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# Sea Cucumber (Echinodermata: Holothuroidea) Species Richness at Selected Localities in Malaysia

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## ABSTRACT

This study aimed at documenting species richness and distribution of sea cucumbers (Phylum Echinodermata: Class Holothuroidea) in Malaysia. Sea cucumber collections were conducted from August 2004 until November 2011 from several study sites in Peninsular Malaysia and Sabah. A total of fifty two morphospecies of sea cucumbers from four orders comprising of 12 genera were documented. Thirty eight species were recorded for Sabah, followed by 24 species for Peninsular Malaysia, and 10 species were recorded in both regions. However, nine species required further taxonomic works for their identification. Of the 15 *Actinopyga* species recorded, 14 species were from Sabah and one species was from Peninsular Malaysia. The order Aspidochirotida in general, and genus *Holothuria* in particular were the dominant taxa. *Holothuria* (*Mertensiothuria*) *leucospilota* (Brandt, 1835) is the dominant species in Malaysia as it was observed and documented at all collection sites. Future studies on the species richness of sea cucumbers are required in Sarawak marine waters and the molecular phylogeny of the sea cucumbers in order to obtain a better understanding of the evolutionary relationships between the sea cucumbers of Malaysia.

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## INTRODUCTION

Malaysia is one of the 12 mega diverse countries in the world that houses many marine taxa including sea cucumbers (Phylum Echinodermata; Class Holothuroidea). Biogeographically, Malaysia lies within the Oriental Region (Huggett, 1998) but Sabah and Sarawak are situated adjacent to the Wallacea Region, with the former being closer. According to Mohsin and Ambak (1991), southern Thailand, southern Indo-China, Sumatra, Java, Peninsular Malaysia and Borneo were connected by the Sunda Platform during the Pleistocene Epoch. The lowering of sea level forming the Sunda Platform is speculated to have caused the unique biogeographic distribution patterns of flora and fauna, including the sea cucumbers, especially throughout the Malaysian marine waters (Cannon *et al*., 2009).

The sea cucumber is considered as a marine heritage of Malaysia and it is estimated that more than 80 species of sea cucumbers inhabit the marine and coastal waters of Malaysia (Kamarul Rahim *et al*., 2010). Local names for the sea cucumber include *timun laut*, *gamat*, *bat*, *balat*, and *brunok*. The sea cucumber is also referred to as *hoi sum* or *hai shen* by the Malaysian Chinese community, which is translated to sea ginseng due to its healing properties. The local name *gamat* is the accepted name among Malaysians and it is used as reference for all the sea cucumber species within the family Stichopodidae. There are two genera within the Stichopodidae family found to date in Malaysia, i.e. *Stichopus* and *Thelenota*. The *gamat* species includes *Stichopus horrens* (Selenka, 1867) (Dragonfish) and *Thelenota anax* (Clark, 1921) (Amberfish). *Gamat* is well known in the traditional medicine industry, especially in the Langkawi and Pangkor islands. *Stichopus horrens* is the most popular and the most well-studied *gamat* species, where it has been commercially exploited for its body fluid extracts (*air gamat*), lipid extracts (*minyak gamat*) and also for the *gamat*-based dietary supplements or health food products produced via modern technologies. In Sabah, sea cucumbers are exploited for the food industry and contribute to the state's economy.

The diversity and commercial values of Malaysia's sea cucumbers have made the marine animals the focus of various studies to date. Early studies in Malaysia on the presence and distribution of sea cucumbers were conducted by Ridzwan and Che Bashah (1985), George and George (1987), Ridzwan (1987), Kaswandi *et al*. (1990), Ridzwan (1993), Ridzwan and Kaswandi (1995), Ridzwan *et al*. (1995), Kaswandi *et al*. (1995), Ridzwan *et al*. (1996), Ridzwan *et al*. (1998a), and Ridzwan *et al*. (1998b). The above studies were mainly focused in Sabah, while the other studies were carried out in Langkawi Island (Kedah), Balik Pulau (Penang), Pangkor Island (Perak), Tioman Island (Pahang), Besar Island and Aur Island (Johor) in Peninsular Malaysia, as well as in Brunei (Baine & Forbes, 1998; Forbes & Ilias, 1999; Siti *et al*., 1999a; Siti *et al*., 1999b; Zulfigar & Tan, 1999; Zulfigar *et al*., 2000; Lane *et al*., 2000; Zainuddin &

Forbes, 2000; Zaidnuddin, 2002; Kamarul Rahim & Ridzwan, 2005; Zulfigar *et al*., 2007; Zulfigar *et al*., 2008; Sim *et al*., 2008; Sim *et al*., 2009; Kamarul Rahim *et al*., 2009; Kamarul Rahim *et al*., 2010). Among the sea cucumbers that were reported from the previous studies, some were not identified to the species level.

Thus, the aim of this study was to document the sea cucumber species and their distributions in several localities of Peninsular Malaysia and Sabah. Updates on species identification from previous studies including that of Kamarul Rahim *et al*. (2009, 2010) are also reported.

## MATERIALS AND METHODS

### *Study Sites and Collection Method*

Several localities in Peninsular Malaysia and Sabah were selected based on the known distributions of the sea cucumbers (Fig.1). Sea cucumber collection was conducted for approximately seven years, i.e. from August 2004 until November 2011. The researchers sought the assistance of professional divers and employed local residents, and there were no fixed sampling hours allocated. Global Positioning System (GPS) was utilised to record each sampling site (not specifically shown in Fig.1). The

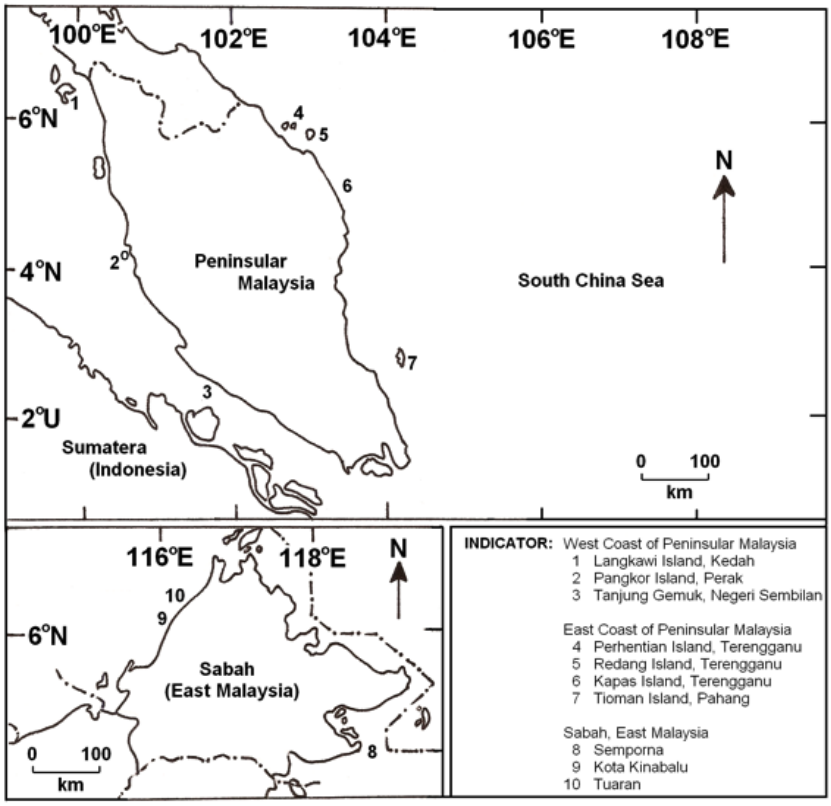


Fig.1: Sea cucumber collection sites in Malaysia (Adapted from Kamarul Rahim *et al*., 2009)

sea cucumber specimens of sea cucumber were observed, collected, photographed, measured and released, or collected after an official permission as reference specimens. The collection of sea cucumbers was conducted during low tide.

*Species Identification*

Sea cucumber species identification was done by referring to the experts [(namely, Assoc. Prof. Alexander M. Kerr from Marine Laboratory, University of Guam, USA) and the participants of NSF PEET Holothuroid Systematics Workshop held on 7-16 June 2010 at the Marine Laboratory, UOG, USA)], Ridzwan (2011), the World Register of Marine Species database at http://www.marinespecies.org/index.php, and also through the information given by local residents. The undetermined species were temporarily designated as local names. Several updates to the undetermined sea cucumber taxa recorded from previous studies were also done. The collected specimens were placed at the laboratories of the Department of Museum Malaysia, Universiti Kebangsaan Malaysia (UKM) Bangi, and at the International Islamic University Malaysia (IIUM), Indera Mahkota Campus in Kuantan.

*Storage and Preservation*

For short-term storage, live and dead specimens of sea cucumbers were kept in ice boxes while in the laboratory, sea cucumber specimens were transferred into -20$^{o}$C or -80$^{o}$C freezers for long-term storage or preserved in 70% ethanol. All the sea cucumber specimens were catalogued accordingly.

## RESULTS AND DISCUSSION

The present study recorded 52 morphospecies of sea cucumbers from 4 orders comprising 12 genera (see Table 1, Fig.2-Fig.53). Of the total number of sea cucumber species collected, 16 species (i.e. 31%) were from the genus *Holothuria*, followed by *Actinopyga* (15 species; 29%), *Stichopus* (8 species; 15%), *Bohadschia* (4 species; 8%) and *Synapta* (2 species; 4%). Meanwhile, the genera *Pearsonothuria*, *Thelenota*, *Molpadia*, *Polycheira*, *Leptosynapta*, *Thyone*, and *Cercodemas* comprised 1 species each. The species richness of *Actinopyga* from the present study was higher than that recorded by Ridzwan (1993), Baine and Forbes (1998), and Forbes and Ilias (1999). *Holothuria (Mertensiothuria) leucospilota* (Brandt, 1835), which is commonly known as *bat puntil or white threads fish* is the most dominant species in Malaysia, as it was observed and documented at all collection sites. Kamarul Rahim *et al*. (2009) also reported that *H. leucospilota* is the most dominant species in Malaysia. It is estimated that there are more than 80 species of sea cucumbers present in the marine and coastal waters of Malaysia (Kamarul Rahim *et al*., 2010).

Thirty eight species of sea cucumbers were collected from Sabah while 24 species were collected from Peninsular Malaysia, with 10 species overlapping [namely, *H. leucospilota*, *Holothuria*

TABLE 1
Presence, richness and distribution of sea cucumbers in Malaysia. PM=Peninsular Malaysia, S=Sabah.

| No. | Species | Local Name | PM | S |
|---|---|---|---|---|
| | Order Aspidochirotida | | | |
| | Family Holothuriidae | | | |
| 1 | *Holothuria (Mertensiothuria) leucospilota* (Brandt, 1835) | *Bat puntil / White threads fish* | x | x |
| 2 | *Holothuria (Mertensiothuria) hilla* Lesson, 1830 | *Bat / Tiger tail sea cucumber* | x | |
| 3 | *Holothuria (Metriatyla) scabra* Jaeger, 1833 | *Bat putih / Sandfish* | | x |
| 4 | *Holothuria (Metriatyla) ocellata* Jaeger, 1833 | *Bat* | x | |
| 5 | *Holothuria (Metriatyla) lessoni* Massin, Uthicke, Purcell, Rowe & Samyn, 2009 | *Bat putan / Golden sandfish* | | x |
| 6 | *Holothuria (Halodeima) atra* Jaeger, 1833 | *Bat hitam / Lollyfish* | x | x |
| 7 | *Holothuria (Halodeima) edulis* Lesson, 1830 | *Bat senjata anjing / Pinkfish* | x | x |
| 8 | *Holothuria (Microthele) nobilis* (Selenka, 1867) | *Bat susu / White teatfish* | | x |
| 9 | *Holothuria (Microthele) fuscopunctata* Jaeger, 1833 | *Bat / Elephant trunkfish* | | x |
| 10 | *Holothuria (Acanthotrapeza) coluber* Semper, 1868 | *Bat sumping / Snakefish* | x | x |
| 11 | *Holothuria (Lessonothuria) pardalis* Selenka, 1867 | *Bat* | x | |
| 12 | *Holothuria (Theelothuria) notabilis* Ludwig, 1875 | *Bat* | x | |
| 13 | *Holothuria (Thymiosycia)* aff. *impatiens* | *Bat* | x | |
| 14 | *Holothuria (Panningothuria) forskali* Delle Chiaje, 1823 | *Bat* | x | |
| 15 | *Holothuria* sp. - 3 | *Bat brown* | | x |
| 16 | *Holothuria* sp. - 6 | *Bat kasut* | | x |
| 17 | *Bohadschia argus* (Jaeger, 1833) | *Bat / Leopardfish / Tigerfish* | | x |
| 18 | *Bohadschia vitiensis* (Semper, 1868) | *Bat nangka / Brown sandfish / Bat sawa* | x | x |
| 19 | *Bohadschia* sp. - 1 | *Bat* | x | |
| 20 | *Bohadschia* sp. - 2 | *Bat* | x | |
| 21 | *Actinopyga lecanora* (Jaeger, 1833) - 1 | *Bat puyuh / Stonefish* | | x |
| 22 | *Actinopyga lecanora* (Jaeger, 1833) - 2 | *Bat puyuh / Stonefish* | | x |
| 23 | *Actinopyga lecanora* (Jaeger, 1833) - 3 | *Bat puyuh / Stonefish* | | x |
| 24 | *Actinopyga lecanora* (Jaeger, 1833) - 4 | *Bat puyuh / Stonefish* | | x |
| 25 | *Actinopyga lecanora* (Jaeger, 1833) - 5 | *Bat puyuh / Stonefish* | | x |
| 26 | *Actinopyga lecanora* (Jaeger, 1833) - 6 | *Bat puyuh / Stonefish* | | x |
| 27 | *Actinopyga lecanora* (Jaeger, 1833) - 7 | *Bat puyuh / Stonefish* | | x |
| 28 | *Actinopyga lecanora* (Jaeger, 1833) - 8 | *Bat puyuh / Stonefish* | | x |
| 29 | *Actinopyga lecanora* (Jaeger, 1833) - 9 | *Bat puyuh / Stonefish* | | x |
| 30 | *Actinopyga lecanora* (Jaeger, 1833) - 10 | *Bat puyuh / Stonefish* | | x |
| 31 | *Actinopyga lecanora* (Jaeger, 1833) - 11 | *Bat puyuh / Stonefish* | | x |
| 32 | *Actinopyga lecanora* (Jaeger, 1833) - 12 | *Bat puyuh / Stonefish* | | x |
| 33 | *Actinopyga lecanora* (Jaeger, 1833) - 13 | Bat puyuh / Stonefish | | x |
| 34 | *Actinopyga lecanora* (Jaeger, 1833) - 14 | Bat puyuh / Stonefish | | x |

TABLE 1 (*continue*)

| No. | Species | Local Name | PM | S |
|---|---|---|---|---|
| | Order Aspidochirotida | | | |
| | Family Holothuriidae | | | |
| 35 | *Actinopyga lecanora* (Jaeger, 1833) - 15 | *Bat puyuh / Stonefish* | x | |
| 36 | *Pearsonothuria graeffei* (Semper, 1868) | *Bat / Flowerfish / Blackspotted sea cucumber* | | x |
| | Family Stichopodidae | | | |
| 37 | *Stichopus rubermaculosus* Massin, Zulfigar, Hwai & Boss, 2002 | *Gamat* | | x |
| 38 | *Stichopus chloronotus* Brandt, 1835 | *Talifan varieti hitam / Greenfish* | x | x |
| 39 | *Stichopus horrens* Selenka, 1867 | *Gamat / Dragonfish* | x | x |
| 40 | *Stichopus ocellatus* Massin, Zulfigar, Hwai & Boss, 2002 | *Gamat* | x | x |
| 41 | *Stichopus herrmanni* Semper, 1868 | *Gamat / Curryfish* | x | |
| 42 | *Stichopus vastus* Sluiter, 1887 | *Gamat batu / Gamat kiulu* | x | x |
| 43 | *Stichopus* sp. - 1 | *Kumbatas* | | x |
| 44 | *Stichopus* sp. - 2 | *Kambatan* | | x |
| 45 | *Thelenota anax* H.L. Clark, 1921 | *Bat / Amberfish* | | x |
| | Order Molpadiida | | | |
| 46 | *Acaudina molpadioides* (Semper, 1867) | *Bat hati / Beronok /Brunok* | x | x |
| | Order Apodida | | | |
| 47 | *Synapta maculata* (Chamisso & Eysenhardt, 1821) | *Taliaga* | | x |
| 48 | *Synapta* sp. - 1 | *Taliaga* | | x |
| 49 | *Polycheira rufescens* (Brandt, 1835) | *Bat* | x | |
| 50 | *Leptosynapta* sp. - 1 | *Bat* | x | |
| | Order Dendrochirotida | | | |
| 51 | *Thyone* sp. - 1 | *Bat* | x | |
| 52 | *Cercodemas anceps* (Selenka, 1867) | *Bat* | x | |

*(Halodeima) atra* (Jaeger, 1833); *Holothuria (Halodeima) edulis* (Lesson, 1830); *Holothuria (Acanthotrapeza) coluber* (Semper, 1868); *Bohadschia vitiensis* (Semper, 1868); *Stichopus chloronotus* (Brandt, 1835); *S. horrens*; *Stichopus ocellatus* (Massin, Zulfigar, Hwai & Boss, 2002); *Stichopus vastus* (Sluiter, 1887), and *Acaudina molpadioides* (Semper, 1867)]. There were two undetermined species of *Holothuria*, *Bohadschia* and *Stichopus*, while one species was undetermined from *Synapta*, *Leptosynapta* and *Thyone* (Table 1). Interestingly, 14 out of the 15 *Actinopyga* species recorded were from Sabah, while only one was recorded from Redang Island (east coast of Peninsular Malaysia). Nine species required further species identification (based on ossicle characters, behaviour and molecular phylogeny).

**Order Aspidochirotida** (45 species)

**Family Holothuriidae** (36 species)

**Genus *Holothuria*** (16 species – Fig.2 through Fig.17)

Fig.2: *Holothuria (Mertensiothuria) leucospilota* (Brandt, 1835) (Photo source: Kamarul Rahim Kamarudin)

Fig.3: *Holothuria (Mertensiothuria) hilla* Lesson, 1830 (Photo source: Kamarul Rahim Kamarudin)

Fig.4: *Holothuria (Metriatyla) scabra* (Jaeger, 1833). Left photo = dorsal view, right photo = ventral-dorsal view (Photo source: Ridzwan Hashim)

Fig.5: *Holothuria (Metriatyla) ocellata* (Jaeger, 1833). Left photo = dorsal view, right photo = ventral view (Photo source: Department of Museums Malaysia)

Fig.6: *Holothuria (Metriatyla) lessoni* (Massin, Uthicke, Purcell, Rowe & Samyn, 2009). Left photo = dorsal view, right photo = ventral view (Photo source: Ridzwan Hashim)

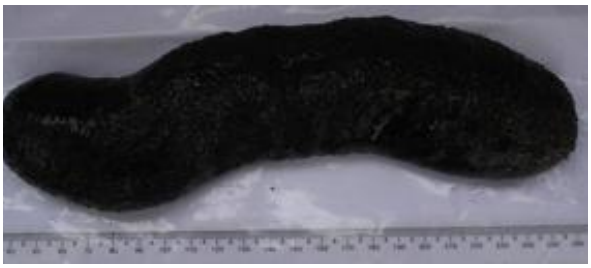

Fig.7: *Holothuria (Halodeima) atra* (Jaeger, 1833) (Photo source: Kamarul Rahim Kamarudin)

Fig.8: *Holothuria (Halodeima) edulis* (Lesson, 1830). Left photo = dorsal view, right photo = ventral view (Photo source: Department of Museums Malaysia)

Fig.9: *Holothuria (Microthele) nobilis* (Selenka, 1867). Left photo = dorsal view, right photo = ventral view (Photo source: Ridzwan Hashim)

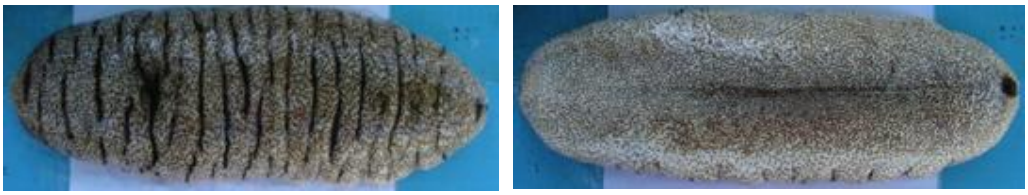

Fig.10: *Holothuria (Microthele) fuscopunctata* (Jaeger, 1833). Left photo = dorsal view, right photo = ventral view (Photo source: Ridzwan Hashim)

Fig.11: *Holothuria (Acanthotrapeza) coluber* (Semper, 1868) (Photo source: Ridzwan Hashim)

Fig.12: *Holothuria (Lessonothuria) pardalis* (Selenka, 1867) (Photo source: Kamarul Rahim Kamarudin)


Fig.13: *Holothuria (Theelothuria) notabilis* Ludwig, 1875. Left photo = dorsal view, right photo = ventral view. Photo source: Department of Museums Malaysia

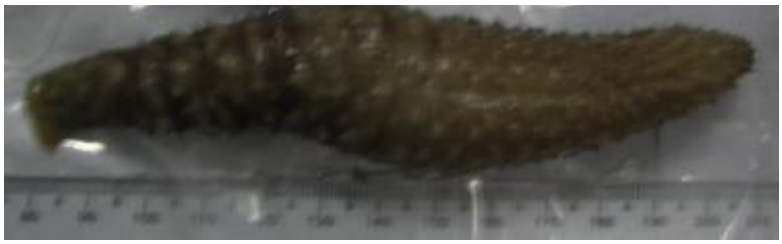

Fig.14: *Holothuria (Thymiosycia)* aff. *impatiens* (Photo source: Kamarul Rahim Kamarudin)

Fig.15: *Holothuria (Panningothuria) forskali* (Delle Chiaje, 1823)
(Photo source: Kamarul Rahim Kamarudin)

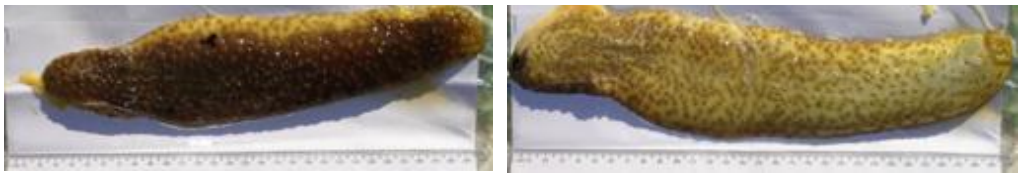

Fig.16: *Holothuria* sp. – 3; Left = dorsal view, right = ventral view (Photo source: Ridzwan Hashim)

Fig.17: *Holothuria* sp. – 6; Left = dorsal view, right = ventral view (Photo source: Ridzwan Hashim)

The undetermined species in Peninsular Malaysia were from the genera *Bohadschia* (2 taxa), *Leptosynapta* (1 taxon) and *Thyone* (1 taxon), while the undetermined species in Sabah were from the genera *Holothuria* (2 taxa), *Stichopus* (2 taxa) and *Synapta* (1 taxon). The higher species richness and distribution of the sea cucumbers in Sabah as compared to Peninsular Malaysia were probably related to its proximity

to the Wallace's line and better marine water quality. Further studies, however, are required especially to determine the phylogenetic relationships of the Peninsular Malaysia's species and the Borneo species so as to further understand their distribution and adaptive radiation.

According to Ho (1992), the coral reef in Sabah within the Sulawesi Sea that includes the Bodgaya and Ligitan group of islands is well developed and provides suitable habitats for the sea cucumbers. The abundant organic matters in the coral reef areas in the tropical region (for example, seagrass detritus, coral mucus and algal remnants) are food for sea cucumbers and coupled with the multitude habitats, provide rich feeding areas for the soft-bodied marine-living echinoderms (Ridzwan, 1993). The above two factors may have contributed to the diverse species of sea cucumbers in the marine waters of Semporna, Maiga Island (part of Bodgaya group) and Mabul Island (part of Ligitan group). Approximately 139 tonnes of sea cucumbers were landed in Sabah (Annual Fisheries Statistics, Sabah, 2000–2005), as estimated by the Sabah Fisheries Department. This places the state as the most significant for sea cucumber fisheries in Malaysia. A wide variety of species are targeted mainly for the food industry of beche-de-mer in Sabah such as *Holothuria (Metriatyla) scabra* (Jaeger, 1833), *Holothuria (Halodeima) atra* (Jaeger, 1833), *Holothuria (Halodeima) edulis* (Lesson, 1830), *H. leucospilota*, *Stichopus herrmanni* (Semper, 1868), *Stichopus chloronotus* (Brandt, 1835), and *Thelenota ananas* (Jaeger, 1833) (Choo, 2008). Sound management practices of the marine parks in Sabah (for example, the Tunku Abdul Rahman Park, Kota Kinabalu) may have contributed to the higher species richness in Sabah (Kamarul Rahim *et al*., 2009). Besides that, recreational and reserve zones are being implemented in the marine waters of Manukan Island, Sabah, in the effort to retain the sea cucumber gene pool while developing eco-tourism in the state.

There is paucity of literature on the sea cucumbers of Sarawak. Ridzwan (1993) mentioned the use of *brunok* (Order: Molpadiida) as fishing bait among Sarawak residents. *Brunok* or *Beronok* is also known as *bat hati* in Sabah (Table 1). Ho (1992) stated that the growth of coral reefs surrounding Talang-Talang Besar, Talang-Talang Kechil, Sampadi, Satang Besar and Satang Kechil Islands in the marine waters of Sarawak is limited due to high turbidity and influx of freshwater from inland rivers. The condition has worsened due to tourism activities and also the close proximity of the islands to the mainland. These factors may have brought about the low species diversity of not only sea cucumbers but also other marine organisms in the Sarawak marine waters. Meanwhile, 14 morphospecies of sea cucumbers are known from Brunei Darussalam marine waters (Lane, 2005) and the species richness may be similar to those of Sarawak. *Holothuria atra*, *H. edulis*, and four species from the genus *Bohadschia* are among the sea cucumbers present in the marine waters of Brunei Darussalam. Lane (2005) stated that two of the four

*Bohadschia* species collected were possibly new species. Unlike Sabah, sea cucumbers in Brunei Darussalam have not been fully explored and are relatively unexploited (Lane, 2004).

Direct exploitation, introduced species, extinction cascades, habitat loss and degradation are among the factors responsible for species decline and extinction (Gaston & Spicer, 2004). In relation to these, the regular import of sea cucumbers from Adang, Thailand, during the 1990s (Baine and Sze, 1998) could possibly indicate the decreasing stocks of sea cucumbers in the marine waters of Peninsular Malaysia. Ho (1992) stated that the patchy distributions of coral reefs as habitat and food, as well as high water turbidity along the west coast of Peninsular Malaysia are the possible factors affecting species richness of the sea cucumbers. Forbes and Ilias (1999) reported that *S. horrens* was rare in Langkawi, which is one of the main traditional fishery sites in the West Coast of Peninsular Malaysia, beside Pangkor Island, thus supporting the possibility of stock decline of local sea cucumbers, more so the *gamat* species. *Gamat* has become popular as the main ingredient in the traditional medicine industry, as well as in the health food industry in Malaysia. *Stichopus horrens* (the golden *gamat*) has been exploited for its body fluid extracts (*air gamat*) and lipid extracts (*minyak gamat*). Baine and Sze (1998) suggested a three-pronged approach to help maintain sea cucumber stocks for trade in Langkawi: through sea cucumber restocking initiatives, imports from Thailand in a trade agreement and from Pangkor Island, as part of a managed fishery.

The present study recorded nine species of *gamat* comprising eight *Stichopus* species and one *Thelenota* species (Table 1) [*Stichopus rubermaculosus* (Massin, Zulfigar, Hwai & Boss, 2002) (see Fig.38), *Stichopus chloronotus* (Brandt, 1835) (see Fig.39), *S. horrens* (Fig.40), *Stichopus ocellatus* (Massin, Zulfigar, Hwai & Boss, 2002) (see Fig.41), *Stichopus herrmanni* (Semper, 1868) (see Fig.42), *Stichopus vastus* (Sluiter, 1887) (see Fig.43), *Stichopus* sp. - 1 (see Fig.44), *Stichopus* sp. - 2 (see Fig.45) and *Thelenota anax* (Clark, 1921) (see Fig.46). Two unidentified specimens, labelled as *Stichopus* sp. 1 and *Stichopus* sp. 2, were collected in Sabah. *Thelenota ananas* (Jaeger, 1833) was listed as one of Malaysia's commercial species (Choo, 2008), increasing the total number of Malaysia's *gamat* species to date to 10 taxa. Sabah shows higher species richness of the *gamat* species as compared to Peninsular Malaysia. Four species (namely, *S. chloronotus*, *S. horrens*, *S. ocellatus*, and *S. vastus*) were recorded in both Peninsular Malaysia and Sabah (Table 1), suggesting a low species overlap.

Fifty two species of Asia's sea cucumbers are commercially exploited as food, with most being tropical and sub-tropical species from the Holothuriidae and Stichopodidae (Choo, 2008). This suggests high species richness of sea cucumbers in the marine waters of the Asian region benefitting countries in terms of their economy. Indonesia is the world's

top producer of Holothuroidea from its capture fishery with 35 commercial species, followed by China (27), the Philippines (26), Malaysia (19), Japan and Vietnam (11 each) and Thailand (8). No commercial species were recorded for Singapore and Brunei Darussalam (Choo, 2008); thus, supporting the findings of Lane (2004) with regards to non-exploitation of sea cucumbers in Brunei Darussalam. Malaysia, Thailand, Indonesia, the Philippines, and Vietnam have five species of sea cucumbers exploited as food; these are *Holothuria (Metriatyla) scabra* (Jaeger, 1833), *H. atra*, *H. edulis*, *H. leucospilota*, *Stichopus herrmanni* (Semper, 1868), *Stichopus chloronotus* (Brandt, 1835) and *Thelenota ananas* (Jaeger, 1833). Therefore, continuous studies on the sea cucumbers in Malaysia, with reference to their species presence and richness, distribution and stock assessment, are important for their sustainability, not only for the gene pool but also as food and medicinal resources.

**Genus *Bohadschia*** (4 species – see Fig.18 to Fig.21)

Fig.18: *Bohadschia argus* (Jaeger, 1833); Left = dorsal view, right = ventral view (Photo source: Ridzwan Hashim).

Fig.19: *Bohadschia vitiensis* (Semper, 1868); Left = dorsal view, right = ventral view (Photo source: Ridzwan Hashim)


Fig.20: *Bohadschia* sp. – 1; Left = dorsal view, right = ventral view (Photo source: Department of Museums Malaysia)

Fig.21: *Bohadschia* sp. – 2; Left = dorsal view, right = ventral view
(Photo source: Kamarul Rahim Kamarudin)

**Genus *Actinopyga*** (15 species – Fig.22 to Fig.36)

Fig.22: *Actinopyga lecanora* (Jaeger, 1833) – 1; Left = dorsal view, right = ventral view
(Photo source: Ridzwan Hashim)

Fig.23: *Actinopyga lecanora* (Jaeger, 1833) – 2; Left = dorsal view, right = ventral view
(Photo source: Ridzwan Hashim)

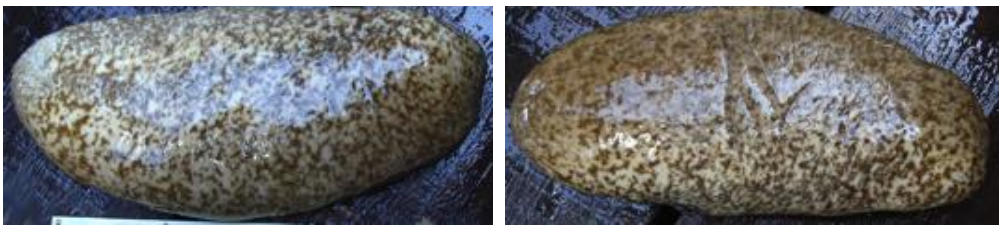

Fig.24: *Actinopyga lecanora* (Jaeger, 1833) – 3; Left = dorsal view, right = ventral-dorsal view
(Photo source: Ridzwan Hashim)

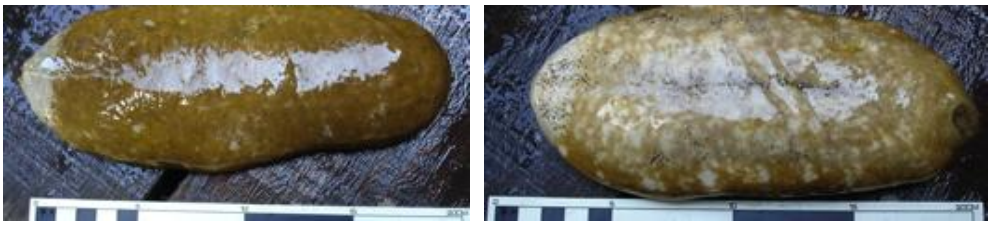

Fig.25: *Actinopyga lecanora* (Jaeger, 1833) – 4; Left = dorsal view, right = ventral view (Photo source: Ridzwan Hashim)

Fig.26: *Actinopyga lecanora* (Jaeger, 1833) – 5; Left = dorsal view, right = ventral view (Photo source: Ridzwan Hashim)

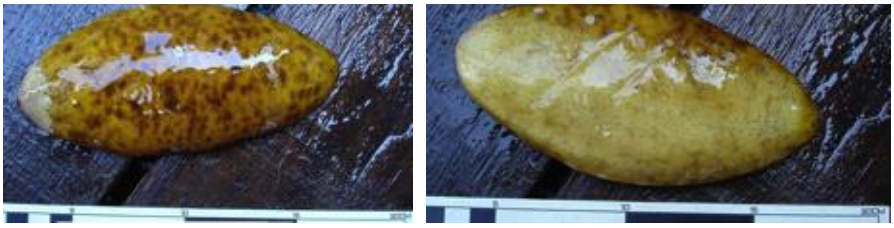

Fig.27: *Actinopyga lecanora* (Jaeger, 1833) – 6; Left = dorsal view, right = ventral view (Photo source: Ridzwan Hashim)

Fig.28: *Actinopyga lecanora* (Jaeger, 1833) – 7; Left = dorsal view, right = ventral-dorsal view (Photo source: Ridzwan Hashim)

Fig.29: *Actinopyga lecanora* (Jaeger, 1833) – 8; Left = dorsal view, right = ventral view
(Photo source: Ridzwan Hashim)

Fig.30: *Actinopyga lecanora* (Jaeger, 1833) – 9; Left = dorsal view, right = ventral view
(Photo source: Ridzwan Hashim)

Fig.31: *Actinopyga lecanora* (Jaeger, 1833) – 10; Left = dorsal view, right = ventral view
(Photo source: Ridzwan Hashim)

Fig.32: *Actinopyga lecanora* (Jaeger, 1833) – 11; Left = dorsal view, right = ventral view
(Photo source: Ridzwan Hashim)

Fig.33: *Actinopyga lecanora* (Jaeger, 1833) – 12; Left = dorsal view, right = ventral view
(Photo source: Ridzwan Hashim)

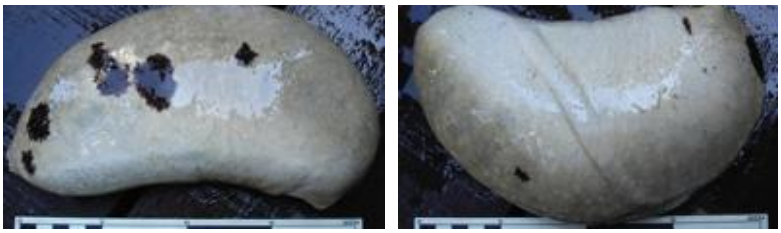

Fig.34: *Actinopyga lecanora* (Jaeger, 1833) – 13; Left = dorsal view, right = ventral-dorsal view
(Photo source: Ridzwan Hashim)

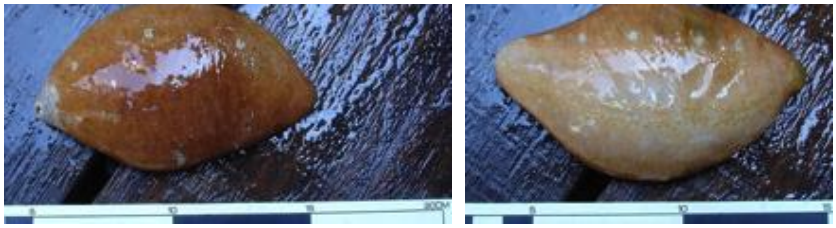

Fig.35: *Actinopyga lecanora* (Jaeger, 1833) – 14; Left = dorsal view, right = ventral view
(Photo source: Ridzwan Hashim)

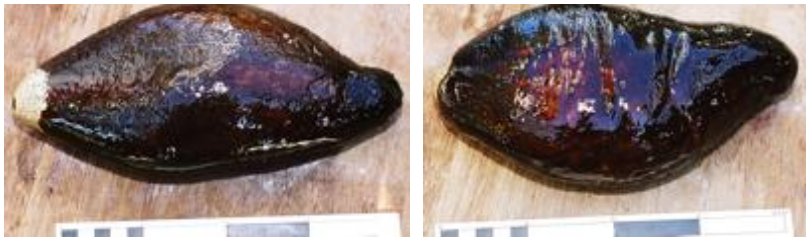

Fig.36: *Actinopyga lecanora* (Jaeger, 1833) – 15; Left = dorsal view, right = ventral view
(Photo source: Ridzwan Hashim)

**Genus *Pearsonothuria*** – 1 species

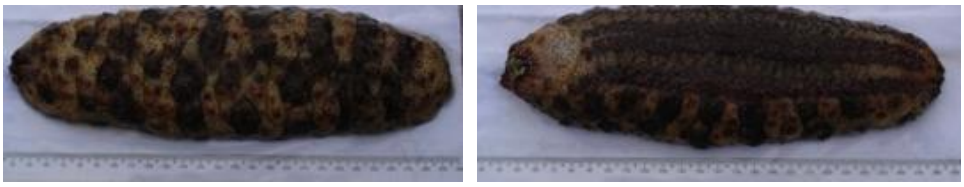

Fig.37: *Pearsonothuria graeffei* (Semper, 1868); Left = dorsal view, right = ventral view (Photo source: Ridzwan Hashim)

**Family Stichopodidae** (9 species)

**Genus *Stichopus*** – 8 species – Fig.38 until Fig.45


Fig.38: *Stichopus rubermaculosus* **(**Massin, Zulfigar, Hwai, & Boss, 2002); Left = dorsal view, right = ventral view (Photo source: Ridzwan Hashim)

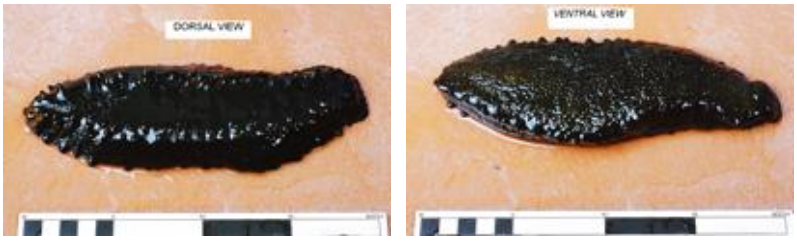


Fig.39: *Stichopus chloronotus* (Brandt, 1835); Left = dorsal view, right = ventral view (Photo source: Department of Museum, Malaysia)

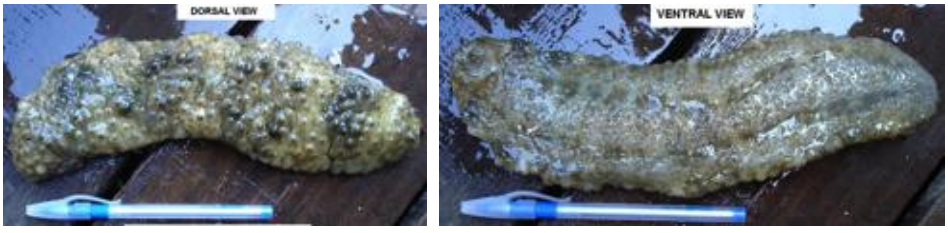


Fig.40: *Stichopus horrens* (Selenka, 1867); Left = dorsal view, right = ventral view (Photo source: Ridzwan Hashim)


Fig.41: *Stichopus ocellatus* (Massin, Zulfigar, Hwai, & Boss, 2002); Left = dorsal view, right = ventral view (Photo source: Ridzwan Hashim)

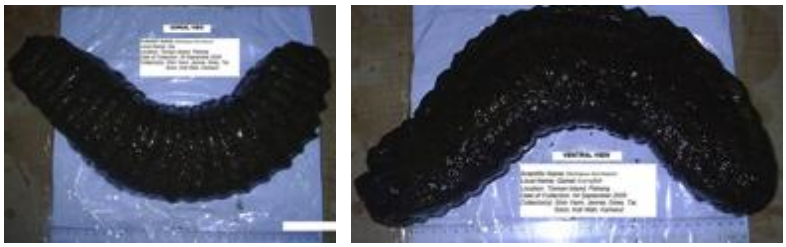

Fig.42: *Stichopus herrmanni* (Semper, 1868); Left = dorsal view, right = ventral view (Photo source: Kamarul Rahim Kamarudin)

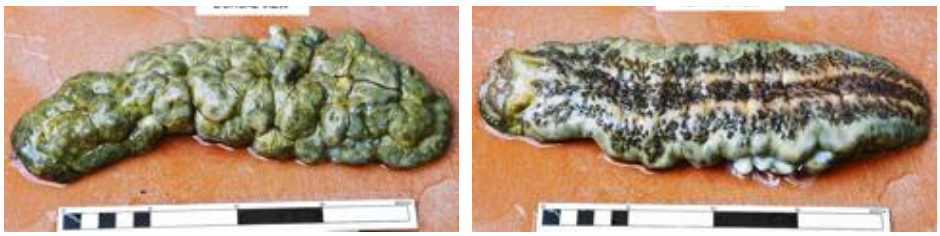

Fig.43: *Stichopus vastus* (Sluiter, 1887); Left = dorsal view, right = ventral view (Photo source: Department of Museum, Malaysia)


Fig.44: *Stichopus* sp. – 1; Left = dorsal view, right = ventral view (Photo source: Ridzwan Hashim)

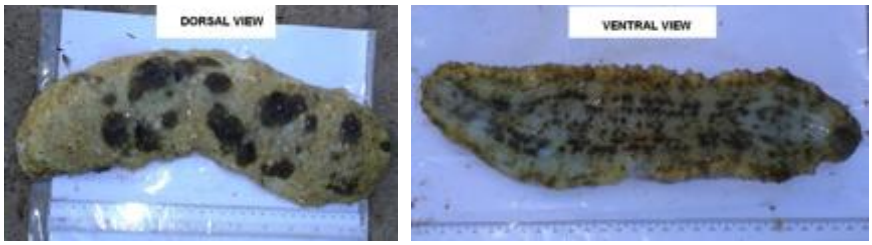


Fig.45: *Stichopus* sp. – 2; Left = dorsal view, right = ventral view (Photo source: Ridzwan Hashim)

**Genus *Thelenota*** – 1 species


Fig.46: *Thelenota anax* (Clark, 1921); Left = dorsal view, right = ventral view (Photo source: Ridzwan Hashim)

**Order Molpadiida** (1 species)

**Genus *Acaudina*** - 1 species


Fig.47: *Acaudina molpadioides* (Semper, 1867) (Photo source: Department of Museum, Malaysia)

**Order Apodida** (4 species)

**Genus *Synapta*** – 2 species


Fig.48: *Synapta maculata* (Chamisso & Eysenhardt, 1821) (Photo source: Ridzwan Hashim)

Fig.49: *Synapta* sp. - 1 (Photo source: Ridzwan Hashim)

**Genus *Polycheira*** – 1 species

Fig.50: *Polycheira rufescens* (Brandt, 1835) (Photo source: Kamarul Rahim Kamarudin)

**Genus *Leptosynapta*** – 1 species

Fig.51: *Leptosynapta* sp. – 1 (Photo source: Kamarul Rahim Kamarudin)

**Order Dendrochirotida (2 species)**

**Genus *Thyone*** – 1 species


Fig.52: *Thyone* sp. - 1 (Photo source: Department of Museum, Malaysia)

**Genus *Cercodemas*** – 1 species


Fig.53: *Cercodemas anceps* (Selenka, 1867); Left = dorsal view, right = ventral view (Photo source: Department of Museum, Malaysia)

## CONCLUSION

Fifty two morphospecies of sea cucumbers were recorded from the present study. Four orders comprising 12 genera with 38 species were found in Sabah, 24 species in Peninsular Malaysia and 10 species that were overlaps were recorded. With regard to the *Actinopyga* genus, 14 species were found to be from Sabah and one species from Peninsular Malaysia. Further species identification was required for the nine species. High species richness was recorded from the order Aspidochirotida and within the genus *Holothuria Holothuria* (*Mertensiothuria*) *leucospilota* (Brandt, 1835), locally known as *bat puntil*, which is suggested as the most dominant species in Malaysia. Sabah showed higher diversity of sea cucumbers as compared to Peninsular Malaysia. More study sites including from Sarawak and molecular phylogeny may lead to a better understanding of the distribution of sea cucumbers in Malaysia.

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