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New records of peanut worms (Sipuncula) from Singapore

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Abstract. Sipunculans collected from intertidal and subtidal habitats in Singapore waters during the 2010–2015 Comprehensive Marine Biodiversity Survey (CMBS) were examined. Ten species are recognised: Sipunculidae — *Sipunculus* (*Sipunculus*) *nudus* Linnaeus; Golfingiidae — *Nephasoma* (*Nephasoma*) *pellucidum pellucidum* (Keferstein); Phascolionidae — *Phascolion* (*Isomya*) *convestitum* Sluiter, and *Phascolion* (*Phascolion*) *hibridum* Murina; Phascolosomatidae — *Antillesoma antillarum* (Grube & Oersted), *Apionsoma* (*Apionsoma*) *trichocephalus* Sluiter, *Phascolosoma* (*Phascolosoma*) *arcuatum* (Gray), and *Phascolosoma* (*Phascolosoma*) *nigrescens* (Keferstein); Aspidosiphonidae — *Aspidosiphon* (*Aspidosiphon*) *muelleri* Diesing, and *Aspidosiphon* (*Paraspidosiphon*) *steenstrupii* Diesing. With the exception of *S.* (*S.*) *nudus*, *N.* (*N.*) *pellucidum pellucidum* and *P.* (*P.*) *arcuatum*, the remaining seven species are recorded for the first time from Singapore. This study brings the total number of sipunculan species found in Singapore since the last century to 16 species.

Key words. Sipunculidae, Phascolionidae, Phascolosomatidae, Aspidosiphonidae

INTRODUCTION

The Sipuncula, commonly known as the peanut worms, is a group of bilaterally symmetrical, non-segmented marine bottom-dwelling worms. There are about 150 extant species, which are distributed in a wide variety of marine habitats and at all depths (Cutler, 1994). They are considered ecologically important in the trophic dynamics of various ecosystems, e.g., formation and degeneration of coral reefs, as well as an ecological indicator for environmental monitoring (Cutler, 1994). In some parts of Asia, peanut worms are a supplemental protein resource (Kohn, 1975; Zhou et al., 2007).

In Singapore, studies on sipunculans date back to the early 20th century. Lanchester (1905a) reported five species in three genera (now five genera, on the basis of reported species as recognised today: *Golfingia* Lankester, 1885, *Nephasoma* Pergament, 1946, *Siphonosoma* Spengel, 1912, *Sipunculus* Linnaeus, 1766, and *Phascolosoma* Leuckart, 1828) from Teluk Ayer, Pasir Panjang and Raffles Light in Singapore. These were *Phascolosoma vulgare* (de Blainville, 1827) (=*Golfingia* (*G.*) *vulgaris vulgaris* (de Blainville, 1827)), *Phascolosoma pellucidum* Keferstein, 1865 (=*Nephasoma* (*N.*) *pellucidum pellucidum* (Keferstein, 1865)), *Sipunculus cumanensis* (Keferstein, 1867) (=*Siphonosoma cumanense* (Keferstein, 1867)), *Sipunculus* (*S.*) *robustus* Keferstein, 1865, and *Phymosoma scolops* (Selenka & De Man, 1883) (=*Phascolosoma* (*P.*) *scolops* (Selenka & De Man, 1883)). More than 50 years later, Chuang (1961, 1972) noted *G. vulgaris*, *S. cumanensis*, *S. robustus*, *S. nudus* Linnaeus, 1766 and *Aspidosiphon gracilis* (Baird, 1868) from Singapore, and Lim (1970) made a detailed study of the digestive system of *Phascolosoma arcuatum* (as *lurco*). Lim (1961) had earlier carried out a survey of sipunculans in Singapore and west coast of peninsular Malaysia as part of a Master's thesis, but his results were not published. Since then, no additional sipunculan taxonomic information from this geographic region is available. With most collecting sites of previous studies now lost to land reclamation, it is timely to re-examine the diversity of sipunculan fauna of Singapore. The Comprehensive Marine Biodiversity Survey (CMBS; 2010–2015) collected some 100 individuals of sipunculans from intertidal mudflats, rocky shores, as well as from a range of subtidal habitats including coral reefs. From these specimens, 10 species were recognised, representing two classes, three orders, five families in seven genera. With the exception of three species, *S. (S.) nudus*, *N. (N.) pellucidum pellucidum* and *Phascolosoma (P.) arcuatum* (Gray, 1828), the remaining seven species are first records for Singapore (see Table 1 for a summary). The present study reports upon these newly encountered sipunculans.

MATERIAL AND METHODS

A range of intertidal and subtidal habitats around Singapore waters was examined during CMBS, and collection was carried out manually on intertidal shores, and subtidally by means of a beam trawl and rectangular dredge from a research vessel. Specimens were fixed with 10% seawater formalin after relaxing with menthol and later transferred to 70% alcohol for preservation. All examined specimens

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in the present study were deposited at the Lee Kong Chian Natural History Museum, National University of Singapore.

TAXONOMY

Class Sipunculidea

Order Golfingiida

Family Phascolionidae Cutler & Gibbs

Genus *Phascolion* Théel

Phascolion (*Isomya*) *convestitum* Sluiter
(Fig. 1A, B)

Phascolion (*Isomya*) *convestitum* Cutler, 1994: 117 (for complete synonymy).

Material examined. One specimen (INT-0092), Pulau Semakau (01°11.4'N, 103°46.0'E); intertidal, sandy/rocky/slightly muddy bottom, collected by CMBS TMSI team, 23 August 2013.

Remarks. This small, single nephridium, phascolionid species (Fig. 1A) from the present study has dorsal and ventral retractor muscles of about equal diameter, a key diagnostic character of the subgenus *Isomya* in the genus *Phascolion* (Cutler & Cutler, 1985; Cutler, 1994). In having holdfast papillae with weak borders of hardened protein (Fig. 1B) and lacking spine-like hooks, the specimens agree with the description of *P.* (*I.*) *convestitum* Sluiter, 1902 (Cutler & Cutler, 1985; Cutler, 1994). Records of this species are mostly from the Indo-west Pacific, although some populations are known from the Mediterranean Sea (Cutler, 1994).

Phascolion (*Phascolion*) *hibridum* Murina
(Fig. 1C, D)

Phascolion (*Phascolion*) *hibridum* Murina, 1981: 348–349; E. Cutler & N. Cutler, 1985: 828; Cutler, 1994: 128.

Material examined. One specimen (SEA-0880), South of Pulau Sebarok (01°12.0'N, 103°49.6'E), approximately 30 m deep, coll. Lim Swee Cheng et al., 12 December 2013.

Remarks. This species possesses tapering tentacles, large papillae at the anterior of trunk, type II hooks (Fig. 1C, D), single nephridium, uneven dorsal and ventral retractor muscles, and looped gut, all of which agree with the description of *P.* (*P.*) *hibridum* Murina, 1981 provided by Cutler (1994). This species is believed to be endemic to the Indo-west Pacific, particularly to Malaysia (Cutler, 1994). Previous depth records of this species were from greater depths (Samoa; 1500–2380 m) (Cutler, 1994); however, the examined specimen was collected from shallow waters.

Class Phascolosomatidea

Order Phascolosomatida

Family Phascolosomatidae Stephen & Edmonds

Genus *Antillesoma* (Stephen & Edmonds)

Antillesoma antillarum (Grube & Oersted)

Antillesoma antillarum Cutler, 1994: 186, 188 (for complete synonymy).

Material examined. One specimen (5718DR1-125), off PA campsite (01°18.3'N, 103°57.1'E), mud bottom, approximately 10 m deep, coll. Ng Heok Hee et al., 24 January 2013; three specimens (5115TB1-074-076), ~200m off international cruise center (01°15.6'N, 103°51.5'E), silty bottom, approximately 18 m deep, coll. Helen Wong et al., 24 January 2013; one specimen (41397), Pulau Ubin (01°24.5'N, 103°58.7'E), intertidal mudflat, coll. Lee Yen-Ling et al., 11 November 2013; 28 specimens (44001-44028), Pulau Tekong (01°25.9'N, 104°03.6'E), intertidal mudflat, coll. Tan Koh Siang et al., 22 November 22 2013.

Remarks. This phascolosomatid species of the present study undoubtedly belongs to the monotypic genus *Antillesoma* (Stephen & Edmonds, 1972), which has a large array of tentacles, contractile vessels with villi but lacking in hooks (Stephen & Edmonds, 1972; Cutler, 1994). This cosmopolitan species is found from intertidal to shallow subtidal waters in tropical and subtropical regions (Cutler, 1994). It is not surprising to collect them in Singapore waters.

Genus *Apionsoma* Sluiter

Apionsoma (*Apionsoma*) *trichocephalus* Sluiter
(Fig. 1E)

Apionsoma (*Apionsoma*) *trichocephalus* Cutler, 1994: 196 (for complete synonymy).

Material examined. Two specimens (59232, 59237), Sungei Loyang (01°22.9'N, 103°57.9'E), intertidal mudflat, coll. Ng Heok Hee et al., 25 May 2012.

Remarks. This *Apionsoma* species of the present study (Fig. 1E) has continuous muscle layers but no papillae on the body wall and no hooks or tentacles on its introvert, which agree with the description of *A.* (*A.*) *trichocephalus* Sluiter, 1902 (Cutler, 1994). This species has a circumtropical distribution (Cutler, 1994).

Genus *Phascolosoma* Leuckart

Phascolosoma (*Phascolosoma*) *nigrescens* (Keferstein)
(Fig. 1F)

Phascolosoma (*Phascolosoma*) *nigrescens* Cutler, 1994: 179 (for complete synonymy).

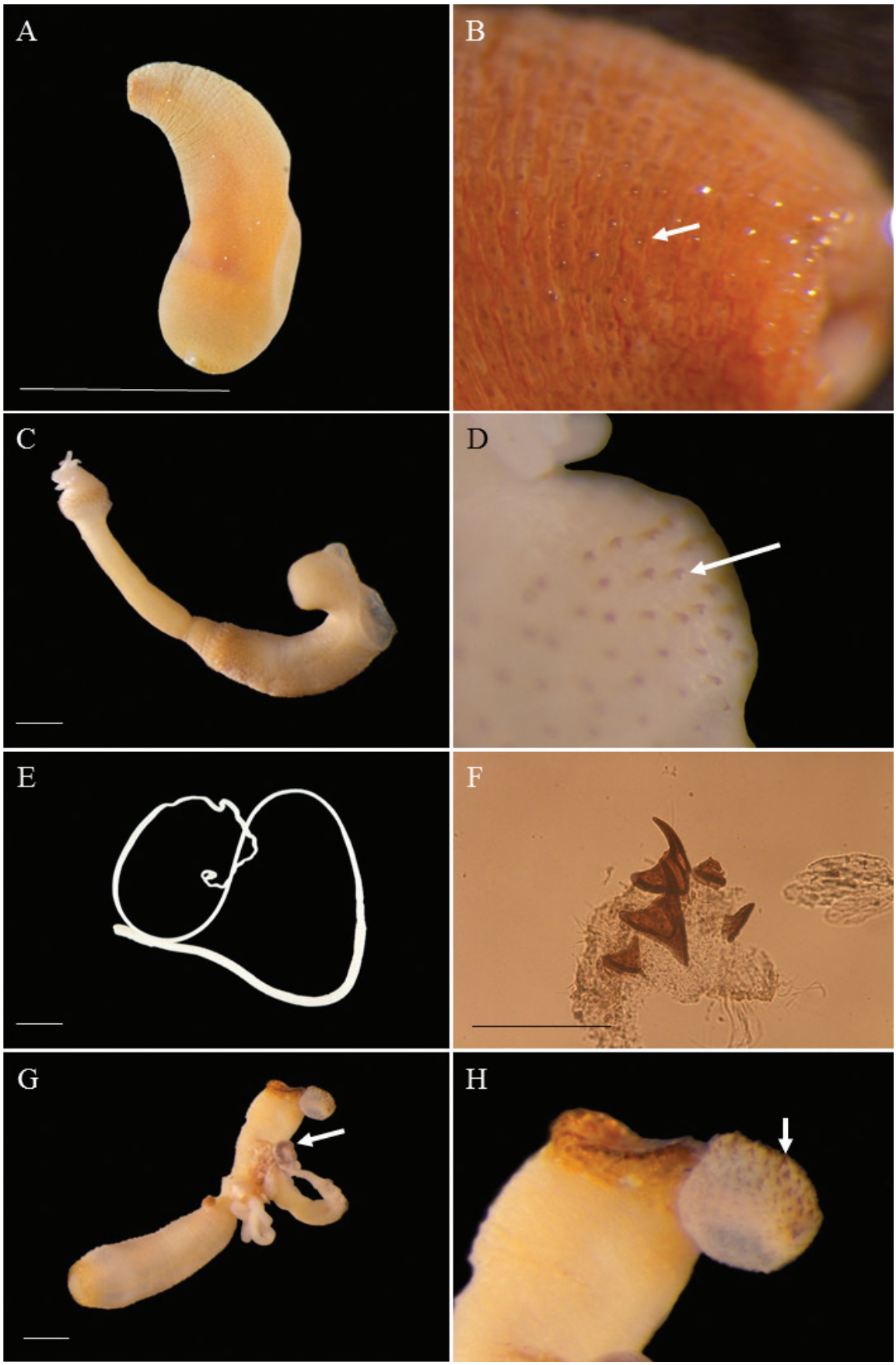

Fig. 1. A, *Phascolion* (*Isomya*) *convestitum* Sluiter; B, anterior trunk of *Phascolion* (*Isomya*) *convestitum* Sluiter, arrow indicates the holdfast papilla; C, *Phascolion* (*P.*) *hibridum* Murina; D, anterior introvert of *Phascolion* (*P.*) *hibridum* Murina, arrow indicates type II hook; E, *Apionsoma* (*A.*) *trichocephalus* Sluiter; F, Introvert hooks of *Phascolosoma* (*Phascolosoma*) *nigrescens* (Keferstein); G, *Aspidosiphon* (*Paraspidosiphon*) *steenstrupii* Diesing, arrow indicates inversed rings of introvert hook; H, close-up view of anal shield and posterior introvert of *Aspidosiphon* (*Paraspidosiphon*) *steenstrupii* Diesing, arrow indicates pyramidal hook. Scale bar = 10 mm [A]; 1.0 mm [C, E–G].

Table 1. Sipunculans from Singapore. Species in bold indicate sipunculans recorded in Singapore for the first time in this study.

Species Count	Order: Family	Genus/species	Remarks
1	Golfingiida: Sipunculidae	*Sipunculus* (*Sipunculus*) *nudus* Linnaeus	Common intertidally in muddy sand at Tanjung Gul, Pasir Ris, Raffles Light (Lim, 1961, unpublished; see also Chuang, 1961); collected from subtidal sand in this study from the Singapore Strait.
2	Golfingiida: Sipunculidae	*Sipunculus* (*Sipunculus*) *robustus* Keferstein	Not recorded in this study, but observed recently (2003) in intertidal gravel at Beting Bronok in the East Johor Strait (Tan, pers. obs.); numerous specimens observed by Lim (1961, unpublished) intertidally at Changi and Pasir Ris. Also recorded by Chuang (1961, 1972). Lanchester (1905a) obtained a few specimens from Teluk Ayer and Pasir Panjang.
3	Golfingiida: Sipunculidae	*Siphonosoma cumanense* (Keferstein)	Not recorded in this study; Lim (1961, unpublished) documented the species as very common in clean intertidal sand at Changi, Tanjung Gul, Pasir Ris and Raffles Light. Lanchester (1905a,b as *Sipunculus cumanensis*) obtained several specimens from Pasir Panjang (Singapore) and Penang (Malaysia).
4	Golfingiida: Phascolionidae	***Phascolion* (*Isomya*) *convestitum* Sluiter**	First record for Singapore (this study)
5	Golfingiida: Phascolionidae	***Phascolion* (*Phascolion*) *hibridum* Murina**	First record for Singapore (this study)
6	Golfingiida: Golfingiidae	*Golfingia* (*Golfingia*) *vulgaris vulgaris* (de Blainville)	Not recorded in this study; Changi (Lim, 1961 unpublished). Lanchester (1905a, as *Phascolosoma vulgare*) obtained several specimens from Raffles Light and Pasir Panjang.
7	Golfingiida: Golfingiidae	*Nephasoma* (*Nephasoma*) *pellucidum pellucidum* (Keferstein)	Singapore Strait. Subtidal, uncommon (this study). Lanchester (1905a, as *Phascolosoma pellucidum*) obtained specimens from Pasir Panjang and Pulau Jawi off Malacca (Malaysia), which interestingly were associated with an entoproct *Loxosoma* (Kerferstein).
8	Golfingiida: Themistidae	*Themiste* (*Lagenopsis*) *langeniformis* (Baird)	Not recorded in this study; Lim (1961) found specimens in rock interstices at Labrador Beach, Singapore. See also Selenka (1883, as *Dendrostomum signifier* Selenka & de Man).
9	Phascolosomatida: Phascolosomatidae	***Antillesoma antillarum* (Grube & Oersted)**	First record for Singapore (this study); Lanchester (1905b) described *Physcosoma gaudens* from Pulau Bidan, Penang; this species is now synonymized with *A. antillarum* (see Cutler, 1994).
10	Phascolosomatida: Phascolosomatidae	***Apionsoma* (*Apionsoma*) *trichocephalus* Sluiter**	First record for Singapore (this study)
11	Phascolosomatida: Phascolosomatidae	*Phascolosoma* (*Phascolosoma*) *arcuatum* (Gray)	Common in mangrove mud (Lim, 1961, 1970; Green & Dunn, 1976; this study). Lanchester (1905b) identified numerous specimens from Terengganu, Malaysia. Lim (1970) showed that their diet comprised mainly of diatoms. Their interesting physiology was studied by Green & Dunn (1976) in Selangor (Malaysia) and Lim & Ip (1991a, b), Chew et al., 1994 and Ip et al., 1994) in Singapore.
12	Phascolosomatida: Phascolosomatidae	***Phascolosoma* (*Phascolosoma*) *nigrescens* (Keferstein)**	First record for Singapore (this study); Lanchester (1905b, as *Physcosoma*) obtained a few specimens from Pulau Bidan, Penang (Malaysia).

Species Count	Order: Family	Genus/species	Remarks
13	Phascolosomatida: Phascolosomatidae	*Phascolosoma* (*Phascolosoma*) *scolops* (Selenka & De Man, 1883)	Not recorded in this study; Lim (1961) observed this species in Seletar (E Johor Strait); Lanchester (1905a, b as *Physcosoma*; also as *P. socium*) recorded this species from Raffles Lighthouse and Selat Sinki (Singapore) and Pulau Bidan, Penang (Malaysia).
14	Aspidosiphonida: Aspidosiphonidae	***Aspidosiphon* (*Aspidosiphon*) *muelleri* Diesing**	First record for Singapore (this study)
15	Aspidosiphonida: Aspidosiphonidae	***Aspidosiphon* (*Paraspidosiphon*) *steenstrupii* Diesing**	Lanchester (1905b) recorded this species from Pulau Bidan, Penang. First record for Singapore (this study)
16	Aspidosiphonida: Aspidosiphonidae	*Aspidosiphon* (*Aspidosiphon*) *gracilis* (Baird)	Not recorded in this study; however see Lim (1961, unpublished); Chuang (1972).

Material examined. One specimen (INT-0179), Lazarus Island (01°13.4'N, 103°51.4'E), intertidal rocky/sandy bottom, coll. Helen Wong et al., 12 December 2013.

Remarks. Morphology of introvert hooks of the present species (Fig. 1F) agrees well with that of *P.* (*P.*) *nigrescens* (Keferstein, 1865) (Cutler & Cutler, 1990; Cutler, 1994). This species has a circumtropical distribution in shallow waters of the Indian, Pacific, and Atlantic Oceans (Cutler, 1994). It was collected at Pulau Bidan off the northern coast of Penang in the Malacca Strait by Lanchester (1905b).

Order Aspidosiphonida

Family Aspidosiphonidae de Quatrefages

Genus *Aspidosiphon* Diesing

Aspidosiphon (*Aspidosiphon*) *muelleri* Diesing

Aspidosiphon (*Aspidosiphon*) *muelleri* Cutler, 1994: 218 (for complete synonymy).

Material examined. One specimen (SEA-0418), Eastern Fairway (01°15.3'N, 103°56.2'E), sandy bottom, coll. Lim Swee Cheng et al., 10 September 2013.

Remarks. The species is easily recognised from its congeners by the presence of dark, well-defined anal shield, which is formed of many small units arranged into plates that are partially separated by longitudinal furrows and by transverse furrows in midsection. Cutler (1994) commented that the species is the most widespread species in the family, with an almost cosmopolitan distribution in temperate to subtropical waters with the exception of the Western Atlantic and Eastern Pacific regions.

Aspidosiphon (*Paraspidosiphon*) *steenstrupii* Diesing
(Fig. 1G, H)

Aspidosiphon (*Aspidosiphon*) *steenstrupii* Cutler, 1994: 225 (for complete synonymy).

Material examined. One specimen (INT-0353), Pulau Semakau (01°11.4'N, 103°46.0'E), sandy bottom with patches of corals, algae & some boulders, coll. Tan Koh Siang et al., 4 November 2013.

Remarks. Morphology of the present species agrees with the description of *A.* (*P.*) *steenstrupii* Diesing, 1859 (Cutler & Cutler, 1989; Cutler, 1994). The species stands out from other members of the subgenus *Paraspidosiphon* in having an anal shield that is lacking in grooves, and in possessing pyramidal hooks (Fig. 1G, H) posterior to the region with bidentate hooks (Cutler & Cutler, 1989; Cutler, 1994). This species has a circumtropical distribution (Cutler, 1994), and it is no surprise to find it in Singapore waters.

DISCUSSION

Even with 16 species reported thus far, the species diversity of sipunculans in Singapore waters is surely underestimated. This geographic region hosts a wide variety of habitats, including extensive mangroves, sand flats, coral reefs, subtidal sand and muddy bottoms, all of which are suitable habitats for sipunculans. Some seven *Sipunculus* and six *Siphonosoma* (family Sipunculidae) species are currently known from tropical Indian and West Pacific Oceans (IWP) (Cutler, 1994), but only two *Sipunculus* and one *Siphonosoma* species have so far been reported from Singapore (Table 1). About 12 species of Golfingiidae, 20 species of Phascolionidae, and six species of Themistidae are known from IWP (Cutler, 1994), but only five species in those three families have so far been found from Singapore (Table 1). Similarly, 17 species of Phascolosomatidae and seven species of Aspidosiphonidae are known to be present in IWP (Cutler, 1994), but only five and three species in the two families respectively have been observed in Singapore (Table 1). Lanchester (1905b) recorded no less than 10 species of sipunculans from Pulau Bidan, a small island lying north of Penang just 1.4 km in length and 600 m wide off the Sungei Merbok estuary in the Malacca Strait. Further field investigations are likely to reveal the existence of additional sipunculan species in and around Singapore.

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