

Zoantharia (Cnidaria: Anthozoa: Hexacorallia) of the South China Sea and Gulf of Thailand: a species list based on past reports and new photographic records

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Abstract. This study is the first review of Zoantharia species in the South China Sea and Gulf of Thailand. In addition to past literature records, new field observations are added from previously unexamined countries and regions. In total 16 species are listed, 15 of which belong to suborder Brachycnemina, and only one to suborder Macrocnemina. Two species are undescribed. The lack of Macrocnemina species is not likely indicative of a low diversity of this suborder in the South China Sea and Gulf of Thailand, but instead of an absence of research below shallow subtidal depths. As the majority of the new records from this study were randomly compiled by researchers who are not experts of Zoantharia, specific surveys by experts are needed in these two marine regions. The present list should provide a solid basis for such future research.

Key words. Southeast Asia, Indo-Pacific, new records, biodiversity, *Zoanthus*, *Palythoa*

INTRODUCTION

The South China Sea is one of the most important marine regions in terms of commercial shipping, and is currently subject to contentious and overlapping territorial claims by no less than eight countries or regions (People's Republic of China including Macau and Hong Kong, Republic of China (=Taiwan), the Philippines, Malaysia, Brunei, Indonesia, Singapore, and Vietnam) due to the perceived value of its resources, both mineral and biological. Directly to the west/southwest of this is the shallow Gulf of Thailand, bordered by Malaysia, Thailand, and Cambodia. Despite their strategic location, biological knowledge of many marine taxa in these two marine regions is less complete as compared to that of reef-dwelling scleractinians, which have received much attention recently (Hoeksema & Lane, 2014; Waheed & Hoeksema, 2014; Huang et al. 2015; Waheed et al., 2015). For many taxa, even such basic data as species lists and distributional information are absent.

One data-deficient group in the South China Sea and Gulf of Thailand is the order Zoantharia (Cnidaria: Hexacorallia). Species in this order are widespread, and zoantharians are found in most marine ecosystems from shallow tropical coral reefs to the deep sea. Zoantharians are generally colonial, although solitary species also exist. Our understanding of species diversity and taxonomy of this group has traditionally been limited by a combination of many factors, including a lack of diagnostic characters (Ryland & Lancaster, 2003; Reimer et al., 2004), high levels of intraspecific morphological variation (Burnett et al., 1997; Reimer et al., 2004; Ong et al., 2013), and difficulty in performing histological examinations due to sand incrustation in the body wall and coenenchyme (Reimer et al., 2010).

Recently, molecular techniques such as allozymes (Burnett et al., 1997) and DNA markers (Reimer et al., 2004; Sinniger et al., 2005) have helped to investigate the diversity of zoantharians, and have helped reorganise their taxonomy when needed (Sinniger et al., 2010; Fujii & Reimer, 2011, 2013). Many of these studies have focused on shallow-water zooxanthellate species of the Pacific, and combined with recent reports from various regions in the Pacific, the distribution of some species can now be speculated upon. For example, many marine regions surrounding the South China Sea and Gulf of Thailand, such as the Great Barrier Reef (Australia) (Burnett et al., 1997), Singapore (Reimer & Todd, 2009), Palau (Reimer et al., 2014a), the central Coral Triangle (Reimer et al., 2014b), Taiwan (Reimer et al., 2011c, 2013), and Japan (Reimer et al., 2006c, etc.) have been generally well investigated for shallow-water species, with species lists existing for each region. The aim of this paper is to compile a list of the Zoantharia of the South China Sea. The production of a preliminary list will help link data and information between the various surrounding

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regions, and also contribute to understanding of the fauna of the South China Sea.

Aside from Pax & Müller (1957) in Vietnam and Reimer & Todd (2009) in Singapore, no scientific reports have focused on this group in the South China Sea and Gulf of Thailand. Thus, in this study, we have compiled all previous reports of zoantharians in the South China Sea and Gulf of Thailand, combined them with our own field images, and provide the first assessment of Zoantharia diversity in these regions. It is hoped that this study will provide a basis upon which future zoantharian research in this region can be built.

MATERIAL AND METHODS

Previously published records in historical literature. We collected data from both scientific reports and guidebooks. From reports, all data from Pax & Müller (1957) and Reimer & Todd (2009) were included. Additionally, data for all species from Kenting in southern Taiwan were included from Reimer et al. (2011b, c, 2013). Data from Brunei Darussalam from Reimer et al. (2012) were included, as was a single record of *Palythoa singaporensis* from Pax & Müller (1956) from Singapore. Finally, we supplemented these records with our own previous field images from work in the Gulf of Thailand, peninsular Malaysia, Layang-Layang Atoll, Borneo, and Hong Kong. Latitude and longitude for records and specimens were determined as accurately as

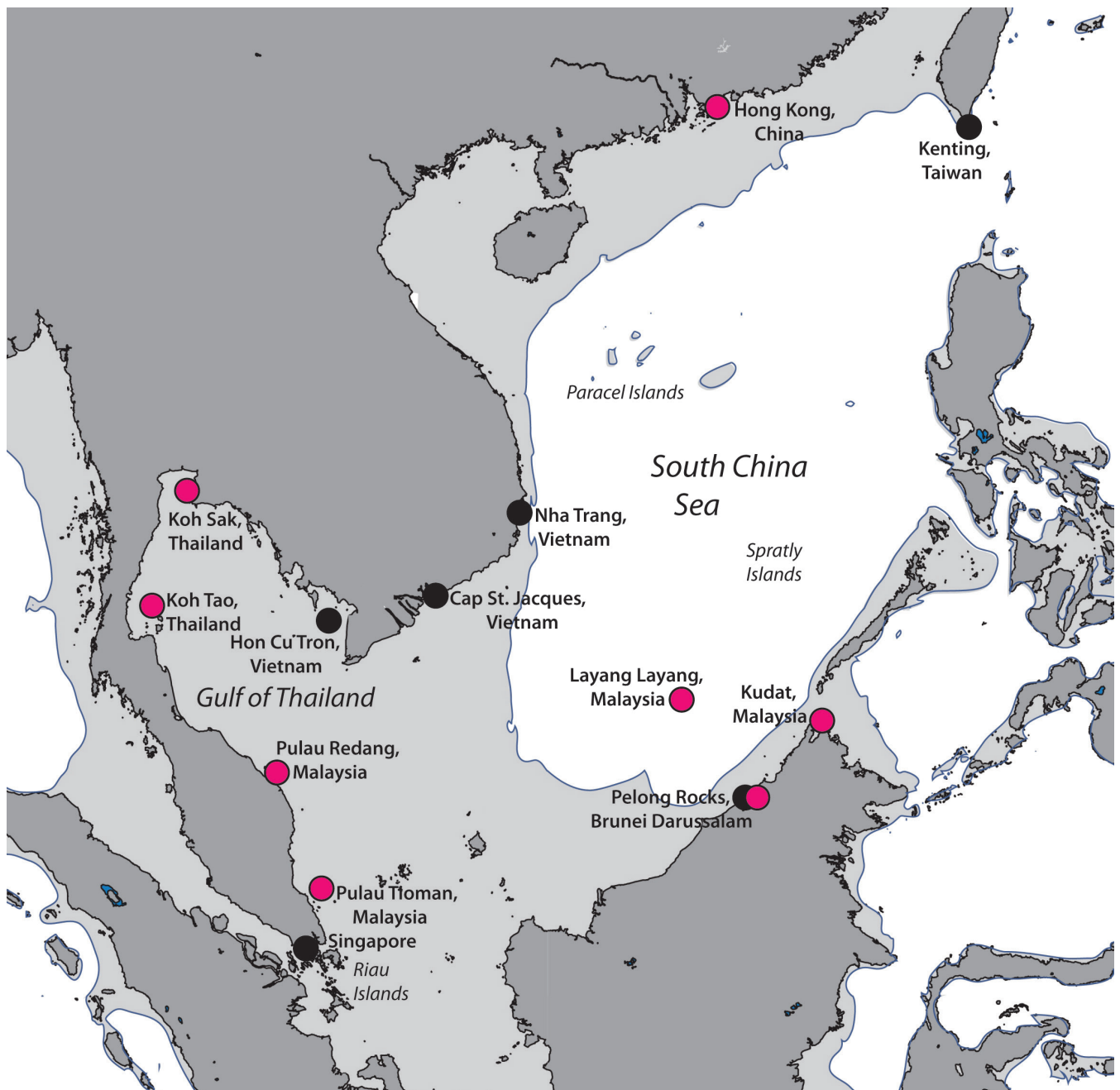


Fig. 1. Map of the South China Sea and Gulf of Thailand showing locations of past literature records of Zoantharia (black dots) and newly reported photographic records in this study (pink dots). Note that within each location (Table 1) there may be more than one locality (details in Table 1 and text).

possible, and data from original reports included (depth, species identification).

Images from guidebooks were utilised, but added only to the “remarks” section of each species, as such publications are not peer-reviewed literature, and furthermore usually only include very approximate locations.

Species identification and treatment. Species determinations were made as in Reimer et al. (2014b) by consulting previous literature (listed with each species). However, some species were only identified to “confers with” (cf.) or “affinity” (aff.) levels. Aside from the data in Pax & Müller (1957), Reimer & Todd (2009), and Reimer et al. (2012), very few records of zoantharians have been formally reported from the South China Sea and Gulf of Thailand regions. Therefore, we followed recent research (Burnett et al., 1994, 1995, 1997; Reimer et al., 2006a, 2007, 2011a, 2012; Sinniger, 2006; Sinniger et al., 2010; Reimer & Todd, 2009; Reimer, 2010; Fujii & Reimer, 2011) from neighboring regions and used species names for which numerous references and accurate descriptions were available, unless specimens and/or images clearly did not match with previously published information.

Our treatment of the species listed in Pax & Müller (1957) also needs explanation. In this focused work, Pax & Müller listed six *Zoanthus* spp., four *Palythoa* spp., and one *Isaurus* species, and six of these species were first described in this publication. However, recent research (Burnett et al., 1997; Reimer et al., 2004) has shown that there are very high levels of synonymy in these two genera owing to repeated redescriptions of the same widely distributed species in different localities. Thus, although we have included the records from Vietnam listed in Pax & Müller (1957) in this study, we have treated the species listed in their paper as follows:

Palythoa anthoplax Pax & Müller, 1957: included as *Palythoa* cf. *tuberculosa* (Esper, 1805) based on phylogenetic results in Reimer et al. (2006c);

Palythoa titanophila Pax & Müller, 1957: included as *P.* cf. *tuberculosa* based on external colony appearance and similar data in Hibino et al. (2014);

Zoanthus cavernarum Pax & Müller, 1957: included as *Z. sansibaricus* Carlgren, 1900 based on a description included in Pax & Müller (1957) compared with this species’ description;

Zoanthus cyanoides Pax & Müller, 1957: included as *Z. sansibaricus* based on a description included in Pax & Müller (1957) compared with this species’ description, as well as data in Burnett et al. (1997). *Z. cyanoides* is very similar to *Z. fraseri* (Pax & Müller, 1957), which has been stated to likely be *Z. coppingeri* (Burnett et al., 1997), which is in turn probably is *Z. sansibaricus* (Reimer, unpublished data);

Zoanthus erythrochloros Pax & Müller, 1957: included as *Z. sansibaricus* based on phylogenetic results in Reimer et al. (2004);

Zoanthus gnophodes Pax & Müller, 1957: included as *Z. sansibaricus* based on phylogenetic results in Reimer et al. (2004);

Zoanthus vietnamensis Pax & Müller, 1957: included as *Z. vietnamensis* as this has been shown clearly to be a distinct species from other Pacific *Zoanthus* species (e.g., Burnett et al., 1997; Reimer et al., 2006a);

Isaurus asymmetricus Haddon & Shackleton, 1891: described from the Torres Strait, Australia, included in this study as *I. tuberculatus* Gray, 1828 based on taxonomic revision as described in Muirhead & Ryland (1985); and

Palythoa singaporensis Pax & Müller, 1956: morphologically very similar to *Palythoa* cf. *toxica* Walsh & Bowers, 1971, and has been included as *P.* cf. *toxica* for this study.

As well, the three Zoantharia species listed below and mentioned in historical literature have been treated as follows:

Gemmaria philippinensis (Gray, 1867): described from the Philippines and based on information in von Heider (1899), this species is unitary with “long” polyps, which fits well with *Sphenopus*. However, researchers (e.g., von Heider, 1899) have long speculated on its true identity. Since we have no new information at our disposal, we have omitted this report from the present study;

Zoanthus robustus Carlgren, 1950: described from South Australia and included in Pax & Müller (1957), included in this study as *Z. robustus*, as although this species has not been examined phylogenetically, it is morphologically different from all other known *Zoanthus* species (for example, see figs. 1, 2 in Grant et al. (2010));

Palythoa stephensoni Carlgren, 1937: described from the Great Barrier Reef, and discussed in Pax & Müller (1957). In this study included as *P. tuberculosa*, based both on discussion in Burnett et al. (1994) and similar results for other species in Hibino et al. (2014).

Unpublished photographic records. In this study, to supplement the scant data available from previous literature, we included our own photographic records of Zoantharia from field work in the region (n = 94 new records). We include a summary of the records from historical literature and the images utilised in this study (Tables 1, 2), and photographic images of species with new records in the South China Sea and Gulf of Thailand (Figs. 2, 4). For photographic images, species identifications were conducted as mentioned above. All details for each specimen or photographic record, including latitude, longitude, and depth, are given in Table 1.

Based on previous zoantharian studies (Reimer & Todd, 2009), accuracy of identification of *Zoanthus* and *Palythoa* species based on gross morphology from in situ photographs may approach ~90%: thus, the photographic image data in this study should not be considered as infallible. Only focused specimen collection and identification with a combination of both morphological and molecular examination should more conclusively confirm the identities we have listed here from the photographic records.

In total, there are Zoantharia records from six regions (not including Gray (1867)) in the South China Sea and Gulf of Thailand in the literature (Fig. 1, black-marked regions). To this, we have added photographic records from seven new regions (Fig. 1, pink-marked regions) and historical data from one additional region. Many of the records we report on below are first records of species in the South China Sea and/or Gulf of Thailand, and also for various countries. Some regions include multiple localities (see Table 1 for details).

Table 1. Historical records and new photographic records of order Zoantharia (Cnidaria: Hexacorallia) from the South China Sea and the Gulf of Thailand.

Study	Specimen or image	Identification (this study)	Original identification	Locality	Latitude	Longitude	Depth (m)	Date	Notes
Pax & Müller 1956	Specimen	<i>Palythoa</i> cf. <i>toxica</i>	<i>Palythoa singaporensis</i>	Singapore	NA	NA	NA	NA	Originally mentioned in von Heider (1899) as <i>P. variabilis</i> .
Pax & Müller 1957	Specimen	<i>Palythoa tuberculosa</i>	<i>Palythoa anthoplax</i>	Poulo Dama (Hon Cu Tron and islands), Vietnam	09°39'56"N	104°22'19"E	NA	1910	Original description of <i>P. anthoplax</i> .
Pax & Müller 1957	Specimen	<i>Palythoa</i> cf. <i>toxica</i>	<i>Palythoa singaporensis</i>	Poulo Dama (Hon Cu Tron and islands), Vietnam	09°39'56"N	104°22'19"E	NA	1910	
Pax & Müller 1957	Specimen	<i>Zoanthus sansibaricus</i>	<i>Zoanthus gnophodes</i>	Poulo Dama (Hon Cu Tron and islands), Vietnam	09°39'56"N	104°22'19"E	NA	1905	Original description of <i>Z. gnophodes</i> .
Pax & Müller 1957	Specimen	<i>Zoanthus sansibaricus</i>	<i>Zoanthus gnophodes</i>	Poulo Dama (Hon Cu Tron and islands), Vietnam	09°39'56"N	104°22'19"E	NA	1910	Original description of <i>Z. gnophodes</i> .
Pax & Müller 1957	Specimen	<i>Zoanthus robustus</i>	<i>Zoanthus robustus</i>	Poulo Dama (Hon Cu Tron and islands), Vietnam	9°39'56"N	104°22'19"E	NA	1910	Only record outside Australia.
Pax & Müller 1957	Specimen	<i>Palythoa</i> cf. <i>toxica</i>	<i>Palythoa singaporensis</i>	Cape St. Jacques, Vietnam	10°18'09"N	107°04'55"E	NA	1908	
Pax & Müller 1957	Specimen	<i>Zoanthus sansibaricus</i>	<i>Zoanthus cavernarum</i>	Southeast point of Hon Mieu Island, Nha Trang, Vietnam	12°10'59"N	109°13'33"E	NA	4 March 1953	Original description of <i>Z. cavernarum</i> .
Pax & Müller 1957	Specimen	<i>Palythoa tuberculosa</i>	<i>Palythoa titanophila</i>	Hon Tre Island, Nha Trang, Vietnam	12°11'52"N	109°15'43"E	NA	26 August 1954	Original description of <i>P. titanophila</i> .
Pax & Müller 1957	Specimen	<i>Isaurus tuberculatus</i>	<i>Isaurus asymmetricus</i>	Hon Tre Island, Nha Trang, Vietnam	12°11'52"N	109°15'43"E	NA	26 August 1954	
Pax & Müller 1957	Specimen	<i>Palythoa tuberculosa</i>	<i>Palythoa stephensoni</i>	Hon Rua in Ca Dau Bay, Nha Trang, Vietnam	12°17'18"N	109°14'32"E	NA	24 December 1953	
Pax & Müller 1957	Specimen	<i>Zoanthus sansibaricus</i>	<i>Zoanthus erythrochloros</i>	Rocher Noir, Ca Dau Bay, Nha Trang, Vietnam	12°35'58"N	109°18'15"E	NA	18 May 1954	Original description of <i>Z. erythrochloros</i> .

Table 1...continued

Study	Specimen or image	Identification (this study)	Original identification	Locality	Latitude	Longitude	Depth (m)	Date	Notes
Pax & Müller 1957	Specimen	<i>Zoanthus sansibaricus</i>	<i>Zoanthus gnophodes</i>	Rocher Noir, Ca Dau Bay, Nha Trang, Vietnam	12°35'58"N	109°18'15"E	NA	18 May 1954	Original description of <i>Z. gnophodes</i> .
Pax & Müller 1957	Specimen	<i>Zoanthus vietnamensis</i>	<i>Zoanthus vietnamensis</i>	Rocher Noir, Ca Dau Bay, Nha Trang, Vietnam	12°35'58"N	109°18'15"E	NA	18 May 1954	Original description of <i>Z. vietnamensis</i> .
Reimer & Todd 2009	Specimen	<i>Palythoa tuberculosa</i>	<i>Palythoa tuberculosa</i>	Raffles Lighthouse, Singapore	01°09'37"N	103°44'25"E	1 to 3	November–December 2006	
Reimer & Todd 2009	Specimen	<i>Zoanthus vietnamensis</i>	<i>Zoanthus vietnamensis</i>	Raffles Lighthouse, Singapore	01°09'37"N	103°44'25"E	1 to 3	November–December 2006	
Reimer & Todd 2009	Specimen	<i>Zoanthus sansibaricus</i>	<i>Zoanthus sansibaricus</i>	Raffles Lighthouse, Singapore	01°09'37"N	103°44'25"E	1 to 3	November–December 2006	
Reimer & Todd 2009	Specimen	<i>Palythoa mutuki</i>	<i>Palythoa mutuki</i>	Raffles Lighthouse, Singapore	01°09'37"N	103°44'25"E	1 to 3	November–December 2006	
Reimer & Todd 2009	Specimen	<i>Palythoa tuberculosa</i>	<i>Palythoa tuberculosa</i>	Kusu Island, Singapore	01°13'14"N	103°51'44"E	1 to 3	November–December 2006	
Reimer & Todd 2009	Specimen	<i>Zoanthus vietnamensis</i>	<i>Zoanthus vietnamensis</i>	Kusu Island, Singapore	01°13'14"N	103°51'44"E	1 to 3	November–December 2006	
Reimer & Todd 2009	Specimen	<i>Zoanthus sansibaricus</i>	<i>Zoanthus sansibaricus</i>	Kusu Island, Singapore	01°13'14"N	103°51'44"E	1 to 3	November–December 2006	
Reimer & Todd 2009	Specimen	<i>Palythoa mutuki</i>	<i>Palythoa mutuki</i>	Kusu Island, Singapore	01°13'14"N	103°51'44"E	1 to 3	November–December 2006	
Reimer & Todd 2009	Specimen	<i>Palythoa cf. toxica</i>	<i>Palythoa sp. singapura</i>	Kusu Island, Singapore	01°13'14"N	103°51'44"E	1 to 3	November–December 2006	
Reimer & Todd 2009	Specimen	<i>Palythoa tuberculosa</i>	<i>Palythoa tuberculosa</i>	Lazarus Island, Singapore	01°13'18"N	103°51'32"E	1 to 3	November–December 2006	
Reimer & Todd 2009	Specimen	<i>Zoanthus sansibaricus</i>	<i>Zoanthus sansibaricus</i>	Lazarus Island, Singapore	01°13'18"N	103°51'32"E	1 to 3	November–December 2006	
Reimer et al. 2011b	Specimen	<i>Acrozoanthus australiae</i>	<i>Acrozoanthus australiae</i>	Ho-bi-hoo, Kenting, Taiwan	21°56'49"N	120°45'19"E	9 to 12	November–December 2006	
Reimer et al. 2011c	Specimen	<i>Palythoa mizigama</i>	<i>Palythoa sp. tokashiki</i>	Wanli Tung, Kenting, Taiwan	21°59'44"N	120°42'23"E	NA	4 September 2009	

Table 1...continued

Study	Specimen or image	Identification (this study)	Original identification	Locality	Latitude	Longitude	Depth (m)	Date	Notes
Reimer et al. 2011c	Specimen	<i>Zoanthus kuroshio</i>	<i>Zoanthus kuroshio</i>	Wanli Tung, Kenting, Taiwan	21°59'44"N	120°42'23"E	NA	4 September 2009	
Reimer et al. 2011c	Image	<i>Isaurus tuberculatus</i>	<i>Isaurus tuberculatus</i>	Kenting, Taiwan	NA	NA	NA	4 September 2009	Only approximate location known.
Reimer et al. 2012	Specimen	<i>Sphenopus marsupialis</i>	<i>Sphenopus marsupialis</i>	Southwest of Pelong Rocks, northwestern Borneo, Brunei Darussalam	05°04'44"N	115°03'05"E	13	23 April 2011	N=13 specimens
Reimer et al. 2013	Specimen	<i>Palythoa tuberculosa</i>	<i>Palythoa tuberculosa</i>	Wanli Tung, Kenting, Taiwan	21°59'44"N	120°42'23"E	2 to 5	4 September 2009	
Reimer et al. 2013	Specimen	<i>Zoanthus vietnamensis</i>	<i>Zoanthus vietnamensis</i>	Wanli Tung, Kenting, Taiwan	21°59'44"N	120°42'23"E	1	4 September 2009	
Reimer et al. 2013	Specimen	<i>Zoanthus sansibaricus</i>	<i>Zoanthus sansibaricus</i>	Wanli Tung, Kenting, Taiwan	21°59'44"N	120°42'23"E	1	4 September 2009	
Reimer et al. 2013	Specimen	<i>Palythoa</i> sp. sakurajimensis	<i>Palythoa</i> sp. sakurajimensis	Wanli Tung, Kenting, Taiwan	21°59'44"N	120°42'23"E	1 to 2	4 September 2009	
Reimer et al. 2013	Specimen	<i>Palythoa mutuki</i>	<i>Palythoa mutuki</i>	Wanli Tung, Kenting, Taiwan	21°59'44"N	120°42'23"E	2	4 September 2009	
Reimer et al. 2013	Specimen	<i>Palythoa tuberculosa</i>	<i>Palythoa tuberculosa</i>	Wanli Tung, Kenting, Taiwan	21°59'44"N	120°42'23"E	3 to 5	1 September 2012	
Reimer et al. 2013	Specimen	<i>Palythoa tuberculosa</i>	<i>Palythoa tuberculosa</i>	Tiao Shi, Kenting, Taiwan	21°57'16"N	120°46'05"E	5 to 8	4 September 2009	
Reimer et al. 2013	Specimen	<i>Palythoa tuberculosa</i>	<i>Palythoa tuberculosa</i>	Longkeng, Kenting, Taiwan	21°56'09"N	120°50'55"E	3 to 5	December 2011	
Reimer et al. 2013	Specimen	<i>Palythoa tuberculosa</i>	<i>Palythoa tuberculosa</i>	Ho-bi-hoo, Kenting, Taiwan	21°56'49"N	120°45'19"E	9	4 September 2009	
This study	Image	<i>Zoanthus sansibaricus</i>		Batu Berlabuh, southeast Pulau Tioman, Pahang, Malaysia	02°46'06"N	104°13'25"E	NA	19 June 2013	Observed by BW Hoeksema.
This study	Image	<i>Zoanthus sansibaricus</i>		Tumok, west Pulau Tioman, Pahang, Malaysia	02°47'34"N	104°07'20"E	NA	17 June 2013	Observed by BW Hoeksema; n=3.

Table 1...continued

Study	Specimen or image	Identification (this study)	Original identification	Locality	Latitude	Longitude	Depth (m)	Date	Notes
This study	Image	<i>Zoanthus sansibaricus</i>		Tanjung Benut, west Pulau Tioman, Pahang, Malaysia	02°48'04"N	104°07'36"E	NA	23 June 2013	Observed by BW Hoeksema.
This study	Image	<i>Zoanthus sansibaricus</i>		Teluk Dalam, northeast Pulau Tioman, Pahang, Malaysia	02°52'37"N	104°11'23"E	NA	25 June 2013	Observed by BW Hoeksema.
This study	Image	<i>Zoanthus sansibaricus</i>		South side of Batu Malang, islet northwest of Pulau Tioman, Pahang, Malaysia	02°54'14"N	104°06'18"E	NA	17 June 2013	Observed by BW Hoeksema.
This study	Image	<i>Palythoa mutuki</i>		Batu Berlabuh, southeast Pulau Tioman, Pahang, Malaysia	02°46'06"N	104°13'25"E	NA	19 June 2013	Observed by BW Hoeksema.
This study	Image	<i>Palythoa heliodiscus</i>		Batu Berlabuh, southeast Pulau Tioman, Pahang, Malaysia	02°46'06"N	104°13'25"E	NA	19 June 2013	Observed by BW Hoeksema.
This study	Image	<i>Palythoa cf. toxica</i>		Tumok, west Pulau Tioman, Pahang, Malaysia	02°47'34"N	104°07'20"E	NA	17 June 2013	Observed by BW Hoeksema.
This study	Image	<i>Palythoa tuberculosa</i>		Tumok, west Pulau Tioman, Pahang, Malaysia	02°47'34"N	104°07'20"E	NA	17 June 2013	Observed by BW Hoeksema.
This study	Image	Unidentified <i>Palythoa</i> sp. 1		Southwest of Pelong Rocks, northwestern Borneo, Brunei Darussalam	05°04'44"N	115°03'05"E	NA	19 April 2011	Observed by BW Hoeksema, n=2.
This study	Image	<i>Palythoa heliodiscus</i>		Southwest of Pelong Rocks, northwestern Borneo, Brunei Darussalam	05°04'44"N	115°03'05"E	NA	19 April 2011	Observed by BW Hoeksema.
This study	Image	<i>Palythoa mutuki</i>		South-southwest of Pelong Rocks, northwestern Borneo, Brunei Darussalam	05°04'41"N	115°03'06"E	NA	19 April 2011	Observed by BW Hoeksema, n=2.

Table 1...continued

Study	Specimen or image	Identification (this study)	Original identification	Locality	Latitude	Longitude	Depth (m)	Date	Notes
This study	Image	<i>Zoanthus sansibaricus</i>		Redang Kalong House Reef, east Pulau Redang, Terengganu, Malaysia	05°45'42"N	103°01'41"E	NA	30 June & 3 July 2013	Observed by BW Hoeksema, n=2. Large colonies cover seafloor.
This study	Image	<i>Palythoa mutuki</i>		Redang Kalong House Reef, east Pulau Redang, Terengganu, Malaysia	05°45'42"N	103°01'41"E	NA	30 June 2013	Observed by BW Hoeksema, n=5
This study	Image	<i>Palythoa</i> cf. <i>toxica</i>		Redang Kalong House Reef, east Pulau Redang, Terengganu, Malaysia	05°45'42"N	103°01'41"E	NA	3 July 2013	Observed by BW Hoeksema.
This study	Image	<i>Palythoa tuberculosa</i>		Che Isa Islet off east Pulau Redang, Terengganu, Malaysia	05°45'37"N	103°02'10"E	NA	1 July 2013	Observed by BW Hoeksema.
This study	Image	<i>Zoanthus sansibaricus</i>		Che Isa Islet off east Pulau Redang, Terengganu, Malaysia	05°45'37"N	103°02'10"E	NA	1 July 2013	Observed by BW Hoeksema, n=7.
This study	Image	<i>Zoanthus sansibaricus</i>		Mak Cantek Islet off east Pulau Redang, Terengganu, Malaysia	05°46'01"N	103°02'22"E	NA	1 July 2013	Observed by BW Hoeksema, n=2.
This study	Image	<i>Zoanthus sansibaricus</i>		Trumbu Kili Island south of Pulau Redang, Terengganu, Malaysia	05°43'56"N	102°59'51"E	NA	3 July 2013	Observed by BW Hoeksema.
This study	Image	<i>Palythoa</i> cf. <i>toxica</i>		Teluk Dalam, Pulau Redang, Terengganu, Malaysia	5°47'20"N	103° 0'56"E	8	18 April 2013	Observed by HB Wee.
This study	Image	<i>Zoanthus sansibaricus</i>		Teluk Dalam, Pulau Redang, Terengganu, Malaysia	5°47'20"N	103° 0'56"E	8	18 April 2013	Observed by HB Wee, n=2.
This study	Image	<i>Palythoa tuberculosa</i>		Ekor Tebu, Pulau Redang, Terengganu, Malaysia	5°44'23"N	103°01'44"E	3	3 July 2013	Observed by HB Wee.
This study	Image	<i>Zoanthus sansibaricus</i>		Pantai Pasir Cina, Pulau Bidong, Terengganu, Malaysia	5°37'18"N	103°03'25"E	3 to 5	11 April 2013	Observed by HB Wee, n=2.

Table 1...continued

Study	Specimen or image	Identification (this study)	Original identification	Locality	Latitude	Longitude	Depth (m)	Date	Notes
This study	Image	<i>Zoanthus vietnamensis</i>		Pantai Pasir Cina, Pulau Bidong, Terengganu, Malaysia	5°37'18"N	103°03'25"E	5	11 April 2013	Observed by HB Wee.
This study	Image	<i>Zoanthus sansibaricus</i>		Pulau Paku, Pulau Redang, Terengganu, Malaysia	5°46'37"N	103°02'32"E	3	5 July 2013	Observed by HB Wee, n=3.
This study	Image	<i>Zoanthus sansibaricus</i>		Pulau Karah, Pulau Bidong, Terengganu, Malaysia	5°35'50"N	103°03'46"E	15	7 April 2013	Observed by HB Wee.
This study	Image	<i>Zoanthus sansibaricus</i>		Chagar Hutang, Pulau Redang, Terengganu, Malaysia	05°48'54"N	103°00'33"E	9	19 April 2013	Observed by HB Wee.
This study	Image	<i>Palythoa</i> cf. <i>toxica</i>		Chagar Hutang, Pulau Redang, Terengganu, Malaysia	05°48'54"N	103°00'33"E	4	19 April 2013	Observed by HB Wee.
This study	Image	<i>Palythoa</i> cf. <i>toxica</i>		Pasir Akar, Pulau Redang, Terengganu, Malaysia	05°44'32"N	103°00'01"E	3	20 April 2013	Observed by HB Wee.
This study	Image	<i>Sphenopus marsupialis</i>		Tajau/Bak Bak, Kudat, Sabah, northernmost tip of Borneo, Malaysia	06°59'36"N	116°50'28"E	NA	25 September 2012	Observed by BW Hoeksema, n=4.
This study	Image	<i>Sphenopus marsupialis</i>		Southeast Tanjung Siagut, Kudat, Sabah, northernmost tip of Borneo, Malaysia	07°20'11"N	117°01'24"E	NA	24 September 2012	Observed by BW Hoeksema, n=7.
This study	Image	<i>Palythoa</i> cf. <i>toxica</i>		Coral Café, east Layang-Layang Atoll, Spratlys, Malaysia	07°22'24"N	113°51'09"E	NA	24 March 2013	Observed by BW Hoeksema.
This study	Image	<i>Palythoa</i> cf. <i>toxica</i>		Wreck Point 1, east Layang-Layang Atoll, Spratlys, Malaysia	07°22'24"N	113°51'02"E	NA	27 March 2013	Observed by BW Hoeksema.
This study	Image	<i>Palythoa</i> cf. <i>toxica</i>		Wreck Point 2, southeast Layang-Layang Atoll, Spratlys, Malaysia	07°22'12"N	113°50'39"E	NA	28 March 2013	Observed by BW Hoeksema.

Table 1...continued

Study	Specimen or image	Identification (this study)	Original identification	Locality	Latitude	Longitude	Depth (m)	Date	Notes
This study	Image	<i>Palythoa tuberculosa</i>		Navigator Lane, north Layang-Layang Atoll, Spratlys, Malaysia	07°23'07"N	113°49'59"E	NA	28 March 2013	Observed by BW Hoeksema.
This study	Image	<i>Palythoa heliodiscus</i>		Navigator Lane, north Layang-Layang Atoll, Spratlys, Malaysia	07°23'07"N	113°49'59"E	NA	28 March 2013	Observed by BW Hoeksema.
This study	Image	<i>Palythoa</i> cf. <i>toxica</i>		Runway, south Layang-Layang Atoll, Spratly Islands, Malaysia	07°21'55"N	113°49'46"E	NA	30 March 2013	Observed by BW Hoeksema.
This study	Image	<i>Acrozoanthus australiae</i>		Runway, south Layang-Layang Atoll, Spratly Islands, Malaysia	07°21'55"N	113°49'46"E	NA	30 March 2013	Observed by BW Hoeksema.
This study	Image	<i>Epizoanthus</i> aff. <i>illoricatus</i>		Shark Cave 2, west Layang-Layang Atoll, Spratlys, Malaysia	07°22'19"N	113°47'19"E	NA	26 March 2013	Observed by BW Hoeksema, n=4.
This study	Image	<i>Palythoa</i> cf. <i>toxica</i>		Shark Cave 2, west Layang-Layang Atoll, Spratlys, Malaysia	07°22'19"N	113°47'19"E	NA	26 March 2013	Observed by BW Hoeksema.
This study	Image	<i>Palythoa tuberculosa</i>		Shark Cave 2, west Layang-Layang Atoll, Spratlys, Malaysia	07°22'19"N	113°47'19"E	NA	26 March 2013	Observed by BW Hoeksema.
This study	Image	<i>Palythoa tuberculosa</i>		Crack Reef, northwest Layang-Layang Atoll, Spratlys, Malaysia	07°22'53"N	113°48'55"E	NA	26 March 2013	Observed by BW Hoeksema, n=4.
This study	Image	<i>Epizoanthus</i> aff. <i>illoricatus</i>		Wrasse Strip 2, northwest Layang-Layang Atoll, Spratlys, Malaysia	07°22'33"N	113°47'22"E	NA	27 March 2013	Observed by BW Hoeksema.
This study	Image	<i>Palythoa heliodiscus</i>		Mid Reef, northwest Layang-Layang Atoll, Spratlys, Malaysia	07°22'44"N	113°48'32"E	NA	29 March 2013	Observed by BW Hoeksema.

Table 1...continued

Study	Specimen or image	Identification (this study)	Original identification	Locality	Latitude	Longitude	Depth (m)	Date	Notes
This study	Image	<i>Zoanthus sansibaricus</i>		Lagoon, House Reef, Layang-Layang Atoll, Spratly Islands, Malaysia	07°22'16"N	113°35'30"E	5	29 March 2013	Observed by BW Hoeksema.
This study	Image	<i>Palythoa tuberculosa</i>		White Rock, Koh Tao, Thailand	10°06'13"N	99°49'03"E	NA	18 & 20 February 2011	Observed by BW Hoeksema, n=3.
This study	Image	<i>Palythoa tuberculosa</i>		Twin Peaks, Koh Tao, Thailand	10°06'51"N	99°48'51"E	NA	19 February 2011	Observed by BW Hoeksema.
This study	Image	<i>Zoanthus sansibaricus</i>		Twin Peaks, Koh Tao, Thailand	10°06'51"N	99°48'51"E	NA	19 February 2011	Observed by BW Hoeksema.
This study	Image	<i>Palythoa tuberculosa</i>		Mango Bay, Koh Tao, Thailand	10°07'21"N	99°50'11"E	NA	19 February 2011	Observed by BW Hoeksema.
This study	Image	<i>Zoanthus</i> cf. <i>kuroshio</i>		Mango Bay, Koh Tao, Thailand	10°07'21"N	99°50'11"E	NA	19 February 2011	Observed by BW Hoeksema.
This study	Image	<i>Zoanthus sansibaricus</i>		Japanese Garden, Koh Tao, Thailand	10°07'03"N	99°49'08"E	NA	20 February 2011	Observed by BW Hoeksema.
This study	Image	<i>Zoanthus sansibaricus</i>		Hin Wong Pinnacle, Koh Tao, Thailand	10°06'29"N	99°51'16"E	NA	21 February 2011	Observed by BW Hoeksema.
This study	Image	<i>Palythoa tuberculosa</i>		Shark Island, Koh Tao, Thailand	10°03'35"N	99°50'55"E	NA	22 February 2011	Observed by BW Hoeksema.
This study	Image	<i>Palythoa tuberculosa</i>		Pottery Pinnacles, Koh Tao, Thailand	10°04'51"N	99°49'03"E	NA	21 February 2011	Observed by BW Hoeksema.
This study	Image	<i>Zoanthus sansibaricus</i>		Southern Koh Sak, Inner Gulf of Thailand, Thailand	12°56'33"N	100°47'31"E	NA	13 February 2011	Observed by BW Hoeksema.
This study	Image	<i>Zoanthus giganteus</i>		Pak Lap Tsai, Hong Kong	22°21'14"N	114°21'58.9"E	6	10 July 2013	Observed by PO Ang + Tsang Ho Leung.
This study	Image	<i>Zoanthus sansibaricus</i>		Pak Lap Tsai, Hong Kong	22°21'14"N	114°21'58.9"E	6	10 July 2013	Observed by PO Ang + Tsang Ho Leung.
This study	Image	<i>Zoanthus sansibaricus</i>		Hoi Ha Wan, Hong Kong	22°28'17.5"N	114°20'05"E	2 to 3	29 January 2013	Observed by PO Ang + Ng Tsz Yan.

Table 1...continued

Study	Specimen or image	Identification (this study)	Original identification	Locality	Latitude	Longitude	Depth (m)	Date	Notes
This study	Image	<i>Palythoa mutuki</i>		Knob Reef, Tolo Harbour, Hong Kong	22°28'01.3"N	114°17'00.9"E	2	5 March 2014	Observed by PO Ang + Chui Pui Yi.
This study	Image	<i>Zoanthus vietnamensis</i>		Moon Island, Hoi Ha Wan, Hong Kong	22°28'17.5"N	114°20'5.0"E	2.6	30 October 2013	Observed by PO Ang + Leung Yu Hin.
This study	Image	<i>Zoanthus sansibaricus</i>		Wu Pai, Hong Kong	22°31'51.9"N	114°18'53.4"E	2 to 3	7 November 2011	Observed by PO Ang + Ng Tsz Yan.
This study	Image	<i>Zoanthus sansibaricus</i>		A Ma Wan, Tung Ping Chau, Hong Kong	22°32'49"N	114°25'30"E	5	5 March 2014	Observed by PO Ang + Chui Pui Yi.
This study	Image	<i>Zoanthus sansibaricus</i>		Tung Ping Chau, Hong Kong	22°32'49"N	114°25'30"E	NA	22 June 2006	Observed by JD Reimer, n=4.
This study	Image	<i>Palythoa cf. toxica</i>		Tung Ping Chau, Hong Kong	22°32'49"N	114°25'30"E	NA	22 June 2006	Observed by JD Reimer.
This study	Image	<i>Palythoa heliodiscus</i>		Tung Ping Chau, Hong Kong	22°32'49"N	114°25'30"E	2	May 1998	Observed by PO Ang.

SPECIES LIST OF ZOANTHARIA IN THE SOUTH CHINA SEA AND GULF OF THAILAND

Order Zoantharia Gray, 1832

Suborder Brachyneremina Haddon & Shackleton, 1891a

Family Zoanthidae Rafinesque, 1815

Genus *Acrozoanthus* Saviile-Kent, 18931. *Acrozoanthus australiae* Saviile-Kent, 1893

(Fig. 2a, see also fig. 2 in Reimer et al. (2011b))

Previously published locations in the South China Sea and Gulf of Thailand (n = 1). Ho-bi-hoo, Kenting, Taiwan; in Reimer et al. (2011b) (Table 1).

New photographic record locations in the South China Sea and Gulf of Thailand (n = 1). Runway, south Layang-Layang Atoll, Spratly Islands, Malaysia (Table 1). First record for Malaysia.

Description. From Reimer et al. (2014b): “Non-incrusted zooxanthellate zoantharian that inhabits the outside of eunicid worm tubes (Haddon, 1895), with a unique asexual form of “budding” (Ryland, 1997). Easily recognisable as it is an epibiont on outside surface of eunicid worm tube, and has a reduced stoloniferous coenenchyme, long pale yellow-green or pale purple tentacles (n=approx. 40–50) with occasional fluorescent green markings and black tips, and light brown/purple to white ectoderm with similarly coloured oral disks. Preserved specimens in this study had polyps of average 6.0 mm in height (range 2.5–14 mm), 3.2 mm in width (range 2–5 mm) (n=8 specimens examined ..., and oral disks approximately 6 mm in diameter when expanded in situ (partially adapted from Reimer et al. 2011c).”

Remarks: This zooxanthellate species is in symbiosis with *Symbiodinium* clade D in Taiwan (Reimer et al., 2011b). It appears to be distributed across the northern half of the South China Sea based on our results.

Genus *Zoanthus* Lamarck, 18012. *Zoanthus sansibaricus* Carlgren, 1900

(Fig. 2b, see also plate XI, fig. 1 in plate XII, and figs. 1, 3 in plate XIII in Pax & Müller (1957), fig. 7A in Reimer & Todd (2009), fig. 2A in Reimer et al. (2011c))

Previously reported locations in the South China Sea and Gulf of Thailand (n = 7). Poulo Dama (Hon Cu Tron & islands), Vietnam as *Zoanthus gnophodes* (n = 2); southeast point of Ile Hon Mieu, Nha Trang, Vietnam as *Z. cavernarum*; Rocher Noir, Ca Dau Bay, Nha Trang, Vietnam as *Z. cyanoides* and *Z. erythrochloros* (n = 1 each); all in Pax & Müller (1957); Raffles Lighthouse, Singapore; Kusu Island, Singapore; Lazarus Island, Singapore; all in Reimer & Todd (2009); Wanli Tung, Kenting, Taiwan; in Reimer et al. (2013) (Table 1).

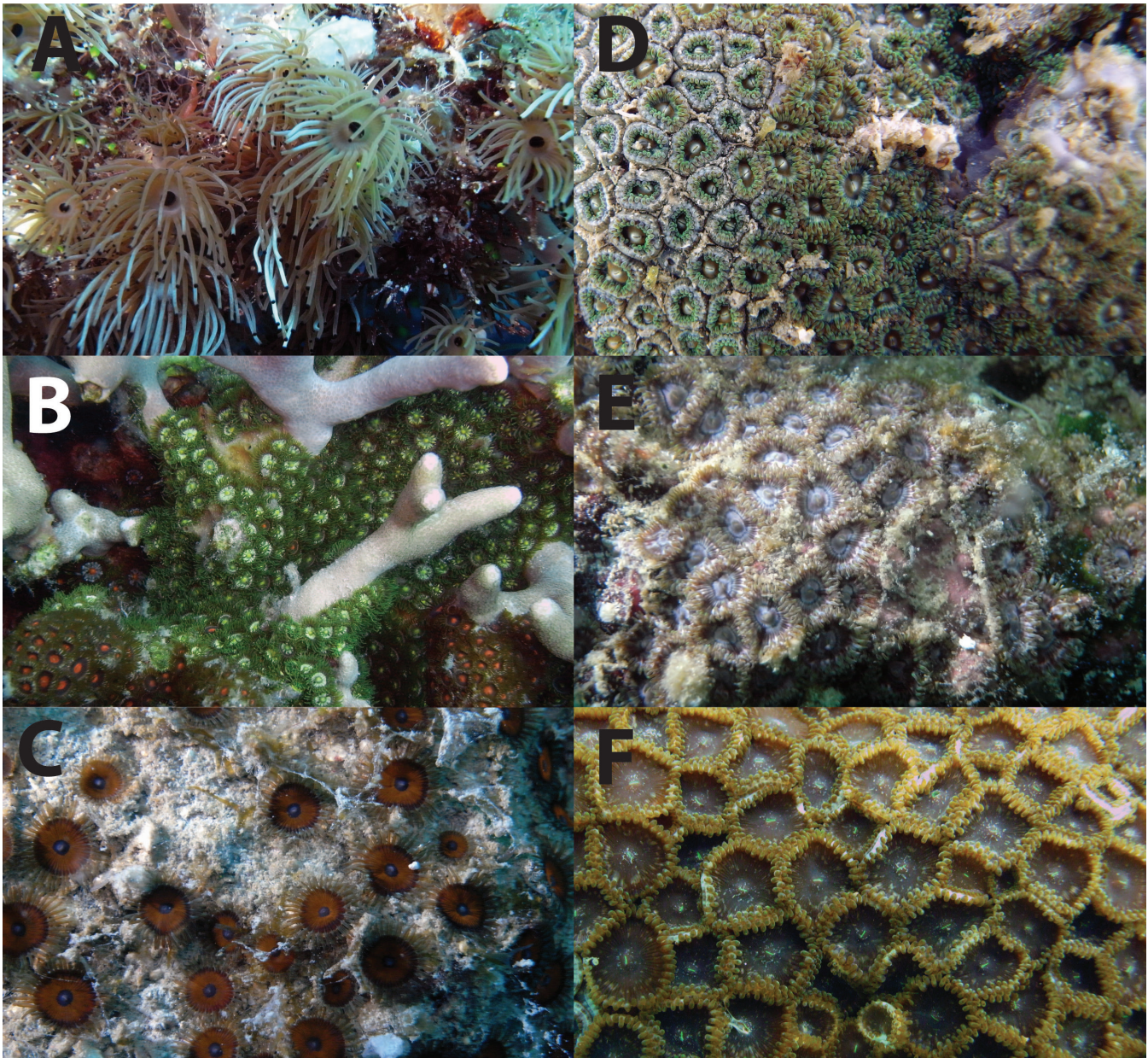


Fig. 2. Species of the family Zoanthidae in the South China Sea. A, *Acrozoanthus australiae* at Runway, south Layang-Layang Atoll, Spratly Islands, Malaysia; B, *Zoanthus sansibaricus* at Redang Kalong House Reef, east Pulau Redang, Terengganu, Malaysia; C, *Z. sansibaricus* at Batu Berlabuh, southeast Pulau Tioman, Pahang, Malaysia; D, *Z. vietnamensis* at Hoi Ha Wan, Hong Kong (photograph by Leung Yu Hin); E, *Z. kuroshio* at Mango Bay, Koh Tao, Thailand; and F, *Z. gigantus* at Pak Lap Tsui, Hong Kong (photograph by Tsang Ho Leung). Detailed image information given in Table 1.

New photographic record locations in the South China Sea and Gulf of Thailand (n = 34). Batu Berlabuh, southeast Pulau Tioman, Pahang, Malaysia; Tumok, west Pulau Tioman, Pahang, Malaysia, n = 3; Tanjung Benut, west Pulau Tioman, Pahang, Malaysia; Teluk Dalam, northeast Pulau Tioman, Pahang, Malaysia; south side of Batu Malang, islet northwest of Pulau Tioman, Pahang, Malaysia; Chagar Hutang, Pulau Redang, Terengganu, Malaysia; Pulau Karah, Pulau Bidong, Terengganu, Malaysia; Pantai Pasir Cina, Pulau Bidong, Terengganu, Malaysia, n = 2; Trumbu Kili Island south of Pulau Redang, Terengganu, Malaysia; Che Isa Islet off east Pulau Redang, Terengganu, Malaysia; Redang Kalong House Reef, east Pulau Redang, Terengganu, Malaysia; Mak Cantek Islet off east Pulau Redang, Terengganu, Malaysia; Pulau Paku, Pulau Redang, Terengganu, Malaysia; Teluk

Dalam, Pulau Redang, Terengganu, Malaysia; Lagoon, House Reef, Layang-Layang Atoll, Spratly Islands, Malaysia; Hin Wong Pinnacle, Koh Tao, Thailand; Twin Peaks, Koh Tao, Thailand; Japanese Garden, Koh Tao, Thailand; southern Koh Sak, Inner Gulf of Thailand, Thailand; Hoi Ha Wan, Hong Kong, n = 3; Pak Lap Tsai, Hong Kong, n = 2; Tung Ping Chau, Hong Kong, n = 5; Wu Pai, Hong Kong, n = 2 (Table 1). First records for Malaysia, Thailand, Hong Kong.

Description. From Reimer et al. (2014b): “Can form colonies of up to 1 m², but often forming much smaller colonies in cracks and small overhangs in intertidal and shallow waters (<5 m), with polyps well clear and free of the coenenchyme (“liberae”) (Reimer et al., 2006b, Pax, 1910). Adult polyps 2–12 mm in diameter when open, up to 20 mm in length but

Table 2. Order Zoantharia (Cnidaria: Hexacorallia) species and recorded locations from the South China Sea and the Gulf of Thailand.

Species	Singapore	Pulau Tioman	P. Redang & P. Bidong	Koh Tao	Koh Sak	Hon Cu Tron	Cape St. Jacques	Nha Trang	Pelong Rocks	Layang-Layang	Kudat	Hong Kong	Kenting
<i>Acrozoanthus australiae</i>			■							■			●
<i>Zoanthus sansibaricus</i>	●	■	■	■	■	●		●		■		■	●
<i>Zoanthus vietnamensis</i>	●		■					●				■	●
<i>Zoanthus kuroshio</i>				■									●
<i>Zoanthus giganteus</i>											■		
<i>Zoanthus robustus</i>						●							●
<i>Isaurus tuberculatus</i>								●					●
<i>Palythoa</i> sp. 1									■				
<i>Palythoa</i> cf. <i>mutuki</i>	●	■							■			■	●
<i>Palythoa heliodiscus</i>		■							■	■		■	
<i>Palythoa</i> cf. <i>toxica</i>	●	■	■			●	●			■		■	
<i>Palythoa tuberculosa</i>	●	■	■	■		●		●		■			●
<i>P. sp. sakurajimensis</i>													●
<i>Palythoa mizigama</i>													●
<i>Sphenopus marsupialis</i>								●	■		■		
<i>Epizoanthus</i> aff. <i>illoricatus</i>										■			

usually shorter, particularly in locations with strong currents or waves. ...External polyp surface generally uniform, light to dark gray-blue with no significant markings or patterns. Tentacles 40–58, mesenteries 48–54. Wide variation in oral disk colors, patterns, and in colors of tentacles... (Reimer et al. 2004, 2006a) (partially adapted from Reimer & Hickman 2009).”

Remarks. As mentioned earlier, in this study we have included *Z. cyanoides*, *Z. cavernarum*, *Z. erythrochloros*, and *Z. gnophodes* within this species. An additional image of this species is shown in Chou’s (1992) guidebook to marine life in Singapore. This species is distributed widely in the Indo-Pacific, from South Africa (Risi & Macdonald, 2015) to the Galapagos (Reimer & Hickman, 2009).

3. *Zoanthus vietnamensis* Pax & Müller, 1957

(Fig. 2c, see also fig. 2 in plate XII and fig. 2 in plate XIII in Pax & Müller (1957), fig. 7B in Reimer & Todd (2009))

Previously reported locations in the South China Sea and Gulf of Thailand (n = 4). Raffles Lighthouse, Singapore; Kusu Island, Singapore; in Reimer & Todd (2009). Rocher Noir, Ca Dau Bay, Nha Trang, Vietnam, original description; in Pax & Müller (1957). Wanli Tung, Kenting, Taiwan; in Reimer et al. (2013) (Table 1).

New photographic record locations in the South China Sea and Gulf of Thailand (n = 1). Hoi Ha Wan, Hong Kong (22°28’17.5”N, 114°20’5.0”E), n = 1) (Table 1). First record for Hong Kong.

Description. From Pax & Müller (1957) (translated from German): “...tentacle in the living polyps colored gray-green, white aperture rim. Coenenchyme forms a ‘cushion’ (up to 3 mm thick). Distance of polyps small (0–2 mm). Proximal sphincter more than twice as long as the distal sphincter, comprised of about 40 mesh muscles. Spirocysts in tentacle ectoderm present but very sparse, 13–14 µm long. Mesenteries quite pigmented.”

Remarks: This species appears to be distributed throughout the South China Sea as it is found at both the north and south ends of this region, with the type locality in the middle. In Japan and Taiwan, this species is more common in slightly cooler (subtropical waters) (Reimer et al., 2013) compared to *Z. kuroshio*, and more research is needed in the Central Indo-Pacific region to clearly ascertain its distribution.

4. *Zoanthus kuroshio* Reimer & Ono in Reimer, Iwama, Takishita, Tsukahara & Maruyama, 2006

(Fig. 2d, see also fig. 2B in Reimer et al. (2011c))

Previously reported locations in the South China Sea and Gulf of Thailand (n = 1). Wanli Tung, Kenting, Taiwan; in Reimer et al. (2011c) (Table 1).

New photographic record locations in the South China Sea and Gulf of Thailand (n = 1). Mango Bay, Koh Tao, Thailand (Table 1). First record for Gulf of Thailand, and Thailand.

Description. From Reimer et al. (2006a): “...when oral disks are closed polyps crowded and barely protrude from a well-developed, thick, rubbery, lamellate coenenchyme, (“intermediae” or “immerse” (Pax, 1910))... Edge of coenenchyme often “tongue-like” in form. Coenenchyme generally lighter in color (pale purple) than polyps. Occasionally external polyp surface around the oral disk edge lighter than the rest of the polyp, almost cream in color... External polyp surface light purple with no patterned markings... Oral disk and tentacles vary slightly in color (generally pale pink, tentacles pale pink, light green, or gray) between individual colonies... Expanded polyps 6 to 12 mm in diameter (closed polyps approximately 3 mm in diameter) and up to 7 mm in length. ... Polyps much narrower in diameter towards the oral opening than at the base... Tentacle count approximately 50–64... often in massive colonies (1.5 m²).”

Remarks. Research has shown that this species, although closely related to *Z. vietnamensis* (Reimer et al., 2006b), is subtly different phylogenetically (Reimer et al., 2013). Similar to *Z. vietnamensis*, more research is needed in the Central Indo-Pacific region to clearly ascertain its distribution.

5. *Zoanthus gigantus* Reimer & Tsukahara in Reimer, Iwama, Takishita, Tsukahara & Maruyama, 2006

(Fig. 2e)

Previously reported locations in the South China Sea and Gulf of Thailand (n = 0). none.

New photographic record locations in the South China Sea and Gulf of Thailand (n = 1). Pak Lap Tsai, Hong Kong; (Table 1). First record for South China Sea.

Description. From Reimer et al. (2006a): “...polyps extend from a poorly developed lamellate coenenchyme and not crowded, i.e., “liberae” form (Pax, 1910)... Expanded polyps from 6 to 25+ mm in diameter, up to 30–40 mm in length... External polyp surface with cream/white striped vertical markings on the upper half... Oral disk and tentacles vary in color (green, brown, gray, blue, red), sometimes fluorescent... Tentacle count approximately 42–60, with 62–63 mesenteries... Polyps over twice as wide in diameter towards the oral opening as at the base...”

Remarks. Despite surveys, this species has not previously been reported from Singapore (Reimer & Todd, 2009), or at any other locations in the South China Sea and Gulf of Thailand. Previously, it has primarily been reported from southern Japan (Reimer et al., 2006a) and Taiwan (Reimer et al., 2011c, 2013).

6. *Zoanthus robustus* Carlgren, 1950

(See figs. 1, 2 in Grant et al. (2008) in Australia – no images available for South China Sea specimens)

Previously reported locations in the South China Sea and Gulf of Thailand (n = 1). Poulo Dama (Hon Cu Tron and islands), Vietnam in Pax & Müller (1957) (Table 1).

New photographic record locations in the South China Sea and Gulf of Thailand (n = 0). none.

Description. Green in colour, with polyps “up to 3 cm long and 0.8 cm broad” (Carlgren, 1950). From Carlgren (1950): “Polyps large, rather robust, very closely set, joined with inconsiderable coenenchyme. Scapus provided with a thick cuticle to which foreign bodies are attached... Tentacles small. Siphonoglyph weak. Mesenteries about 50 in number...”

Remarks. Described from Western Australia, this species has only been seen once in the South China Sea and Gulf of Thailand (as above), and this represents the only known report outside of Australia.

Genus *Isaurus* Gray, 1828**7. *Isaurus tuberculatus* Gray, 1828**

(See plates 4, 5 in Reimer (2007) in Japan – no images available for South China Sea specimens)

Previously reported locations in the South China Sea and Gulf of Thailand (n = 2): West coast of Hon Tre Island, Nha Trang, Vietnam as *I. asymmetricus* in Pax & Müller (1957); Kenting, Taiwan; in Reimer et al. (2011c) (Table 1).

New photographic record locations in the South China Sea and Gulf of Thailand (n = 0): none.

Description. From Reimer et al. (2014b): “Species in this genus are zooxanthellate, not incrustated, with a simple mesogleal sphincter muscle, and have non-erect, recumbent polyps that do not have lacunae or mesogleal canals, unlike *Zoanthus* species. *Isaurus tuberculatus* has tubercles on the exterior surface of polyps (=endodermal invagination)...” For detailed discussion of *I. tuberculatus*, refer to Muirhead & Ryland (1985), with phylogenetic analyses in Reimer et al. (2008c).

Remarks. As mentioned earlier, includes *I. asymmetricus*. *Isaurus* species are very cryptic and likely occur in low densities, and based only on two records here, it is almost impossible to speculate on distribution. Overall, reported from many areas over the subtropical/tropical Indo-Pacific.

Family Sphenopidae Hertwig, 1882**Genus *Palythoa* Lamouroux, 1816****8. Unidentified *Palythoa* sp. 1**

(Fig. 3a)

Previously reported locations in the South China Sea and Gulf of Thailand (n = 0). none.

New photographic record locations in the South China Sea and Gulf of Thailand (n = 2). Southwest of Pelong Rocks, northwestern Borneo, Brunei Darussalam, n = 2 (Table 1).

Description. Resembles *P. mutuki*, with 44–52 tentacles up to approximately 50% of the oral disk diameter. Tentacles and majority of the oral disk light brown in colour, with white patchy markings around the oral opening and the inner half of the oral disk, with some random white spots also found on the outer half of the oral disk. Oral opening slightly pale green. Observed colonies small, only one or two polyps. Zooxanthellate.

Remarks. Images resemble *P. sp. sakurajimensis*, which also often has white markings on the oral disk, but with so little information available on this species, for now we can only identify to genus level with certainty.

9. *Palythoa* cf. *mutuki* (Haddon & Shackleton, 1891b)

Fig. 3b, also fig. 7D in Reimer & Todd (2009).

Previously reported locations in the South China Sea and Gulf of Thailand (n = 3). Raffles Lighthouse, Singapore; Kusu Island, Singapore; both in Reimer & Todd (2009); Wanli Tung, Kenting, Taiwan; in Reimer et al. (2013) (Table 1).

New photographic record locations in the South China Sea and Gulf of Thailand (n = 6). Batu Berlabuh, southeast Pulau Tioman, Pahang, Malaysia; south-southwest of Pelong Rocks, northwestern Borneo, Brunei Darussalam; Redang Kalong House Reef, east Pulau Redang, Terengganu, Malaysia; Knob Reef, Tolo Harbour, Hong Kong n = 3 (Table 1). First records for Brunei Darussalam, Malaysia, Hong Kong.

Description. From Reimer et al. (2014b): Originally described from the Torres Strait, Australia, this species was redescribed in detail in Ryland & Lancaster (2003). Although all specimens in this grouping match with previously reported *P. mutuki* based on sizes (average polyp height 9.6 mm, range 3–31 mm, average width 4.8 mm, range 2–8 mm, n=12 specimens) and overall morphology (‘intermediae’ or ‘liberae’ [Pax, 1910]; visible capitulary ridges on closed polyps [Ryland & Lancaster 2003]) ..., we have identified all specimens in this study as “cf.”. Recent work has shown the presence of more than two closely related species groups within *P. mutuki* (Reimer et al., 2006b, 2007b, 2011b, 2013b; Mizuyama & Reimer, unpubl. data) that are exceedingly difficult to distinguish without molecular data. For this reason, we have preliminarily assigned “cf.” to these specimens.

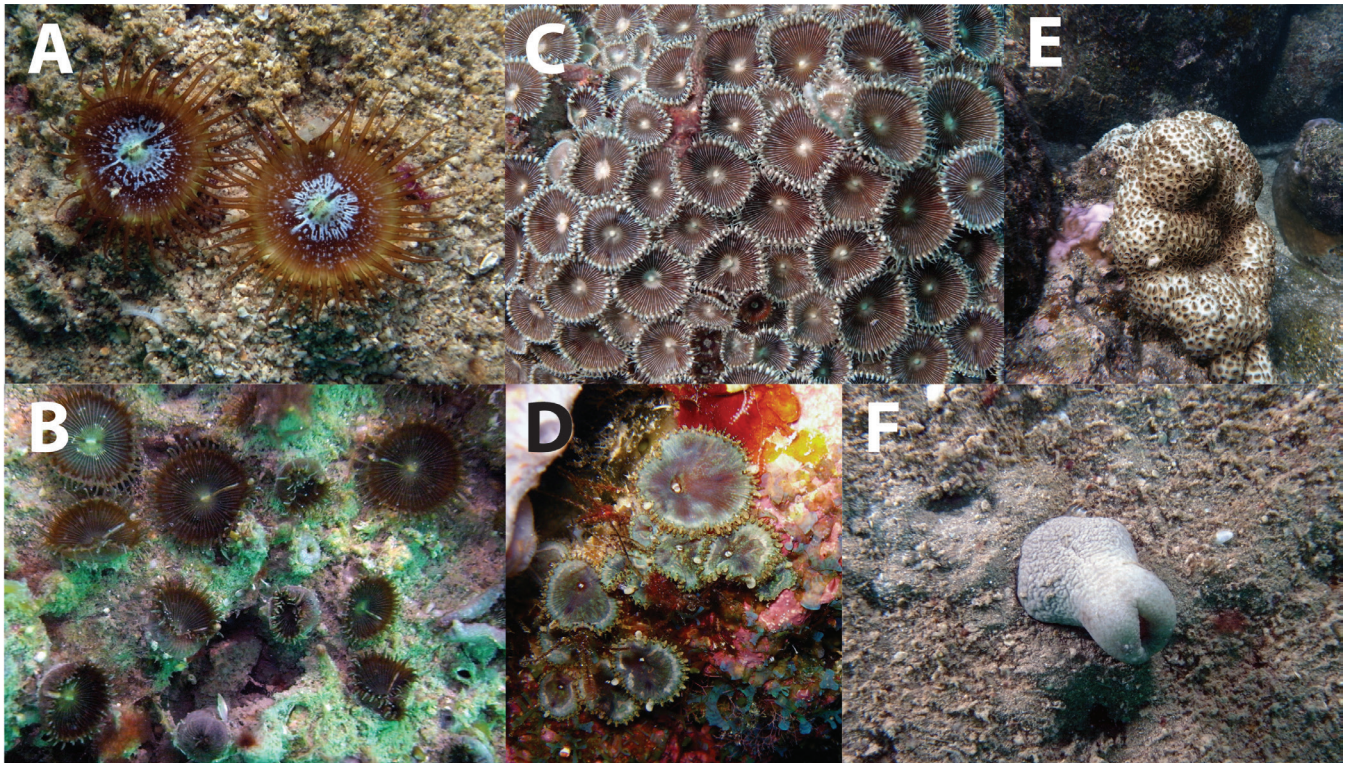


Fig. 3. Species of the family Sphenopidae in the South China Sea. A, unidentified *Palythoa* sp. 1 southwest of Pelong Rocks, northwestern Borneo, Brunei Darussalam; B, *P. cf. mutuki* south-southwest of Pelong Rocks, northwestern Borneo, Brunei Darussalam; C, *P. heliodiscus* at Batu Berlabuh, southeast Pulau Tioman, Pahang, Malaysia; D, *P. cf. toxica* at Wreck Point 2, southeast Layang-Layang Atoll, Spratlys, Malaysia; E, *P. tuberculosa* at Ekor Tebu, Pulau Redang, Terengganu, Malaysia; and F, *Sphenopus marsupialis* at sandy shoal without name southwest of Pelong Rocks, northwestern Borneo, Brunei Darussalam. Detailed image information given in Table S1.

Remarks. Although there are only six total records for this species, it is likely distributed throughout the South China Sea and Gulf of Thailand, as there are records from Singapore, Taiwan, and Redang and Tioman Islands in Malaysia. This species may include several closely related species (Mizuyama & Reimer, unpublished data) and is closely related to *P. tuberculosa* (Reimer et al., 2007; Shiroma & Reimer, 2010).

10. *Palythoa heliodiscus* (Ryland & Lancaster, 2003)
(Fig. 3c)

Previously reported locations in the South China Sea and Gulf of Thailand (n = 0). none.

New photographic record locations in the South China Sea and Gulf of Thailand (n = 5). Batu Berlabuh, southeast Pulau Tioman, Pahang, Malaysia; south-southwest of Pelong Rocks, northwestern Borneo, Brunei Darussalam; Navigator Lane, north Layang-Layang Atoll, Spratlys, Malaysia; Mid Reef, northeast Layang-Layang Atoll, Spratlys, Malaysia; Tung Ping Chau, Hong Kong (Table 1). First record for South China Sea.

Description. From Reimer et al. (2014b): “This zooxanthellate species was described in detail recently by Ryland and Lancaster (2003). Superficially similar in appearance to *P. mutuki*, externally the species can be distinguished by its short tentacles (length <20% of oral disk) and subtidal

distribution, compared to primarily intertidal *P. mutuki*, which also has longer tentacles (~45% of oral disk) (Ryland & Lancaster 2003).

Sizes of specimens agree well with specimens seen in other localities (average polyp heights 11.3 mm and 17.0 mm for each specimen, range 7–20 mm; average width 3.9 mm and 4.4 mm for each specimen, range 3.5–5.5 mm; n=2 specimens of 8 and 5 polyps, respectively). Depth of collected specimens (12 and 35 m) also fits well with the description of this species as primarily subtidal in the original description, and from data in Okinawa, Japan (e.g., Reimer, 2010).”

From original description (Ryland & Lancaster, 2003): “Very low intertidal or subtidal *Protopalalythoa* with smallish zooids (11–17 by ~ 4–6 mm), somewhat knobbed in contraction and often of tricorn appearance in semi-expansion. Tentacles minute, 35–40 per cycle. Microcnemes in TS lacking a conspicuous basal canal. Septal filaments without basitrichs, and the holotrichs not above ~50 µm in length. Zooxanthellae transmitted via the oocytes (vertical transmission).”

Remarks. This species and *P. cf. toxica* were listed together in another recent paper, focusing on Zoantharia in the Central Indo-Pacific (Reimer et al., 2014b), but are separated here due to an abundance of both records and excellent in situ images for both species. Common in the western Pacific in both southern and northern hemispheres (Ryland & Lancaster, 2003; Reimer et al., 2007).

11. *Palythoa* cf. *toxica* Walsh & Bowers, 1971

Fig. 3d, see also fig. 7E in Reimer & Todd (2009), fig. 2E in Reimer et al. (2011c).

Previously reported locations in the South China Sea and Gulf of Thailand (n = 4). Singapore (locality not given) in Pax & Müller (1956); Pulo Dama (Hon Cu Tron and islands), Vietnam; Cape St. Jacques, Vietnam; both in Pax & Müller (1957); Kusu Island, Singapore; in Reimer & Todd (2009) (Table 1).

New photographic record locations in the South China Sea and Gulf of Thailand (n = 11). west Pulau Tioman, Pahang, Malaysia; Pasir Akar, Pulau Redang, Terengganu, Malaysia; Redang Kalong House Reef, east Pulau Redang, Terengganu, Malaysia; Tulak Dalam, Pulau Redang, Terengganu, Malaysia; Chagar Hutang, Pulau Redang, Terengganu, Malaysia; Runway, south Layang-Layang Atoll, Spratlys, Malaysia; Wreck Point 2, southeast Layang-Layang Atoll, Spratlys, Malaysia; Shark Cave 2, west Layang-Layang Atoll, Spratlys, Malaysia; Wreck Point 1, southeast Layang-Layang Atoll, Spratlys, Malaysia; Coral Café, east Layang-Layang Atoll, Spratlys, Malaysia; Tung Ping Chau, Hong Kong (Table 1). First records for Malaysia and Hong Kong.

Description. From Reimer et al. (2014b): "...polyps have either green or purple oral disks with various semi-irregular patterns, as well as blue/gray or light orange tentacles (Figures 8C, 8D)."

From original description (Walsh & Bowers, 1971): "Polyp erect, with slight swelling at base; heavily encrusted; column of expanded, preserved specimens to 14 mm high and 7 mm in diameter; capitular ridges to 30 in number, mesenteries and tentacles to 60; epidermal and gastrodermal canals absent from mesoglea; sphincter weak, with cavities approximately the same size throughout; basal canals of macrocnemes to five in number; color of oral disk light or dark brown, often with a random pattern of small white spots around mouth."

Remarks. In this study, this species includes *P. singaporensis* (record in Pax & Müller, 1956) and *P. sp. singapura* (in Reimer & Todd, 2009). Recent work by Nishimura and Reimer (unpublished data) indicates that *P. sp. singapura* is closely related to *P. heliodiscus* but has slightly different ITS-rDNA sequences. Morphologically, these specimens (and images in this study) closely resemble *P. toxica* Walsh & Bowers, 1971 described from Hawai'i, and we have grouped all similar specimens in this species for now. Future investigations should ascertain the true identity of this group. If all specimens are *P. toxica*, this species has a wide distribution in the Pacific, including the South China Sea, Taiwan (Reimer et al., 2013), Okinawa (Nishimura & Reimer, unpublished data), Palau (Reimer et al., 2014a), and Hawai'i.



Fig. 4. *Epizoanthus* aff. *illoricatus* at Shark Cave 2, west Layang-Layang Atoll, Spratlys, Malaysia. Detailed image information given in Table 1.

12. *Palythoa tuberculosa* (Esper, 1805)

Fig. 3e, see also figs. 3, 4 from plate XII in Pax & Müller (1957), fig. 7C in Reimer & Todd (2009).

Previously reported locations in the South China Sea and Gulf of Thailand (n = 11). Raffles Lighthouse, Singapore; Kusu Island, Singapore; Lazarus Island, Singapore; all in Reimer & Todd (2009); Pulo Dama (Hon Cu Tron and islands), Vietnam as *P. anthoplax*; west coast of Hon Tre Island, Nha Trang, Vietnam as *P. titanophila*; Hon Rua in Ca Dau Bay, Nha Trang, Vietnam as *P. stephensoni*; all in Pax and Müller (1957); Longkeng, Kenting, Taiwan; Ho-bi-hoo, Kenting, Taiwan; Tiao Shi, Kenting, Taiwan; Wanli Tung, Kenting, Taiwan (n = 2); all in Reimer et al. (2013) (Table 1).

New photographic record locations in the South China Sea and Gulf of Thailand (n = 14). Tumok, west Pulau Tioman, Pahang, Malaysia; Ekor Tebu, Pulau Redang, Terengganu, Malaysia, 3 m; Che Isa Islet off east Pulau Redang, Terengganu, Malaysia; Wreck Point 2, southeast Layang-Layang Atoll, Spratlys, Malaysia; Shark Cave 2, west Layang-Layang Atoll, Spratlys, Malaysia; Crack Reef, northwest Layang-Layang Atoll, Spratlys, Malaysia; Navigator Lane, north Layang-Layang Atoll, Spratlys, Malaysia; Shark Island, Koh Tao, Thailand; Pottery Pinnacles, Koh Tao, Thailand; White Rock, Koh Tao, Thailand, n = 3; Twin Peaks, Koh Tao, Thailand; Mango Bay, Koh Tao, Thailand (Table 1). First record for Malaysia.

Description. From Reimer et al. (2014b): "This zooanthellate species was originally described from India (Esper, 1805), and subsequently redescribed utilising specimens from the Red Sea (Klunzinger, 1877). Recent work by Hibino et al. (2014) indicates the species may include some junior synonyms, and has a wide distribution across the subtropical and tropical Indo-Pacific. Polyps are embedded within a well-developed coenenchyme ('immersae', Pax, 1910), and colonies vary in color from fluorescent green-yellow to dark brown or even ochre ..."

Specimens in this study averaged 4.7 mm in polyp diameter (n=29 specimens), ranging from 2 to 8 mm. One specimen, RMNH Coel 40553, was notable for its very small polyps (average diameter 2.4 mm, n=10 polyps). Other colonies ranged from 3.1 to 6.5 mm in average diameter, similar to previous reported sizes. All specimens were ‘immersae’. Generally, morphology fit well within the accepted range of *P. tuberculosa* (see Table 1 in Hibino et al., 2014), although some specimens’ polyps were somewhat smaller than previously observed. These smaller sizes may also be partly due to preservation methods.

Remarks. As mentioned earlier, includes *P. anthoplax*, *P. titanophila*, and *P. stephensoni*. Additional guidebook images of this species include Chou (1992) in Singapore and Gosliner et al. (1996) at Batangas, southwest Luzon, Philippines. This species is widely distributed in the Pacific (Hibino et al., 2014) and generally very common (Irei et al., 2011). From the results of this study, it is clear that this species is distributed throughout the South China Sea and Gulf of Thailand.

13. *Palythoa* sp. *sakurajimensis* sensu Reimer et al. 2007

(See fig. 5 in Reimer et al. (2011a) in Ogasawara Islands – no images available for South China Sea specimens)

Previously reported locations in the South China Sea and Gulf of Thailand (n = 1). Wanli Tung, Kenting, Taiwan; in Reimer et al. (2013) (Table 1).

New photographic record locations in the South China Sea and Gulf of Thailand (n = 0). none.

Description. Morphologically very similar to *P. mutuki*, this undescribed “liberae” (Pax, 1910) species forms small colonies or exists even as single polyps. Many (but not all) observed specimens have white markings around their oral opening, and have mottled green and brown oral disks. Phylogenetically, this species is clearly distinct from all other *Palythoa* spp. examined thus far (Reimer et al. 2007, 2011a).

Remarks. This species has been reported in very low numbers from both Taiwan (Reimer et al., 2013) and Japan (Reimer et al., 2007, 2011a). With only one record from the South China Sea, it is premature to speculate on its distribution.

14. *Palythoa mizigama* Irei, Sinniger & Reimer, 2015
(See fig. 3D from Reimer et al. (2011c))

Previously reported locations in the South China Sea and Gulf of Thailand (n = 1). Wanli Tung, Kenting, Taiwan; in Reimer et al. (2011c) (Table 1), reported again in Irei et al. (2015).

New photographic record locations in the South China Sea and Gulf of Thailand (n = 0): none.

Description. From Irei et al. (2015): “Azooxanthellate brachycnemic zoantharian with heavily sand incrustated

ectoderm and mesoglea. Colonies usually composed of several to 20 polyps, with each polyp loosely connected to others by a thin stolon (=“liberae”, Pax 1910). Solitary polyps are also commonly seen. Polyp is cylindrical and upper part of the polyp around pharynx is occasionally constricted when closed (Figure 3a). Expanded polyps are flared, with column becoming wider towards the oral disk and a large oral disk (Figure 2a, c). Columns occasionally have several horizontal wrinkles (1 to up to 10 in number) of one quarter to half the length of column periphery, mostly on inner side of bent polyps....” And “*Polyp size.* Approximately 0.5–1.0 cm in length and 0.2–0.4 cm in width after fixation in 4–10% seawater formalin or 70–99.5% ethanol.”

Remarks. This azooxanthellate cave-dwelling species has been reported from both Taiwan (Reimer et al., 2013; Irei et al., 2015) and Japan (Reimer, 2010; Irei et al., 2015). Currently, it is known from the southern Ryukyu Islands, Taiwan, and New Caledonia (Irei et al., 2015).

Genus *Sphenopus* Steenstrup, 1856

15. *Sphenopus marsupialis* (Gmelin, 1791)
(Fig. 3f, see also fig. 1 in Reimer et al. (2012))

Previously reported locations in the South China Sea and Gulf of Thailand (n = 14). Southwest of Pelong Rocks, northwestern Borneo, Brunei Darussalam, n = 14; from Reimer et al. (2012) (Table 1).

New photographic record locations in the South China Sea and Gulf of Thailand (n = 13). Tajau/Bak Bak, Kudat, Sabah, northernmost tip of Borneo, Malaysia, n = 4; southeast Tanjung Siagut, Kudat, Sabah, northernmost tip of Borneo, Malaysia, n = 7; sandy shoal without name southwest of Pelong Rocks, northwestern Borneo, Brunei Darussalam, n = 2 (Table 1). First record for Malaysia.

Description. From Reimer et al. (2014b): “The type species of the azooxanthellate genus *Sphenopus*, this species has an Indo-West Pacific distribution (Reimer et al. 2012b). Uniquely for the order, species in this genus are unitary (not colonial), and usually free-living, as they are not attached to substrate, and instead embedded in sand or loose gravel/substrate ... Individuals can often grow to large sizes (for zoantharians); up to several cm in both length and polyp diameter. Taxonomic examination of this genus is quite limited, with only two recent studies (Soong et al. 1999, Reimer et al. 2012b), both of which clearly state that further research is needed to more clearly understand this group.”

Remarks. Additionally, there is one image of this species in a guidebook (Erhardt & Knop, 2005) at Pulau Tioman, Malaysia. This species grouping could possibly include *Gemmaria philippinensis* based on the description in von Heider’s (1899) report, which was originally described as *Triga philippinensis* in Gray (1867), although the image in Erhardt & Knop (2005) may alternately be *S. pedunculatus* Hertwig, 1888, or another species and genus altogether. From the few records included here, as well as from information

in Soong et al. (1999) and Reimer et al. (2012), it appears this species is distributed at least along the eastern coasts and northern end of the South China Sea.

Suborder Macrocnemina Haddon & Shackleton, 1891a

Family Epizoanthidae Delage & Hérouard, 1901

Genus *Epizoanthus* Gray, 1867

16. *Epizoanthus* aff. *illoricatus* Tischbierek, 1930
(Fig. 4)

Previously reported locations in the South China Sea and Gulf of Thailand (n = 0): none.

New photographic record locations in the South China Sea and Gulf of Thailand (n = 5): Shark Cave 2, west Layang-Layang Atoll, Spratlys, Malaysia (n = 4); Wrasse Strip 2, Layang-Layang Atoll, Spratlys, Malaysia (Table 1). First record for the South China Sea.

Description: From Reimer et al. (2014b): “Azooxanthellate. ... obligate epibiont on eunicid worms. Polyps of this putative species are at least twice as big in diameter as *E. illoricatus* (note: sensu stricto – see Reimer et al., 2014b) (average 2.1 mm, compared with a maximum of 2 mm for *E. illoricatus*), and many times bigger in terms of volume. Additionally, both specimens have brown coenenchyme and scapus, different from the light grey coenenchyme and brownish oral disk reported for *E. illoricatus* ... In situ images show colonies with cream, brown, red-brown, orange-brown or tan coenenchyme and scapus, often with white tentacles that are comparatively shorter and thicker than in *E. illoricatus*. The coenenchyme of this putative species is much more developed than *E. illoricatus*, with polyps arising from not only bends of the zig-zag shaped eunicid tube, but also from other locations. The result is a colony that has a higher density of polyps than *E. illoricatus*. In *E. illoricatus*, often the zig-zag shape of the eunicid tube is visible between polyps, but this is rarely the case in *E. aff. illoricatus* ...”

Remarks. Images from the South China Sea are almost identical to images from the Central Indo-Pacific (Reimer et al., 2014b), and differ from the original description of the species (*E. illoricatus* sensu stricto), with a more well-developed coenenchyme and larger polyps, resulting the “affinity” designation in this study. In this study, it was seen only at a cave at Layang-Layang Atoll, and may prefer oceanic outer edge coral reef environments and drop-offs.

It should be noted that the type locality for *E. illoricatus* is Manila Bay, although an exact location was not given (Tischbierek, 1930), and the type specimen has since been lost. Although *E. illoricatus* matching the original description of this species was not reported in this study, it has been seen in neighbouring regions of the Indo-Pacific (Sinniger et al., 2005; Sinniger, 2006; Lindsay et al. 2012; Reimer et al., 2014a), and it is likely present in the South China Sea.

DISCUSSION

Based on bathymetry (Fig. 1) we can speculate that the northern South China Sea may harbor more deep-sea species. However, all of the species listed within this report are shallow-water species. While an examination of the spatial patterns of the Zoantharia listed in this study (Table 2) does show some differences between the various species, we feel that speculation on spatial patterns for these shallow water species is premature, and there are several reasons for this. Firstly, all of the species reported in this study, to the potential exception of undescribed *Palythoa* sp. 1, have also been reported outside the South China Sea and the Gulf of Thailand, and to the exception of *Z. robustus*, which is limited to Australia, all of these species have been reported from a wide range of areas (including one or more of New Caledonia (Sinniger, 2006), the Central Indo-Pacific (Sinniger et al. 2005; Reimer et al., 2014b), Taiwan (Reimer et al., 2011b, 2011c, 2013), Japan (e.g., Reimer et al., 2006a; Reimer, 2010), Palau (Reimer et al. 2014a)). As these species appear to be widespread and not limited to the South China Sea/Gulf of Thailand, it does not appear that this region is the edge of the distributional range for any of the species in this study. Furthermore, many of the photographic records included in this study were not obtained by researchers specifically focusing on Zoantharia, and we suspect further field work in the region would yield many more records of most or all of these species, potentially from all over the South China Sea/Gulf of Thailand.

Despite the clear need for more Zoantharia studies in the South China Sea and the Gulf of Thailand, the results of this study can serve as an indication of which research topics should be focused on in future zoantharian diversity work in these regions. From an examination of the results, we can suggest three main avenues of potential zoantharian research in the South China Sea and Gulf of Thailand.

The first line of research would be to examine more oceanic coral reef regions in the South China Sea. While the Gulf of Thailand is generally shallow and consists of continental shelf, the South China Sea has many true “oceanic” reef systems with steep reef edges and strong currents, which appeared to be rich in reef coral species (Waheed & Hoeksema, 2014; Huang et al. 2015). Such areas have proven in the past also to hold relatively high levels of both brachycnemic and macrocnemic zoantharian diversity (Sinniger, 2006; Reimer et al., 2014a).

The second proposed line of zoantharian research would be to investigate deeper areas of the South China Sea. Until now, almost no research has focused on specimens below the range of conventional SCUBA in this region (e.g., >50 m depth). Research in Hawai’i (Sinniger et al., 2013) has shown that deeper regions of the ocean can harbor high levels of macrocnemic zoantharian diversity. In this study 15 of 16 species listed in the results are in the suborder Brachycnemina, which are limited to shallow waters, further demonstrating the need to investigate deeper areas in this region.

Finally, it naturally follows from the first two lines of research that efforts should be made to create and curate a regional Zoantharia collection for the South China Sea and Gulf of Thailand. At the same time, the disputed control of the deep, northern part of the South China Sea makes it difficult to properly investigate this area. One solution could be an international team of scientists aboard a third-party nation research vessel, a workshop/survey at a research station (e.g., Hsu et al., 2013), or dive resort inside this area (Waheed et al., 2015). Ideally, such a collection would be housed within the region, offering relatively easy access to local researchers. The new Lee Kong Chian Natural History Museum in Singapore is one logical choice to house such a collection, as it already houses the specimens from Reimer & Todd (2009) as well as some other assorted zoantharians from Singapore.

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