zooxanthellate. Tentacles sticky (the source of the animal's species name). Pedal disc and column narrow, attached deep in hole; animal sensitive, so when disturbed withdraws readily. Rare individuals harbour the anemonefish *Amphiprion clarkii* (see Dunn, 1981, Fautin & Allen, 1992) but this symbiosis has not been recorded in Singapore.

Habitat. – Coral reefs.

Distribution. – First record for Singapore. England (1987) included *C. adhaesivum* in a discussion of anemones that occur where wave action is low in Gan and Singapore, but the record is vague. Occurs throughout the tropical and subtropical Indo-West Pacific in shallow water, from the Red Sea, across the Indian Ocean, to French Polynesia, and Japan to Australia (Dunn, 1981; Fautin & Allen, 1992; Fautin, 2008).

Remarks. – Species of the genus *Stichodactyla* have short tentacles that cover the oral disc, and the tentacles may be somewhat sticky, but all the tentacles are similar in form (although they may vary in length), by contrast with *C. adhaesivum*, in which tentacles are of two morphologies.

Stichodactylidae Andres, 1883

Stichodactyla gigantea (Forsskål, 1775)

(Fig. 12)

Material examined. – Pulau Sekudu; Sentosa; Kusu Island; St. John's Island; Sisters Island; Raffles Lighthouse (Pulau Satumu); Pulau Semakau; Pulau Sudong (ZRC.CNI.0007); Pulau Hantu; Cyrene Reef (ZRC.CNI.0330, ZRC.CNI.0331); Labrador Nature Reserve, Tuas.

Live appearance/external anatomy. – See Fig. 12. Broad, undulating oral disc densely covered with hundreds of short, slightly tapering tentacles; in many individuals, tentacles constantly vibrate. Oral disc around mouth bare, but mouth may be hidden amidst folds of oral disc. Tentacles commonly uniform brown, but end of each may be purple, blue, pink, or other striking colour. Column commonly brown, yellowish, or grey-green with blue or maroon verrucae. See Dunn (1981) and Fautin & Allen (1992) for more details.

Size. – Typically 150–200 mm across oral disc, but can be twice that. Column considerably narrower, relatively short.

Internal anatomy. – See Dunn (1981).

Cnidae. – Cnidom spirocysts, basitrichs, microbasic *p*-mastigophores. For details of distribution, size, and appearance, see Dunn (1981).

Natural history. – Zooxanthellate. Host to anemonefish of eight species throughout its range (Ollerton et al., 2007), the seven reported by Fautin & Allen (1992) and *Amphiprion*

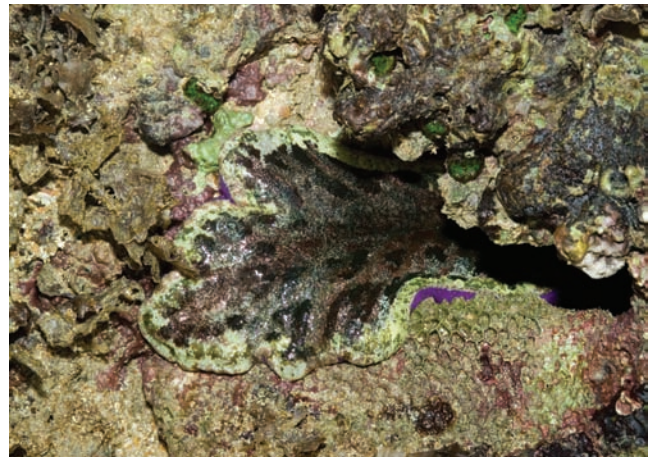


Fig. 11. *Cryptodendrum adhaesivum*: Raffles Lighthouse (Pulau Satumu), not preserved. Photo: Ria Tan.

melanopus; Singapore is within the range of three of them. Fish are found in half or fewer of the individuals in Singapore, most often *Amphiprion ocellaris*, because elsewhere in nature, it is unusual to see anemones lacking anemonefish, it is likely they are removed by collectors in Singapore. This anemone can be sticky to the touch, and tentacles that adhere to a human finger can pull off the animal. It is eaten by people in parts of Indonesia (Dunn, 1981).

Habitat. – Sand in shallow water. Animal commonly attached to rock buried in sand.

Distribution. – Previously reported in Singapore from Pasir Panjang, Buona Vista, Bedok, Pulau Hantu, and Cyrene Reef by England (1987), who referred to it also as *S. kenti*. Occurs in shallow tropical and subtropical seas from the Red Sea, across the Indian Ocean, to New Caledonia, and Japan to Australia (Dunn, 1981; Fautin & Allen, 1992; Fautin, 2008).

Remarks. – This species may be confused with both *S. haddoni* (which we have seen in Singapore) and *S. mertensii* (which we have not). The oral disc of *S. gigantea* typically undulates more deeply than that of *S. haddoni*; the oral disc of *S. mertensii* lies flat, the orange or purple verrucae of the column attached to stones, holding the outspread oral disc against the substratum. All tentacles of *S. gigantea* are identical, whereas in *S. haddoni* larger, blunter tentacles alternate at the margin with less robust, more pointed tentacles. Both *S. gigantea* and *S. haddoni* may live intertidally, whereas *S. mertensii* does not, to our knowledge. Occasionally *S. gigantea* and *S. haddoni* live in the same area in Singapore, but in general *S. gigantea* appears to favour less turbid areas that are richer in coral, whereas *S. haddoni* can be abundant in muddy sand and seagrass beds.

Many names have been used for this widespread animal, including those properly belonging to other species of the genus. See Dunn (1981) and Fautin (2008) for an inventory.

***Stichodactyla haddoni* (Saville-Kent, 1893)**

(Fig. 13)

Discosoma Haddoni Saville-Kent, 1893: 32–33 (original description).

Stoichactis ambonensis – Pax, 1924: 14–15.

Stichodactyla haddoni – Dunn, 1981: 4, 13, 77, 81–91, 95, 98, 104, 107–108.

Material examined. – Pasir Ris; Changi Point beaches; Changi Ferry Terminal beach; Chek Jawa (Pulau Ubin) (ZRC.CNI.0006); Pulau Sekudu; Beting Bronok; Sentosa (ZRC.CNI.0414, ZRC.CNI.0418); Kusu Island; St. John’s Island; Sisters Island; Pulau Semakau; Cyrene Reef; Tuas.

Live appearance/external anatomy. – See Fig. 13. Broad, flat to shallowly undulating oral disc densely covered with hundreds of slightly tapering tentacles; at margin, these tentacles alternate with more robust, blunter tentacles that may be white and are about twice as long (the former are aligned along the endocoels, the spaces between mesenteries that constitute a pair, whereas the latter communicate with the spaces between adjacent pairs). All tentacles can be of one colour (commonly green, yellow, grey), or not: tentacles of the same colour may be arrayed in patches or in radial rows. Most tentacles very short but some individuals with patches of tentacles several times as long. Oral disc around mouth bare, yellowish to orange. Column commonly whitish or brownish with rose or purple verrucae; tapers to pedal disc much narrower than oral disc. See Dunn (1981) and Fautin & Allen (1992) for more details.

Size. – To 500 mm diameter, rarely more.

Internal anatomy. – See Dunn (1981).

Cnidae. – Cnidom spirocysts, basitrichs, microbasic *p*-mastigophores. For details of distribution, size, and appearance, see Dunn (1981).

Natural history. – Zooxanthellate. In response to disturbance, anemone may retract completely into sand. Host to seven species of anemonefish throughout its range (Fautin &

Allen, 1992), of which two may occur in Singapore waters. However, fish are rarely found; because elsewhere in nature, it is unusual to see anemones lacking anemonefish, it is likely they are removed by collectors in Singapore. Two or more specimens of the symbiotic shrimp *Periclimenes brevicarpalis* may occur with an individual of *S. haddoni*. The shrimp are generalists and so are likely to occur with anemones of other species also.

Habitat. – From mid-tide levels to as deep as sufficient light penetrates, in areas where the column can burrow into soft sediment.

Distribution. – First record for Singapore. Occurs in shallow tropical and subtropical seas from the Red Sea, across the Indian Ocean, to New Caledonia, and Japan to Australia (Dunn, 1981; Fautin & Allen, 1992; Fautin, 2008).

Remarks. – This species may be confused with both *S. tapetum* and *S. gigantea*. An individual of *S. tapetum* is much smaller than a typical specimen of *S. haddoni*. Tentacles cover the entire oral disc of *S. haddoni* (except around the mouth), whereas tentacles of *S. tapetum* are arrayed in clear radially-oriented groups, with bare space between; and the tentacles of *S. tapetum* may be so tightly packed together that they are polygonal in outline, like kernels of maize, rather than circular. The exocoelic tentacles of *S. haddoni* are commonly prominent, often projecting radially from the oral disc, and may be pigmented white; those of both *S. tapetum* and *S. gigantea* are less conspicuous. The oral disc of *S. haddoni* typically undulates less deeply than that of *S. gigantea*. Occasionally *S. haddoni* and *S. gigantea* live in the same area in Singapore, but in general *S. haddoni* can be abundant in muddy sand and seagrass beds whereas *S. gigantea* appears to favour less turbid areas that are richer in coral.

The names *Stoichactis kenti* and *Stoichactis giganteum*, which properly belong to *Stichodactyla gigantea*, have been misapplied to this species.

***Stichodactyla tapetum* (Hemprich & Ehrenberg in Ehrenberg, 1834)**

(Fig. 14)

Actinia Tapetum Hemprich & Ehrenberg in Ehrenberg, 1834: 256 (original description).

Homactis rupicola Verrill, 1869: 71–72 (original description).

Discosoma tapetum – Klunzinger, 1877: 83.

Ricordea rupicola – Haddon, 1898: 481.

?*Discosoma ambonensis* – Kwietniewski, 1898: 387, 410–412, 413.

Discosomoides tapetum – Haddon, 1898: 469–470.

Isacmaea Tapetum – Carlgren, 1899a: 15.

Stoichactis tapetum – Carlgren, 1900: 94–97.

Stoichactis laevis Lager, 1911: 240–241 (original description).

Stoichactis australis Lager, 1911: 241–243 (original description).

Stoichactis ambonensis – Stephenson, 1922: 299.

Stoichactis rupicola – Carlgren, 1949: 73.

Stichodactyla tapetum – Dunn, 1981: 5, 73–78, 90, 106, 108.

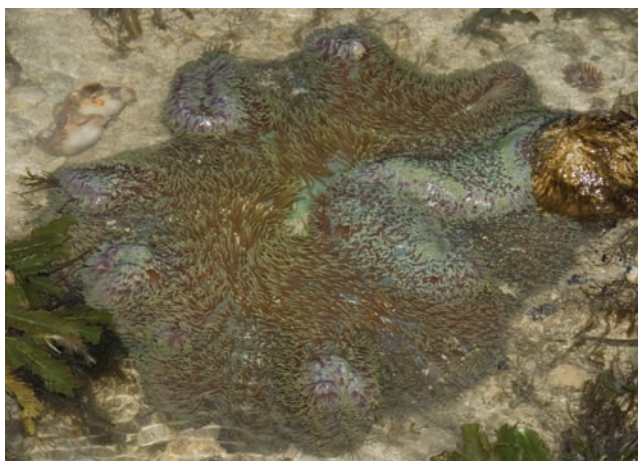


Fig. 12. *Stichodactyla gigantea*: Pulau Sekudu, not preserved. Photo: Ria Tan.

Material examined. – Changi Point beaches (ZRC.CNI.0005, ZRC.CNI.0407); Changi Ferry Terminal beach; Katong (ZRC.CNI.0004); Sentosa (ZRC.CNI.0413); Pulau Sudong (ZRC.CNI.0003).

Live appearance/external anatomy. – See Fig. 14. Oral disc flat (not undulating); short, bulbous tentacles arrayed in clear radially-oriented groups from mouth to margin, with bare space between; within a wedge, tentacles so tightly packed together they may be polygonal in outline, like kernels of maize.

Size. – Oral disc diameter typically 10–30 mm, but may be larger.

Internal anatomy. – See Dunn (1981).

Cnidae. – Cnidom spirocysts, basitrichs, microbasic *p*-mastigophores. For details of distribution, size, and appearance, see Dunn (1981).

Natural history. – Zooxanthellate. Do not harbour anemonefish.

Habitat. – Muddy sand beaches, rocky shores.

Distribution. – First record for Singapore. Occurs in shallow

tropical and subtropical seas from the Red Sea, across the Indian Ocean, to New Caledonia, and Japan to Australia (Dunn, 1981; Fautin & Allen, 1992; Fautin, 2008).

Remarks. – An individual of *Stichodactyla tapetum* may be mistaken for a small one of *S. haddoni*. However, bare oral disc visible between wedge-shaped groups of tentacles of *S. tapetum* whereas tentacles cover the entire oral disc of *S. haddoni* (except around the mouth); and the tentacles of *S. haddoni* are circular in outline whereas those of *S. tapetum* may not be. Exocoelic tentacles of *S. tapetum* are not as prominent as those of *S. haddoni*, which may project radially from the oral disc, and be pigmented white.

***Heteractis crisa* (Hemprich & Ehrenberg in Ehrenberg, 1834)
(Fig. 15)**

Actinia (Entacmaea) crisa Hemprich & Ehrenberg in Ehrenberg, 1834: 260 (original description).

Actinia paumotensis Couthouy in Dana, 1846: 141 (original description).

Discosoma macrodactylum Haddon & Shackleton, 1893: 117, 120–121 (original description).

Radianthus Kükenthali Kwietniewski, 1896: 389–390 (original description).



Fig. 13. *Stichodactyla haddoni*; Chek Jawa, not preserved. Photo: Ria Tan.

Discosoma tuberculata Kwietniewski, 1898: 387, 412–413 (original description).

Radianthus lobatus Kwietniewski, 1898: 387, 414–415 (original description).

Discosomoides tuberculata – Pax, 1910: 227.

Stoichactis tuberculata – Stephenson, 1922: 299.

Heteractis crispa – Dunn, 1981: 3, 26, 40, 44, 47–57, 62, 65, 71, 103, 105, 107–108.

Material examined. – Pulau Semakau, Pulau Sudong (ZRC. CNI.0002).

Live appearance/external anatomy. – See Fig. 15. Oral disc brownish in most individuals, green in some; much wider than column and pedal disc, covered with several hundred long white to grey tentacles, each tapering to a point; some may have spot of colour (bright green, blue, or mauve) at tip. Actinopharynx white to yellow; may have spot of same colour as tentacle tip where it meets oral disc. Column with prominent verrucae of same colour in flared part; texture leathery; colour white to cream, may have yellowish mottling near base.

Size. – Oral disc to 500 mm diameter, but typically 150–200 mm; longest tentacles somewhat less than oral disc diameter. Column about as long as oral disc diameter; lower column and pedal disc about a quarter expanded oral disc diameter.

Internal anatomy. – See Dunn (1981).

Cnidae. – Cnidom spirocysts, basitrichs, microbasic *p*-mastigophores. For details of distribution, size, and appearance, see Dunn (1981).

Natural history. – Zooxanthellate. Host to 14 species of anemonefish throughout its range (Dunn, 1981; Fautin & Allen, 1992), of which five may occur in Singapore waters. However, fishes were rarely found during our field surveys. Elsewhere in nature, it is unusual to see anemones lacking anemonefish and we postulate that the fishes were removed by collectors in Singapore.



Fig. 14. *Stichodactyla tapetum*: Changi Ferry Terminal, not preserved. Photo: Ria Tan.

Habitat. – Soft sediments, where an anemone lives with the column buried in the substratum, and coral thickets, where the anemone lives attached to a coral branch.

Distribution. – First record for Singapore. Occurs in shallow tropical and subtropical seas from the Red Sea, across the Indian Ocean, to French Polynesia, and Japan to Australia (Dunn, 1981; Fautin & Allen, 1992; Fautin, 2008).

Remarks. – *Heteractis crispa* resembles in shape, size, and habitat *Macroactyla doreensis*. The former has more (and generally shorter) tentacles than the latter. The verrucae of *H. crispa* are circular and are the same colour as the column, whereas those of *M. doreensis* are eye-shaped and white. The texture of the column of *H. crispa* is leathery, whereas that of *M. doreensis* is thin.

Many variants of the various synonyms have been used for this widespread animal, and some names properly referring to other species have been applied to it. See Dunn (1981) and Fautin (2008) for an inventory.

Heteractis magnifica (Quoy & Gaimard, 1833)

(Fig. 16)

Actinia magnifica de Blainville, 1830: 293 (nomen nudum).

Actinia magnifica Quoy & Gaimard, 1833: 140–141 (original description).

Corynactis magnifica – Milne Edwards, 1857: 259.

Ropalactis magnifica – Andres, 1883: 259.

Helianthopsis ritteri – Kwietniewski, 1898: 387, 417–419.

Helianthopsis Mabrucki Carlgren, 1900: 102–103 (original description).

Radianthus mabrucki – Stephenson, 1922: 299.

Antheopsis ritteri – Stephenson, 1922: 300.

Anemone 4 – Verwey, 1930: 313–314.

Radianthus ritteri – Carlgren, 1949: 74.

Radianthus paumotensis – Friese, 1972: 76.

Radianthus malu – Allen, 1978: 13, 55, 56, 69, 70, 75, 80, 81, 96.

Heteractis magnifica – Dunn, 1981: 3–6, 27, 39–48, 103–108.

Heteractis ritteri – Cutress & Arneson, 1987: 54, 55, 57, 59.

Material examined. – Kusu Island; Pulau Semakau; Pulau Sudong; Pulau Hantu.

Live appearance/external anatomy. – See Fig. 16. Pillar-like column solid colour (red, green, brown, white, blue, pink common), thin, with distal verrucae same colour as column. Brownish oral disc flat or gently undulate, covered by moderately long tentacles that are typically blunt or slightly inflated at end; tentacle end may be brighter colour than rest (which is typically brown). When the animal contracts, tentacles may be pointed, as they commonly are in preserved specimens. Mouth may be raised on cone; area around it yellow in many individuals.

Size. – Oral disc may exceed 500 mm diameter, but typically less than that. Column pillar-like, somewhat smaller diameter than oral disc, equal to pedal disc.

Internal anatomy. – See Dunn (1981).

Cnidae. – Cnidom spirocysts, basitrichs, microbasic *p*-mastigophores. For details of distribution, size, and appearance, see Dunn (1981).

Natural history. – Zooxanthellate. Host to anemonefish of 12 species throughout its range (Ollerton et al., 2007), the 11 reported by Fautin & Allen (1992) and *Amphiprion frenatus*. Singapore is within the range of five of those anemonefishes. However, fishes are rarely found in this anemone in Singapore. Elsewhere in nature, it is unusual to see these anemones lacking anemonefish and it is likely they are removed by collectors in Singapore.

Habitat. – On hard substrata, mostly subtidal but may be exposed at unusually low tides.

Distribution. – Previously reported in Singapore from Pulau Hantu by England (1987) as *Radianthus magnifica*. Occurs in shallow tropical and subtropical seas from the Red Sea, across the Indian Ocean, to French Polynesia, and Japan to Australia (Dunn, 1981; Fautin & Allen, 1992; Fautin, 2008).

Remarks. – This is perhaps the most widely photographed

species of sea anemone in the world, due not only to its large size and the brilliant colours of its column, which attract attention, but to the fact that the animal typically attaches to high prominences, where it is conspicuous. In aquaria, it moves around a great deal, and seeks out the highest object in the tank, which makes it an unsuitable pet. Few species anywhere in the world can be confused with it, and none in Singapore.

Aiptasiidae Carlgren, 1924a

Paraiptasia radiata (Stimpson, 1856)

(Figs. 17, 18)

Actinia radiata Stimpson, 1856: 375 (original description).

Sagarta [sic] *radiata* Verrill, 1866: 50.

Sagarta radiata – Verrill, 1869: 55–56.

Paraiptasia radiata – England, 1992: 49, 89–93.

Material examined. – Sungei Buloh Wetland Reserve (ZRC.CNI.0046, ZRC.CNI.0379–0381, ZRC.CNI.0384–0386); Pasir Ris (ZRC.CNI.0257–0260); Changi Point beaches (KUDIZ 2917); Changi Ferry Terminal beach (ZRC.CNI.0043, ZRC.CNI.0044); Chek Jawa (Pulau Ubin) (ZRC.CNI.0042); Kusu Island (ZRC.CNI.0045); Little Sister Island (Pulau Subar Darat) (ZRC.CNI.0231).

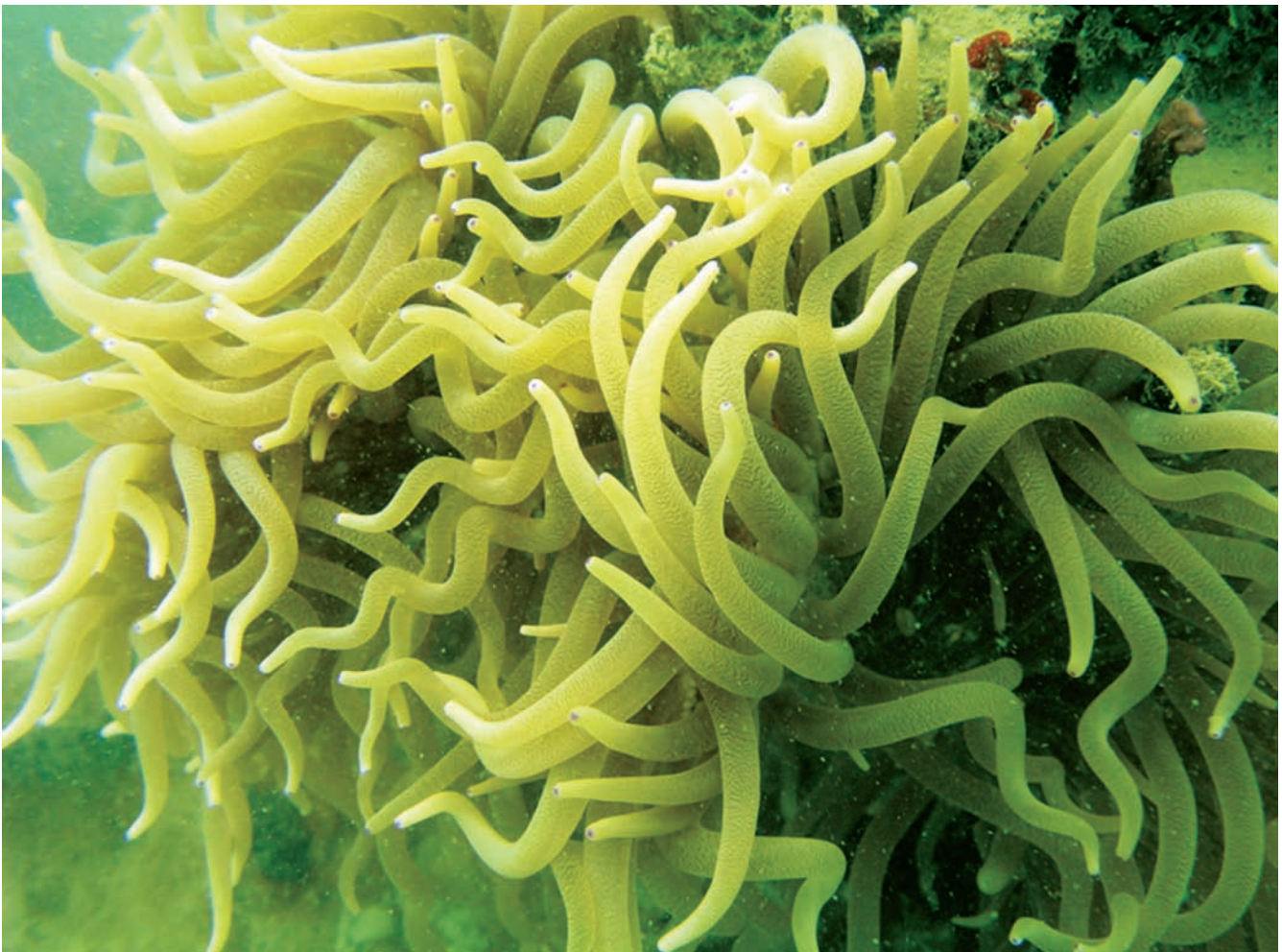


Fig. 15. *Heteractis crispa*: northeast of Pulau Semakau, 1 Sep.2006, not preserved. Photo: Eugene Goh.



Fig. 16. *Heteractis magnifica*: Pulau Hantu, not preserved. Photo: Ria Tan.

Live appearance/external anatomy. – See Figs. 17–18. Smooth greenish, brownish, or greyish column not divided into regions, with longitudinal white stripes, some of which may have a yellowish tinge, some of which occur only near base or margin; typically a dark dot in centre of each white stripe right at limbus. Stripes that occur entire length alternately broader and narrower; colour and pattern in some individuals muted but in many very bold. Oral disc deep rich brown in many specimens; alternating dark and light radial stripes originate at mouth, some with orange cast; individuals with bold column stripes have bold oral disc striping, including, in many, an orange wedge at marginal base of some tentacles or white chevron at base of some tentacles. Tentacles typically number 48, arise at margin, taper to blunt point; translucent with dark and white spots along oral face, or dark and light rings. No fosse. Actinopharynx white. Contracted animal pyramidal (Fig. 18).

Size. – To 12 mm basal diameter and length; typically base is ovoid, being about twice as long as wide. Oral disc diameter similar to basal. Inner tentacles longer than outer; longest nearly as long as oral disc diameter.

Internal anatomy. – See England (1992).

Cnidae. – Cnidom: spirocysts, basitrichs, microbasic *p*-mastigophores, microbasic amastigophores, mesobasic amastigophores, mesobasic *p*-mastigophores, atrichs. For details of distribution, size, and appearance, see England (1992).

Natural history. – Every specimen we found was attached to the shell of a living snail. England (1992) reported it from *Nassarius* sp.; most specimens we found were attached to *Nassarius livescens* (Philippi, 1849) ZRC CNI.0042–0044, with two anemones attached to one of the shells, but one each were on *N. crenoliratus* (A. Adams, 1852) (ZRC CNI.0044) and *N. jacksonianus* (Quoy & Gaimard, 1833) (ZRC.CNI.045). In addition, we found one specimen on *Cerithium coralium* Kiener, 1841 (ZRC CNI.0231) and another on *Thais lacera* (Born, 1778) (ZRC CNI.0042). Acontia are not emitted even when animal is disturbed.

Habitat. – This anemone, found only on shells of living snails living in or on sand or mud, occurs in the greatest diversity of habitats of any species of sea anemone in Singapore.

Distribution. – Previously reported in Singapore from Pungol [sic] Point, Kampong Loyang, and Pasir Ris by England (1992). Known also from Hong Kong, Japan (England, 1992; Fautin, 2008).

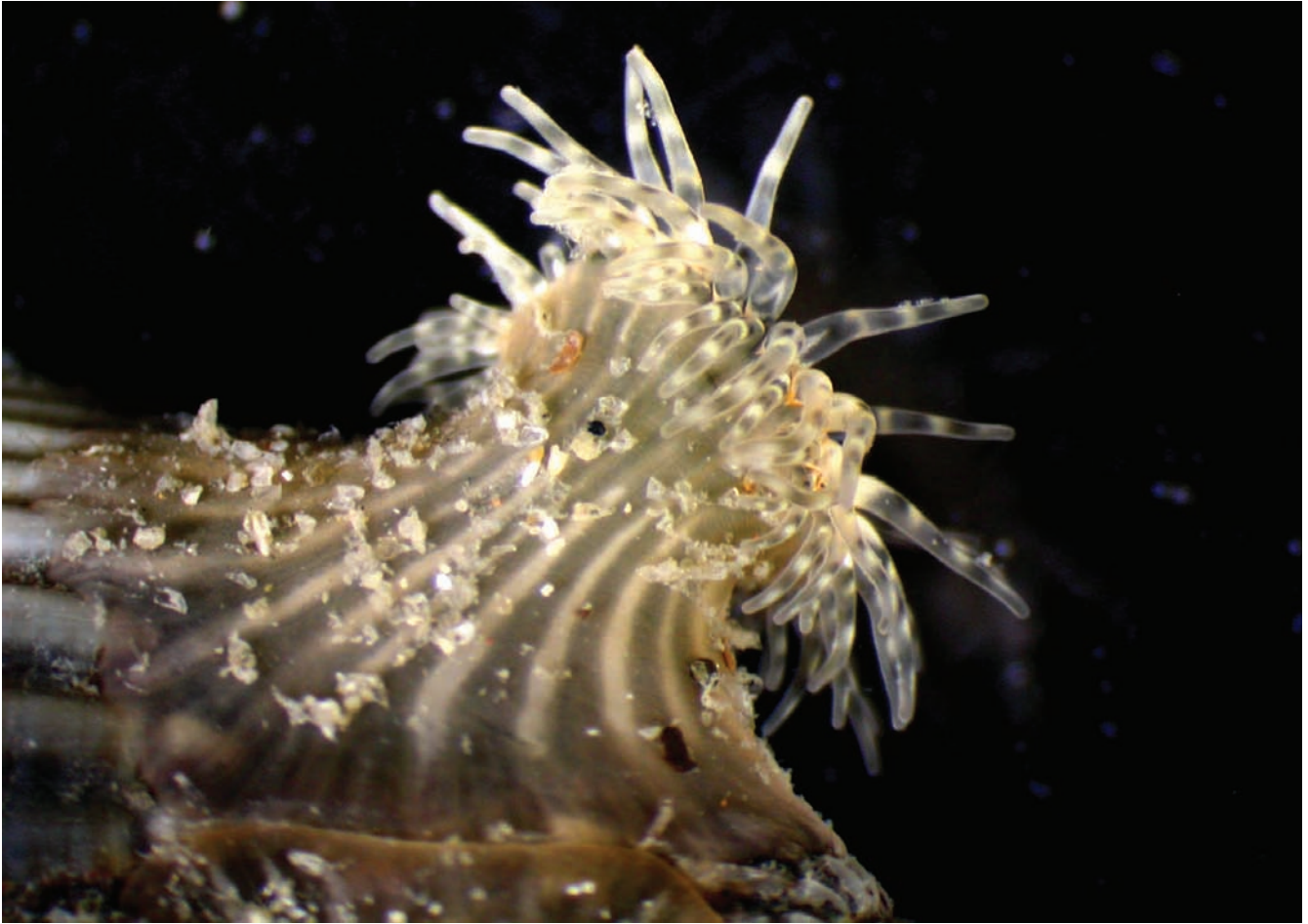


Fig. 17. *Paraiptasia radiata* (expanded): Changi Ferry Terminal beach (ZRC.CNI.0044). Photo: S. H. Tan.

Remarks. – Individuals of *P. radiata* are distinctive in both appearance and habitat. However, some individuals of two other species in Singapore may be confused with it. 1) Individuals of *Diadumene lineata* are green with longitudinal lines, but the lines of *P. radiata* are bolder, and although both species have acontia, an individual of *P. radiata* does not readily emit them when disturbed, whereas an individual of *D. lineata* does. We have never found *D. lineata* attached to a snail shell. 2) We have found specimens of at least one other species of sea anemone attached to snail shells, but its stripes are much less prominent.

Diadumenidae Stephenson, 1920

Diadumene lineata (Verrill, 1869)

(Figs. 19, 20)

Sagartia lineata Verrill, 1869: 57 (original description).

Sagartia luciae Verrill, 1898: 493–494 (original description).

Diadumene luciae – Carlgren, 1927: 444.

Aiptasiomorpha luciae – Carlgren, 1949: 109.

Haliplanella luciae – Hand, 1956: 211–222.

Diadumene lineata – Williams, 1980: 84–86.

Material examined. – Sungei Buloh Wetland Reserve (ZRC.CNI.0382); Pasir Ris (ZRC.CNI.0270); Changi Creek; Chek Jawa (Pulau Ubin) (ZRC.CNI.0031–0033); Pulau Sekudu (ZRC.

CNI.0034, ZRC.CNI.0035); fouling panels at St. John's Island.

Live appearance/external anatomy. – See Figs. 19, 20. Smooth green column with longitudinal white and yellow, orange, or even red lines, singly or in pairs. Oral disc of those with red lines may have red spot at base of some tentacles; oral disc may be solid dark colour or a wedge may be white (Fig. 20). Tentacles typically dark but rare ones may be cream colour. Can emit acontia when disturbed.

Size. – Rarely more than a few millimetres across and high.

Internal anatomy. – See Hand (1956).

Cnidae. – Cnidom spirocysts, basitrichs, holotrichs, microbasic *p*-mastigophores, microbasic amastigophores. For details of distribution, size, and appearance, see Hand (1956) and Williams (1975), who referred to the species as *Haliplanella luciae*.

Natural history. – The most widely distributed species of sea anemone in the world, this animal has been spread by human agency, probably attached to ships and presumably from a source in east Asia (Carlton et al., 2004). It commonly occurs in harbours and shipping lanes (Dunn, 1983). It reproduces asexually by pedal laceration and longitudinal fission. It was studied in Peninsular Malaysia (Dunn, 1983).



Fig. 18. *Paraiptasia radiata* (contracted): Changi Ferry Terminal beach (ZRC CNI.0044). Photo: S. H. Tan.



Fig. 19. *Diadumene lineata*: Chek Jawa (Pulau Ubin) (ZRC.CNI.0031). Photo: S. H. Tan.

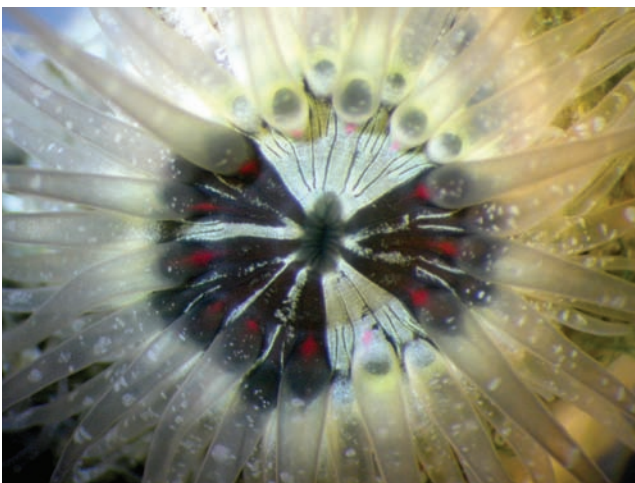


Fig. 20. *Diadumene lineata* (oral disc): Chek Jawa (Pulau Ubin) (ZRC.CNI.0031). Photo: S. H. Tan.

Habitat. – Very high intertidal, commonly in barnacle tests or on oyster shells.

Distribution. – First record for Singapore. Occurs through much of the tropics and subtropics (Hong Kong, Peninsular Malaysia, Rio de Janeiro) to higher latitudes (San Francisco Bay, Auckland Harbour, Plymouth (UK), Woods Hole). It has not been certainly recorded from Australia.

Remarks. – Although individuals of *D. lineata* are very distinctive, those of two species in Singapore may be confused with it. 1) Both *D. lineata* and *Anthopleura dixoniana* live very high in the intertidal. When the tide is out, the very small and numerous animals of both species look dark and shiny; *D. lineata* is easily distinguished by being green with longitudinal white and orange or red lines, and an individual will readily emit its acontia when disturbed (*An. dixoniana* lacks acontia). 2) Individuals of *Paraiptasia radiata* can also be green with longitudinal lines, but its lines are bolder and dark. Although both species have acontia, an individual of *P. radiata* does not readily emit them when disturbed, whereas an individual of *D. lineata* does.

BIOGEOGRAPHY

As stated at the outset, there are no unresolved taxonomic problems for these 16 species, all of which are relatively common, conspicuous, or occur in aggregations that are usually easily seen by the casual observer. Another factor contributing to their being well studied is that they are widespread. In these respects they may be atypical of the Singapore sea anemone fauna. Of the others that we have collected since 2007, specimens of some are elusive and require the skills of experienced field collectors and delicate handling to obtain and preserve the material, whereas some that are relatively abundant require additional taxonomic analysis for identification to be certain. These will be the subject of future works on the sea anemone fauna of Singapore.

For 15 of the 16 species reported here, we discerned two broad patterns of distribution; details of distribution of each species are included in the individual species sections, and in Fautin (2008). The one species that did not share a pattern with any other is *Diadumene lineata*, which is cosmopolitan by virtue, it is widely accepted, of being an excellent invader. It has been recorded throughout world, at both tropical and temperate latitudes. Although it had not previously been reported from Singapore, it was known from the Malacca Straits of Malaysia, so we were not surprised to find it in Singapore.

Seven of the 15 species are recorded from the Red Sea into the western Pacific. Because Singapore is in about the centre of that range, for the four of those species not previously reported from Singapore, their presence is not surprising. Five of the seven species are known from the Red Sea to French Polynesia: *Cryptodendrum adhaesivum*, *Entacmaea quadricolor*, *Heteractis crispa*, *H. magnifica*,

and *Stichodactyla tapetum*. *Stichodactyla haddoni* is reported east only as far as Fiji, and *S. gigantea* only as far as New Caledonia. Another reason for the wealth of information about these animals is that all except for *S. tapetum* host clownfish. Five of these seven belong to family Stichodactylidae. Two other species probably should be considered geographically part of this group. *Bolocerooides mcmurrici* extends at least from southern India to the Hawai'ian Islands, but some people have considered similar animals in the western Indian Ocean and Red Sea to belong to another species. Similarly, *Anthopleura nigrescens* has been recorded from the Hawai'ian Islands to western India, but is also known from the Galápagos Islands.

The remaining six species range along the western rim of the tropical Pacific Ocean; Singapore represents their westernmost occurrence. The three that had not been previously recorded from Singapore have isolated occurrences on islands in the western Pacific: *Actinodendron arboreum* had been known from eastern Indonesia and northwestern Australia east to Vanuatu; *Anthopleura buddemeieri*, a relatively recently-described species, was known east to Fiji; and *Macroactyla doreensis* had been known from eastern Indonesia and east to Enewetak. The other three species, which had previously been reported from Singapore, are not known west of the western rim of the Pacific: *Anthopleura dixoniana* is known also from Taiwan and New Guinea; *Anthopleura handi* also occurs in Malaysia, New Guinea, and tropical Queensland; and *Paraipatasia radiata* is known also from Japan and Hong Kong.

KEY TO SEA ANEMONES IN LIFE

This key permits identification of the 16 species reported here. We include information to distinguish each species not only from the other 15 covered in this manuscript, but others we know to occur in Singapore that might be confused with it. Further details are included in the discussion section of each species. All entries involve two choices.

- 1 All tentacles alike 2
 - Tentacles not alike, short: those forming a wide rim near the edge of oral disc globular, those at edge and in centre of oral disc branched from a simple stalk so each resembles a hand; attached deep in crevices into which the animal readily withdraws *Cryptodendrum adhaesivum*
- 2 All tentacles unbranched: tentacle may taper or be uniform diameter entire length, may be pointed or blunt-ended, may be short or long 3
 - All tentacles branched; animal burrowed into soft sediment *Actinodendron arboreum*
- 3 Tentacles short or long but mouth usually can be seen at center of oral disc among them. Typically passive and does not exhibit vigorous swimming activities when disturbed 4
 - Tentacles brown (solid or alternately ringed light and dark), so long and numerous they hide the animal's mouth, but there may be short tentacles among them. When disturbed, some tentacles may be shed and/or the animal may swim by beating the tentacles synchronously *Bolocerooides mcmurrici*

- 4 Column with conspicuous longitudinal stripes, background or stripes may be green; animal small (1 cm or less in basal diameter) 5
 - Column not longitudinally striped; may be spotted or solid in colour 6
- 5 Stripes alternately dark and light, of similar width; animal usually attached to snail shell *Paraipatasia radiata*
 - Some dark stripes broader than light ones; commonly a narrow single or double yellow, orange, or red stripe bisects some of the broad dark stripes; animal commonly lives in crevice or barnacle test *Diadumene lineata*
- 6 Tentacles very short (rare animals have some very long tentacles), cover entire oral disc; oral disc much broader than column, attached in crevice or burrowed into soft sediment7
 - Tentacles long, may be dense or sparse, only near margin of oral disc or cover it entirely 9
- 7 Tentacles short, pointed or blunt-ended, circular in cross-section because tentacles not arrayed in fields; oral disc undulating; animal generally large, to 500 mm diameter (rare individuals even larger) 8
 - Tentacles extremely short, blunt-ended, arrayed in fields, some packed like kernels on an ear of maize (so they are not entirely circular); animal generally less than 150 mm diameter *Stichodactyla tapetum*
- 8 Tentacles of uniform length, taper to blunt point, all same colour (typically distal part brighter than base – green, blue, purple are common colours), may be sticky and vibrate continually *Stichodactyla gigantea*
 - Tentacles composed of cylindrical stalk with pointed to globose end, some of those at margin more robust than the others and (see species treatment for details), tentacles may not all be same colour so animal can appear variegated *Stichodactyla haddoni*
- 9 Tentacles blunt-ended or bulbous near the end, relatively dense especially near margin 10
 - Tentacles taper to point, relatively sparse so oral disc easily seen 11
- 10 Tentacles usually blunt-ended to slightly swollen (tip may be lighter in colour than stalk); column cylindrical, smooth, of uniform colour (red, green, blue, etc.) *Heteractis magnifica*
 - Tentacles brown, usually bulged below pointed or cylindrical tip, bulge with white equator and tip commonly red; column flared, smooth, pinkish to brown; animals may occur in clusters of tens to hundreds *Entacmaea quadricolor*
- 11 Tentacles long, animal medium to large size, column flared from relatively small base but commonly burrowed into soft sediment so column is hidden and oral disc is spread at sediment surface 12
 - Tentacles of medium length; column cylindrical, gravel may adhere to it; animal relatively small, can completely close up, usually attached to firm substratum 13
- 12 Tentacles may have longitudinal white stripe, may assume corkscrew form; column brown or grey with white or cream-coloured eye-shaped verrucae *Macroactyla doreensis*
 - Tentacles of uniform, light colour; column leathery in texture, grayish, upper part with circular verrucae of same colour *Heteractis crispata*

- 13 Column uniform colour, commonly dark 14
 – Column light brown or grey with small red spots its entire length. Acrorhagi pink; commonly lives very high in the intertidal zone *Anthopleura buddemeieri*
- 14 Column with verrucae that are conspicuous and extend nearly to base. Acrorhagi white-tipped *Anthopleura nigrescens*
 – Column with verrucae that are inconspicuous and do not extend far down column. Acrorhagi not white-tipped 15
- 15 Column with lighter-coloured verrucae. Acrorhagi of uniform colour. Many individuals typically occur clustered together
 *Anthopleura dixoniana*
 – Column and verrucae dull grey-green. Acrorhagi of dull grey-green *Anthopleura handi*

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