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Coral Reef Sea Cucumbers in Malaysia

Kamarul Rahim Kamarudin[1*], Aisyah Mohamed Rehan[1], Ahmad Lutfi Lukman[1], Hajar Fauzan Ahmad[1], Mohd Hanafi Anua[1], Noor Faizul Hadry Nordin[1], Ridzwan Hashim[1], Rosnah Hussin[1], and Gires Usup[2]

[1]Sea Cucumber (Echinodermata: Holothuroidea) Research Group, Institute of Oceanography & Maritime Studies (INOCEM), Kulliyyah of Science, International Islamic University Malaysia, Jalan Istana, Bandar Indera Mahkota, 25200 Kuantan, Pahang Darul Makmur, Malaysia.
[2]Marine Microbiology & Biotechnology Research Group, Programme of Marine Science, School of Environmental & Natural Resource Sciences, Faculty of Science & Technology, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor Darul Ehsan, Malaysia.
*School of Biological Sciences, The University of Auckland, Private Bag 92019, Auckland 1142, New Zealand. *physique481@yahoo.co.uk **(***Corresponding author)*
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ABSTRACT This study aims to document species presence and distribution of sea cucumbers (Echinodermata: Holothuroidea) in Malaysia. Several coral reef habitats in Peninsular Malaysia, West Malaysia and Sabah, East Malaysia were selected as study sites. In summary, the present data showed the presence of 50 species of sea cucumbers from three orders and seven genera, with 34 species require further species identification. It was found that Order Aspidochirotida in general and genus *Holothuria* in particular were the major species classes. The most dominant species in Malaysia was *Holothuria leucospilota*. As many as 37 species were found in Sabah, 21 species were recorded in Peninsular Malaysia and 10 species were present in both regions. Of 15 *Actinopyga* species, 14 species recorded were from Sabah. These findings may be due to the extensive distribution of coral reefs and low level of marine pollution. However, the possibility of biogeography factors within and out of the Sunda Platform area cannot be ruled out. In contrast, low level of species diversity was observed in few study sites in Peninsular Malaysia especially in Langkawi Island possibly due to anthropogenic threats. Future studies including more study sites and molecular phylogeny are to be incorporated in order to obtain better view on the presence and distribution of sea cucumbers in Malaysia.

ABSTRAK Kajian ini bertujuan untuk mendokumentasi kewujudan dan taburan spesis timun laut (Ekinodermata: Holothuroidea) di Malaysia. Beberapa habitat batu karang di Semenanjung Malaysia, Malaysia Barat dan Sabah, Malaysia Timur telah dipilih sebagai kawasan kajian. Sebagai rumusan, data terkini menunjukkan kehadiran 50 spesis timun laut dari tiga order dan tujuh genus di seluruh Malaysia, di mana 34 spesis memerlukan pengesahan lanjut. Order Aspidokirotida amnya dan genus *Holothuria* khususnya menunjukkan kehadiran spesis yang tertinggi. *Holothuria leucospilota* secara bandingannya adalah spesis paling dominan di Malaysia. Sebanyak 37 spesis telah dijumpai di Sabah, 21 spesis direkodkan di Semenanjung Malaysia dan 10 spesis ditemui di kedua-dua kawasan tersebut. Daripada 15 spesis *Actinopyga* yang direkodkan, 14 spesis adalah dari Sabah. Penemuan ini mungkin disebabkan taburan batu karang yang luas dan tahap pencemaran laut yang rendah. Walau bagaimanapun, kebarangkalian faktor-faktor biogeografi di dalam atau di luar Pentas Sunda perlu diambilkira. Sebaliknya, kepelbagaian spesis di beberapa kawasan di Semenanjung Malaysia didapati rendah terutamanya di Pulau Langkawi kemungkinan disebabkan oleh ancaman manusia. Kajian lanjut melibatkan lebih banyak kawasan kajian dan filogeni molekul akan dijalankan pada masa hadapan untuk mendapatkan gambaran lebih jelas mengenai kehadiran dan taburan timun laut di Malaysia.

Keywords: Sea cucumber, species presence, distribution, Peninsular Malaysia, Sabah.

INTRODUCTION

Sea cucumber belongs to the phylum Echinodermata. This soft-bodied marine-dwelling echinoderm from the class Holothuroidea is unique due to the existence of evolved skeleton (i.e. ossicles or spicules) and ancient-looked respiratory system called respiratory tree possessed by few species. According to [1], the earliest fossil evidence of sea cucumbers dates from the late Silurian period, approximately 400 million years ago. Until recently, there are six valid orders of class Holothuroidea all around the world namely Apodida, Aspidochirotida, Elasipodida, Molpadiida, Dendrochirotida and Dactylochirotida, with approximately 1,430 species distributed among the orders [2]. The identification of ossicle shape has been one of the main priorities in classification of sea cucumbers into smaller groups. Closely related species are more likely to have very similar ossicles if they have recently evolved from a common ancestor [1].

In Malaysia, sea cucumbers from genera other than *Stichopus* e.g. *Holothuria*, *Actinopyga*, *Pearsonothuria*, *Bohadschia*, *Thelenota* and order Molpadiida are commonly known as *bat*, *balat* and *timun laut*. *Stichopus* species, frequently used as the main ingredients in traditional medicine (i.e. *gamat* oil and *gamat* water) especially in Peninsular Malaysia, are locally known as *gamat*. The same commercial name is used by Sabah and Sarawak residents. In Sabah, sea cucumbers inclusive of *gamat* are commercially marketed as food, and there are minor uses as fishing poison (e.g. holothurins from *Holothuria atra*) and in traditional medication.

Few studies related to sea cucumbers (Echinodermata: Holothuroidea) in Malaysia were reported and published until the year 2005. The studies were conducted on several coral reef habitats of Peninsular Malaysia and Sabah, East Malaysia. Most studies were done using morphological characteristics as the main approach for species identification. Among the morphological characteristics are body shape, body colour, the existence and shape of papillae on both dorsal and ventral parts of sea cucumbers. Only one study on molecular phylogeny of indigenous sea cucumbers was carried out by [3] using Randomly Amplified Polymorphisms of DNA (RAPD) markers in order to examine the genetic diversity between and among sea cucumber species from different localities in Malaysia. Among the early studies in Malaysia on the species presence and distribution of sea cucumbers based on morphology are by [4] and later on by [5] whereby the focus region was coral reef habitats in Sabah, East Malaysia.

Surprisingly, there was no complete report on the species presence and distribution of sea cucumbers in Sarawak. However, [5] mentioned about the use of *brunok*, a local name for a *Molpadia* species from order Molpadiida as fishing bait. Such statement indirectly showed the common use of the local sea cucumbers in Sarawak as one of the best alternative baits in fishing activities. [6] reported that Brunei Darussalam, the adjacent country to Sarawak and Sabah, had shown a wide diversity of sea cucumbers on the coral reef habitats, whereby 14 morphospecies were observed. Among the species documented were *Holothuria atra*, *Holothuria edulis* and few species from genus *Bohadschia* by which the species were found among the coral reef habitats. The findings are also in congruence with previous studies indicating that this unique echinoderm can be found easily within the region of shallow-water coral reefs [5]. [6] also mentioned that two out of the four *Bohadschia* species in Brunei Darussalam were suspected new to science. Even if there was no complete species documentation of sea cucumbers in Sarawak, the documentation in Brunei Darussalam especially by [6] and [7] could give high possibility of the same or greater diversity of sea cucumbers on coral reef habitats in Sarawak. In contrast, sea cucumbers are well known among Sabah residents and the food processing industry of sea cucumbers such as beche-de-mer, *trepang* or dry tunics has become one of the main contributions to the economy of Sabah.

Previously, [4] found that *Colochirus robustus* (the synonym of *Colochirus luteus*) was likely to be a common species around the Bodgaya Islands in Sabah, East Malaysia. [5] Subsequently identified 23 species of sea cucumbers on Sabah coral reef habitats. Out of that, eight species have local names but without clear scientific names, whereby approximately 62.5% (i.e. five species) was represented by genus *Holothuria*. *Stichopus*, *Actinopyga* and *Molpadia* from order Molpadiida

shared the same percentage of 12.5% (i.e. one species each). The above studies were done on Sabah coral reef habitats. Besides, [8] reported the existence of 23 species of sea cucumbers observed at few locations in Peninsular Malaysia with six undetermined species yet to be identified. Furthermore, [9] described 37 species of sea cucumbers from Peninsular Malaysia and Sabah with six species requires further species identification. In Pulau Besar, Johor Darul Takzim [10] observed three genera and seven species of sea cucumbers with four species from the genus *Stichopus* yet to be identified, and *Stichopus* was considered as the most dominant genus. [11] Subsequently published the documentation of nine species of order Dendrochirotida from the North West Coast of Borneo and Peninsular Malaysia.

The species validation of *Stichopus hermanni* to *Stichopus horrens* was highlighted by Zulfigar at.el [12] mentioning that the specimen that was thought to be *Stichopus variegatus* for long time in Malaysia is actually *Stichopus horrens*, based on its colour variation and body wall patterns. *Stichopus variegatus* was the old name for *Stichopus hermanni*. Apart from that, further efforts had been carried out to verify and validate the taxonomic status of sea cucumbers in Malaysia, e.g. an effort taken by Massin at.el [13] in describing two new species from genus *Stichopus* found at the Johor Marine Park, Johor Darul Takzim, Malaysia - *S. ocellatus n. sp.* and *S. rubermaculosus n. sp.* Moreover, a report on the species presence and distribution of sea cucumbers in Malaysia by Kamarul and Ridzwan [14] had indicated that a large number of undetermined species of sea cucumbers (i.e. 19 undetermined species out of total 39 species recorded) were present in Sabah. They also found that southern part of Sabah, i.e. Semporna showed the highest diversity of sea cucumbers, and they speculated that the proximity of Sabah to the Wallace's Line may be one of the factors contributing to the high diversity. The above studies indirectly suggested and revealed the unclear and problematic taxonomic status of sea cucumbers particularly in Malaysia, based on the documentation of a large number of undetermined species. In views of environmental concern, the sudden appearance of a large number of *brunok* from order Molpadiida along few main beach areas in Port Dickson, Negeri Sembilan including Tanjung Gemuk beach on 5th April 2005 about three months after the big tsunami incident on 26th December 2004 has opened the eyes of Malaysians about the possible environmental threatens to indigenous sea cucumbers. However, until now there is still no strong experimental test explaining the real causes of such phenomenon.

Accordingly, the general objective of this study is to document species presence and distribution of sea cucumbers on several coral reef habitats of Malaysia, covering Peninsular Malaysia, West Malaysia and Sabah, East Malaysia. Findings from previous studies on sea cucumbers in Malaysia were used as comparison to the outcomes from this study. Topics on the species presence, distribution and issues related to the ecology and economic aspects were correlated and discussed. The outputs from this present study are foreseen to be main guideline in future research in Malaysia, especially for studies involving molecular techniques as additional approaches.

MATERIALS AND METHODS

Study Sites

Sea cucumbers from several coral reef habitats in Peninsular Malaysia, West Malaysia and Sabah, East Malaysia (Figure 1) were observed, photographed and sometimes collected with official permission. The samplings took place for approximately 3 years, from August 2004 until October 2007. The study sites were on intertidal zone, and most documentation was done during the low tide. No fixed or standard sampling hours were allocated for all sites. Within Peninsular Malaysia, coral reef habitats of Pangkor Island, Perak Darul Ridzuan; Tanjung Gemuk, Negeri Sembilan Darul Khusus and surrounding islands in Langkawi, Kedah Darul Aman were chosen as study sites in the West Coast region. The study sites in the East Coast region were Kapas Island, Perhentian Island and Redang Island in Terengganu Darul Iman; and Tioman Island in Pahang Darul Makmur. Two main study sites were selected in Sabah i.e. Kota Kinabalu and Tuaran in the northern part and Semporna in the southern part. Global Positioning System (GPS) was used to mark and to record the position of each sampling site (not shown specifically, refer to Figure 1).

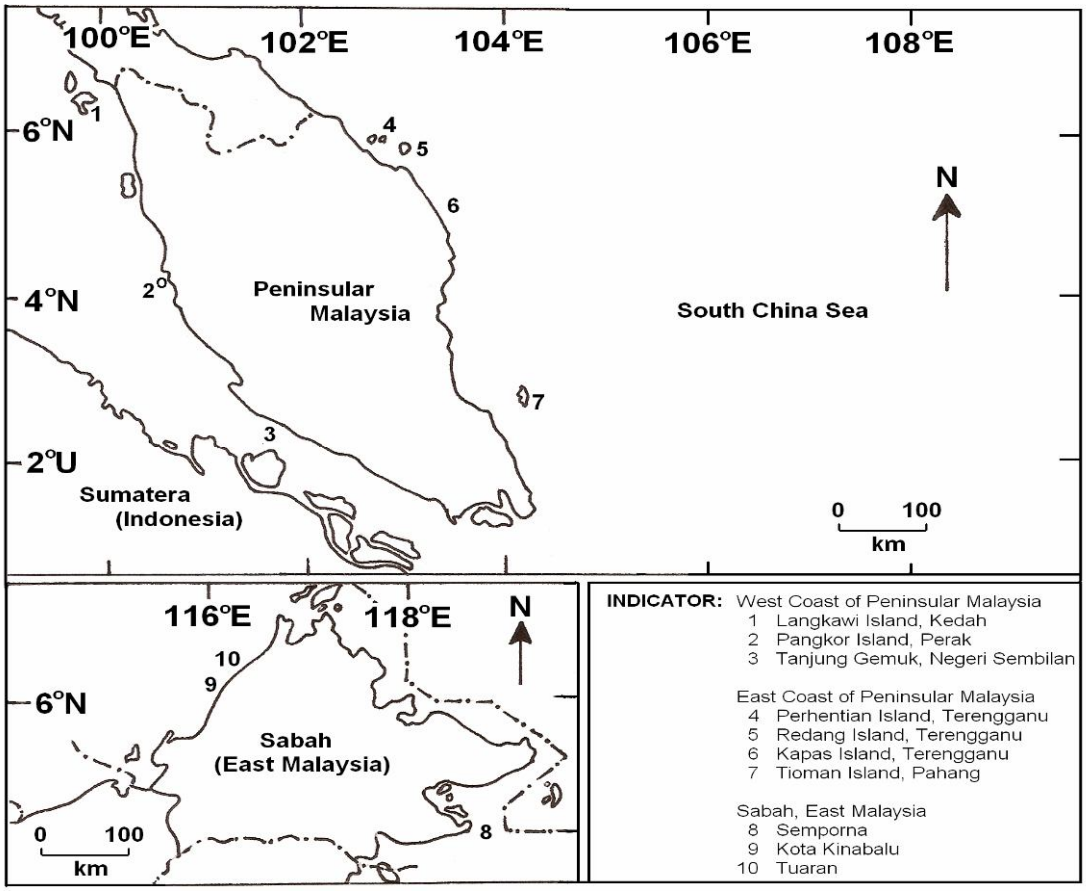

Figure 1. Study area with the 10 main sampling sites (with numbers).

Sampling and Species Identification

Sea cucumbers were sampled with the assistance of professional divers and local residents. Species identification of sea cucumbers by morphology was done by referring to the previous studies, supporting references and also through the information given by local residents. Undetermined species are designated temporarily as *sp.* (e.g. *Stichopus sp.*4; Table 1) with provided local names. Photographs were also taken as backup and further references.

Storage and Preservation

For short-term storage, fresh specimens of dead sea cucumbers were stored in ice boxes containing ice cubes or seawater during sampling. In the laboratories, specimens were transferred into -20°C fridge or -80°C freezer for long-term storage. Specimens are also preserved in 70% ethanol, with proper cataloging.

RESULTS

As many as 50 species of sea cucumbers were found to date in several coral reef habitats of Peninsular Malaysia, West Malaysia and Sabah, East Malaysia (Table 1) with 34 species (Table 2) require further species identification. Of the total number of species, 18 species (i.e. 36%) recorded were from genus *Holothuria*, indicating the highest percentage of species diversity; subsequently followed by genus *Actinopyga* with 15 species (i.e. 30%), and genus *Stichopus* with nine species (i.e. 18%). Percentage of 8% (i.e. four species) was shown by genus *Bohadschia* and 4% (i.e. two species) by genus *Synapta*. The lowest percentage of diversity was shared by genera of *Molpadia* and *Pearsonothuria* with 2% each (i.e. one species each).

The present study showed that 10 species were obtainable from both Peninsular Malaysia and Sabah. In terms of undetermined species, 14

species sampled were from genus *Actinopyga*, nine species from genus *Holothuria*, six species from genus *Stichopus*, two species from genera of *Bohadschia* and *Synapta*; and one species from genus *Molpadia* (Table 2). Interestingly, 13 undetermined *Actinopyga* species were found around coral reef habitats of Binawan Island, Semporna and one undetermined species was recorded in Redang Island, Terengganu Darul Iman, East Coast of Peninsular Malaysia. All the 34 undetermined species greatly need further verification based on ossicle characters, behaviour and molecular phylogeny. It is foreseen that a small number of the undetermined species, especially among *Actinopyga* species observed in Sabah, are new species. With respect to biogeography, the proximity of Sabah region to the Wallace's line may contribute to such possible phenomenon.

In the West Coast of Peninsular Malaysia, low level of sea cucumber diversity was measured around the coral reef habitats of Pangkor Island, Perak Darul Ridzuan and surrounding islands in Langkawi, Kedah Darul Aman. Only three species - *Holothuria leucospilota*, *Holothuria atra* and *bat hati* or *brunok* from order Molpadiida - were observed in Langkawi after two surveys, e.g. around Selat Bagan Pauh, Tanjung Pandan and Intan Besar Island (previously known as Kentut Besar Island); while only *Stichopus horrens* and *Holothuria leucospilota* were documented on coral reef habitats of Teluk Nipah and Pasir Bogak, Pangkor. However, the individual number of *Stichopus horrens* was recorded high around Teluk Cina, Pasir Bogak in Pangkor. In contrast, coral reef habitats of the East Coast, for instance in Terengganu Darul Iman, indicated higher diversity level of sea cucumber (i.e. 11 species), including the findings of eight undetermined species. Furthermore, higher diversity level of sea cucumbers was also shown by Tioman Island, Pahang Darul Makmur. Tioman Island indicated the existence of 15 species of sea cucumbers including seven undetermined species requiring further species identification.

DISCUSSION

Generally, the process of establishing taxonomic update for sea cucumbers (Echinodermata: Holothuroidea) in Malaysia was challenging but progressive with the continuous and consecutive attempts by local scientists and outsiders. The taxonomic revision has become more challenging with the current findings of 34 undetermined species in Malaysia, as well as the previous findings [5], [8], [10] and [13]. In spite of that, the present study along with previous research are likely manageable to provide up-to-date view of species presence and distribution of sea cucumbers in Malaysia, making such update the head start for subsequent future research, particularly in using molecular approaches to revise the taxonomic validity. In fact, organism groups with well-known taxonomies are important to ease the difficulties in listing existing species in a population [15].

In total, three orders of sea cucumbers were currently found in Malaysia i.e. Aspidochirotida, Molpadiida and Apodida; with seven genera and 50 species distributed among the orders. The present findings showed high diversity of sea cucumber in Malaysia. The total number of species recorded is higher than the records by [9], whereby they described 37 species with six species requiring further species identification. The presence of other species had also been recorded previously, [11] recorded the presence of nine species from order Dendrochirotida from the North West Coast of Borneo and Peninsular Malaysia. Furthermore, *Colochirus robustus* (the synonym of *Colochirus luteus*) was likely to be a common species around the Bodgaya Islands in Sabah, East Malaysia [16]. Apart from that, [8] recorded the presence of other species in Malaysia such as *Thelenota ananas*, *Actinopyga echinites*, *Actinopyga miliaris*, *Synapta recta* and *Stichopus hermanni* (formerly known as *Stichopus variegatus*). Some local residents also claimed the presence of large conspicuous *Thelenota anax* and other Synaptids (e.g. *Synapta maculata* and *Euapta godeffroyi*) on Malaysian coral reef habitats. Besides, Siti *et al.* [10] documented three genera and seven species of sea cucumber in Besar Island, Johor Darul Takzim with four species from the genus *Stichopus* yet to be identified. As the species identification became complicated, further effort had been taken by Massin *et al.* [13] in describing two new species from genus *Stichopus* found at the Johor Marine Park, Johor Darul Takzim, Malaysia - *Stichopus ocellatus n. sp.* and *Stichopus rubermaculosus n.*

sp. Accordingly, it is estimated that more than 80 species of sea cucumbers are present in Malaysia.

In the present study, the greatest diversity of sea cucumbers was shown by order Aspidochirotida. This finding is supported by Ridzwan [5] and Baine [8] who identified five genera of order Aspidochirotida namely *Holothuria*, *Stichopus*, *Thelenota*, *Bohadschia* and *Actinopyga* - making this order the most abundant and in the front rank of top species diversity within Malaysian coral reef habitats. As there are many previous research and personal comments showing the presence of other species such as *Thelenota anax*, *Thelenota ananas*, *Stichopus hermanni*, and species from order Dendrochirotida [11] that were not recorded in the present study, further research especially on molecular approaches and more study sites including Sarawak, East Malaysia need to be included in the future. Recent developments in DNA research could ease the difficulties in identifying closely related species when traditional characters have been proven inconclusive [1]. In general, current species abundance of sea cucumbers in Malaysia has displayed patchiness, even if it was relatively high in few study sites.

In Sabah, East Malaysia comprising Bodgaya and Ligitan groups of islands, the coral reef formation is well-developed in seawater region of Sulawesi Sea [17]. Coral reef area in tropical region is the best habitat for sea cucumbers due to the abundant source of organic particles as food [5]. Both statements are in congruence with the current findings of diverse species of sea cucumbers on coral reef habitats of Semporna, Sabah e.g. in Maiga Island (part of Bodgaya group) and Mabul Island (part of Ligitan group). Such uniqueness and privilege have made Sabah the most significant state in Malaysia for sea cucumber fisheries, with the dominant product from processing is beche-de-mer. Around 155 tonnes of sea cucumbers were landed in 1995 as estimated by the Sabah Fisheries Department, by which a wide variety of species are targeted mainly for food industry of beche-de-mer in Sabah. The current observation of 37 species inclusive of 13 undetermined *Actinopyga* species in Sabah also indicated that Sabah in general and Semporna in particular had the best and the most interesting species diversity of sea cucumbers in Malaysia. Relatively, the number of *Actinopyga* species currently recorded was larger in comparison with the overall findings by [5], [8] and [9]. Furthermore, [8] recorded the existence of two *Synapta* species (i.e. *Synapta recta* and *Synapta sp.*1) in Tioman Island and Payar Island, Langkawi. These showed that Synaptids were also present in both Peninsular Malaysia and Sabah. On top of that, proper management of marine park zone, e.g. Tunku Abdul Rahman Park, Kota Kinabalu may have also contributed to the great species richness in Sabah. Recreational zone and reserve zone are being implemented in coral reef habitat of Manukan Island, Kota Kinabalu, Sabah for instance in order to ensure that the gene pool is retained while the eco-tourism is developing. However, some issues brought by [18] pertaining to the lack of manpower in Sabah Fisheries Department and weak monitoring procedures require great concern and immediate action in developing a workable strategy towards management of sea cucumber fisheries.

With respect to biogeography, the proximity of Sabah region to the Wallace's line may also contribute to the high level of species presence and distribution of sea cucumbers on Sabah coral reef habitats. It is postulated that sea cucumber species from both Oriental and Australian regions may have mingled within the Wallace's line, causing the high species diversity within Sabah coral reef habitats. However, the existing data are still considered inadequate and further studies are greatly needed in the future for better view and confirmation. It is further postulated that the connection of Peninsular Malaysia to Sabah, East Malaysia by Sunda Shelf during the Pleistocene maximum lowering of seawater [19] has led to the relatively high difference of species diversity between the two regions, as indicated mainly by species from genus *Actinopyga*.

There was no clear and up-to-date information on the distribution of sea cucumbers in Sarawak, East Malaysia. Biogeographically, Sarawak is situated close to the lowland centre of historic Sunda Platform. According to Ho S.L [20], the growth of coral reefs in seawater region of Sarawak, East Malaysia e.g. coral reef habitats surrounding Talang-Talang Besar Island, Talang-Talang Kechil Island, Sampadi Island, Satang Besar Island and Satang Kechil Island were limited due

to the high turbidity and influx of fresh water from the rivers of Sarawak mainland. The developments in tourism as well as the proximity of surrounding islands to the mainland have also worsened the condition. Only the use of *brunok* from order Molpadiida as fishing bait among Sarawak residents was mentioned by Ridzwan [5]. In Sabah, *brunok* is commonly known as *bat hati* (Table 1). In Brunei Darussalam, Lane [6] reported a wide diversity of sea cucumbers on the coral reef habitats, whereby 14 species were observed. *Holothuria atra*, *Holothuria edulis* and species from genus *Bohadschia* were among the species present on Brunei Darussalam coral reef habitats. However, it was mentioned that the sources of sea cucumbers in Brunei Darussalam are not fully explored and relatively unexploited as compared to most Indo-Pacific reef habitats [7]. Furthermore, Lane [6] also stated that two of the four *Bohadschia* species in Brunei Darussalam were considered new to science. This finding seems further strengthening the proposal that new species could be present on the coral reef habitats of Borneo Island. As Brunei Darussalam is situated next to Sarawak and Sabah within the Borneo Island, it is foreseen that Sarawak may have the same or greater diversity of sea cucumber, even if some observation [17] could be a major contribution to low species diversity.

There are two main regions of coral reefs in Peninsular Malaysia - the East Coast and the West Coast. In present study, the level of sea cucumber diversity in the West Coast of Peninsular Malaysia was considered low, due to the small number of sea cucumber species currently observed in Pangkor Island, Perak Darul Ridzuan; Tanjung Gemuk, Negeri Sembilan Darul Khusus and Langkawi Island, Kedah Darul Aman. Only four species were documented - *Stichopus horrens*, *Holothuria atra*, *Holothuria leucospilota* and *bat hati* from order Molpadiida. [8] showed the almost similar records as from this present study about the species presence in Pangkor Island. However, local residents in Pangkor Island claimed that other species like *Stichopus chloronotus*, *Thelenota ananas* and an undetermined *Stichopus* species were also present on the coral reef habitats of Pangkor Island, Perak Darul Ridzuan. *Stichopus horrens* was rare at Langkawi Island as supported by [9] but the individual number of the same species was recorded high in this study around Pasir Bogak, Pangkor. As a result, *Stichopus horrens* has become the major target by a fisher of Pangkor Island for *gamat* oil and *gamat* water, as stated by [18]. However, the latter statement is contrary to other findings [8] that mentioned the presence of *Stichopus hermanni* (previously accepted as *Stichopus variegatus*) instead. There are also other statements mentioned by [8] contradicting with [18]. It is believed that [18] had made verification and correction to the species identification by [8], as [21] further verified the findings from [18]. Furthermore, [20] found that the distribution of coral reefs along the West Coast of Peninsular Malaysia was deemed poor and the underwater visibility was not good; and these findings were likely related to the low level of sea cucumber diversity currently observed in the West Coast region. Such statement was further supported by [18] referring to the regular importation of sea cucumbers from Adang, Thailand during the 1990s. Limited coral growth is believed to affect the marine-living organisms such as sea cucumbers that depend on the coral reefs as main habitat and food source. Likewise, the present observation also revealed the poor distribution of coral reefs on few coral reef habitats of Peninsular Malaysia, especially in Langkawi Island, possibly due to the negative impacts originated from anthropogenic threats. Direct exploitation, introduced species, extinction cascades, habitat loss and degradation are factors leading to species declines [22]. Hence, it is clear that coral reef destruction is proportional to the reduction of species richness and ecological diversity of sea cucumbers. [9] found that *Stichopus horrens* was rare at Langkawi Island, supporting the possibility of declination in sea cucumber processing and trade industry of the traditional fishery site. In order to help maintaining the stock for sea cucumber trade in Langkawi, [18] suggested that the demand in Langkawi may be supplied from three directions: from within through restocking initiatives, from Thailand in a trade agreement and from Pangkor Island, Perak Darul Ridzuan, Malaysia as part of a managed fishery. Interestingly, Payar Island within Langkawi group showed the presence of 10 species [8] thus making it the prospective study site in future studies.

Until nowadays, sea cucumbers are not included in the list of endangered species in Malaysia, neither it is considered endangered by the World Conservation Union (IUCN) which maintains a global list of endangered species. In terms of the conservation of sea cucumber in Malaysia, [23] emphasized the need to support the inclusion of sea cucumber species from the families of Holothuridae and Stichopodidae into the Appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) as protected species. They suggested that few considerations must be addressed and put into account before such inclusion is made especially issues pertaining to legislation and administration, the status of sea cucumber as a protected species, and research into the status and level of exploitation of sea cucumber resources.

In contrast, the present observation on the diversity level of sea cucumbers in the East Coast region was higher in comparison with the West Coast region. [8] reported the presence of 19 species of sea cucumber in Tioman Island and they found that the high diversity was due to the absence of runoff from rivers along that coast resulting much more diverse and developed coral communities. In future studies, several coral reef habitats in the East Coast of Peninsular Malaysia are to be incorporated to get better up-to-date view of sea cucumber distribution along the region. It is strongly believed that the East Coast region will show greater diversity of sea cucumbers in future studies, based on the fact that the surrounding islands especially Redang Island is currently the main coral reef of the East Coast of Peninsular Malaysia [17].

Furthermore, few species recorded by [5] had also been validated in this study due to wrong morphological identification, for instance *Bohadschia sp.*1 to *Actinopyga lecanora*, and *Stichopus variegatus* Semper, 1868 to *Stichopus hermanni*. It is also foreseen that there is high possibility of new species existence throughout coral reef habitats in Malaysia. Undetermined species observed and listed by [5], [8], [10], [13] and [14] are likely supporting the latter proposal and prediction. In fact, the greatest diversity of floras and faunas is found in the tropical region [24], placing tropical countries including Malaysia in the front rank of top 12 megadiversity countries in the world.

SUMMARY

In summary, the present study showed the presence of three orders of sea cucumber (Echinodermata: Holothuroidea) in Malaysia comprising seven genera and 50 species. Order Aspidochirotida had shown the highest diversity of sea cucumbers (i.e. 47 species; 94%). Large number of diverse sea cucumber species was recorded in Sabah (i.e. 37 species) while Peninsular Malaysia indicated the presence of 21 species. Furthermore, 10 species were obtainable from both regions. Biogeographical factors may have influenced the high diversity of sea cucumber observed on Sabah coral reef habitats, due the proximity of Sabah to the Wallace's line. Within Peninsular Malaysia, the East Coast region indicated higher species diversity than the West Coast region. Pollution originated from anthropogenic threats is suspected to be the main cause of lower species diversity of sea cucumbers in the West Coast Region, Peninsular Malaysia. Relatively *Holothuria leucospilota* was found to be the most abundant species of sea cucumber in Malaysia. Two *Synapta* species from order Apodida were observed only in Sabah, East Malaysia; however the previous studies showed that Synaptids were also present in Peninsular Malaysia. Previous research could not be found to update and subsequently to revise the distribution and taxonomic validity of *brunok* as well as other species of sea cucumbers on coral reef habitats of Sarawak, East Malaysia. Besides, the present data also indicated that in total 34 out of 50 species of sea cucumbers found in Malaysia are undetermined (Table 2). Most of the species are currently identified based on local names (Table 1). The 34 undetermined species are to be further verified and updated, morphologically and genetically in order to see the possibility of new species existence within the coral reef habitats of Malaysia.

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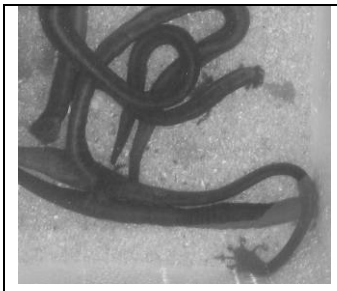
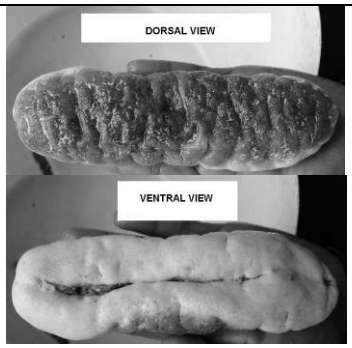
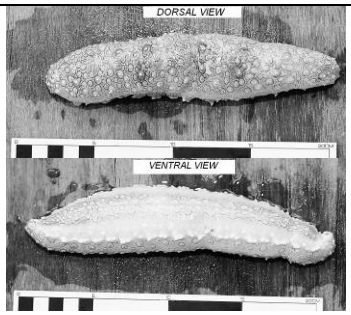
Table 1. List of sea cucumbers from Malaysia.

Order	No	Species	Local Name	Peninsular Malaysia	Sabah	Status
Aspidochirotida	1	*Holothuria (Mertensiothuria) Leucospilota*, Brandt, 1835	*Bat puntil*	x	x	Abundant
	2	*Holothuria (Metriatyla) scabra* Jaeger, 1833	*Bat putih*		x	Rare
	3	*Holothuria* (*Thymiosycia*) *impatiens* Forskal, 1775	*Bat brown*		x	Common
	4	*Holothuria(Halodeima) atra* Jaeger, 1833	*Bat hitam*	x	x	Common
	5	*Holothuria(Haloidema) edulis* Lesson, 1830	*Bat senjata anjing*	x	x	Common
	6	*Holothuria (Microthele) fuscogilva* , Cherbonnier, 1980	*Bat susu*		x	Rare
	7	*Holothuria* (*Thymiosycia*) *hilla* Lesson, 1830	*Bat*	x		Common
	8	*Holothuria* (*Microthele*) *fuscopunctata* , Jaeger, 1833	*Bat*		x	Rare
	9	*Holothuria (Acanthotrapeza) coluber*	*Bat sumping*	x	x	Common
	10	*Holothuria (Theelothuria) notabilis*	*Bat*	x		Common
	11	*Holothuria* sp.4	*Bat*	x		Common
	12	*Holothuria* sp.6	*Bat kasut*		x	Common
	13	*Holothuria* sp.7	*Bat*	x		Common
	14	*Holothuria* sp.8	*Bat*	x		Common
	15	*Holothuria* sp.9	*Bat*	x		Rare
	16	*Holothuria sp.*11	*Bat*	x		Common
	17	*Holothuria sp.*12	*Bat*	x		Rare
	18	*Holothuria* sp.13	*Bat putan*		x	Common
	19	*Bohadschia argus* , Jaeger, 1833	*Bat*		x	Rare
	20	*Bohadschia vitiensis* , Semper 1868	*Bat nangka*	x	x	Rare
	21	*Bohadschia* sp.1	*Bat*	x		Rare
	22	*Bohadschia* sp.2	*Bat*	x		Rare
	23	*Actinopyga lecanora* , Jaeger 1833	*Bat puyuh*		x	Common
	24	*Actinopyga* sp.2	*Bat timpu*		x	Rare
	25	*Actinopyga* sp.3	*Bat timpu*		x	Rare
	26	*Actinopyga* sp.5	*Bat timpu*		x	Rare
	27	*Actinopyga* sp.6	*Bat timpu*		x	Rare
	28	*Actinopyga* sp.7	*Bat timpu*		x	Rare
	29	*Actinopyga* sp.8	*Bat timpu*		x	Rare
	30	*Actinopyga* sp.9	*Bat timpu*		x	Rare
	31	*Actinopyga* sp.10	*Bat timpu*		x	Rare

Table 1. (Continued)

	32	*Actinopyga* sp.11	*Bat timpu*		x	Rare
	33	*Actinopyga* sp.12	*Bat timpu*		x	Rare
	34	*Actinopyga* sp.13	*Bat timpu*		x	Rare
	35	*Actinopyga* sp.14	*Bat timpu*		x	Rare
	36	*Actinopyga* sp.15	*Bat timpu*	x		Rare
	37	*Actinopyga* sp.16	*Bat timpu*		x	Rare
	38	*Pearsonothuria graeffei*, Semper 1868	*Bat*		x	Common
	39	*Stichopus chloronotus* Brandt, 1835	*Talifan varieti hitam*	x	x	Common
	40	*Stichopus horrens* Selenka, 1867	*Gamat*	x	x	Common
	41	*Stichopus ocellatus* Semper, 1868	*Gamat*	x	x	Rare
	42	*Stichopus vastus*	*Gamat*	x	x	Common
	43	*Stichopus* sp.1	*Kumbatas*		x	Rare
	44	*Stichopus* sp.2	*Kambatan*		x	Common
	45	*Stichopus* sp.3	*Gamat*		x	Rare
	46	*Stichopus* sp.6	*Bat*	x		Rare
	47	*Stichopus* sp.7	*Gamat*	x		Rare
Molpadiida	48	*Molpadia* sp.1	*Bat hati/ Brunok*	x	x	Common
Apodida	49	*Synapta* sp.1 (s)	*Taliaga*		x	Common
	50	*Synapta* sp.2 (s)	*Taliaga*		x	Common

Table 2. List of 34 undetermined species of sea cucumbers from Malaysia.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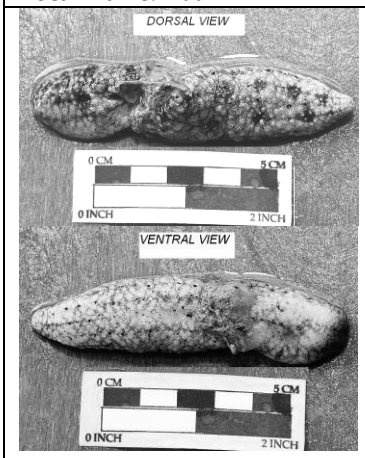	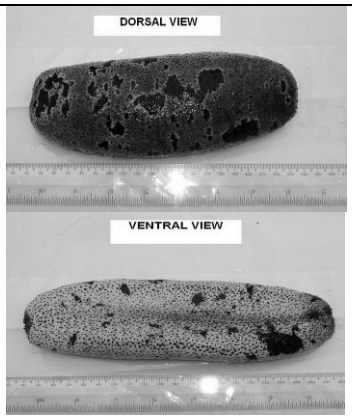	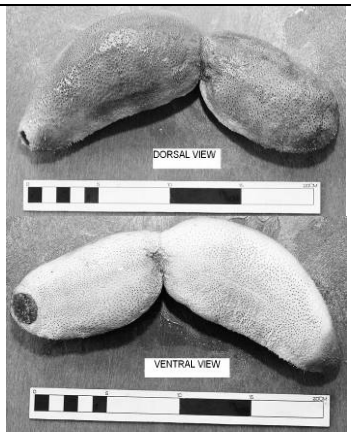
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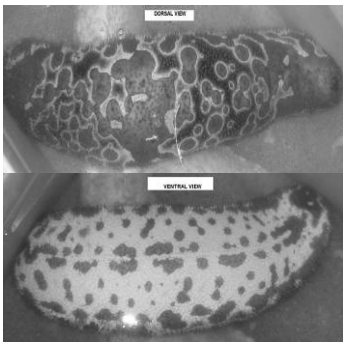
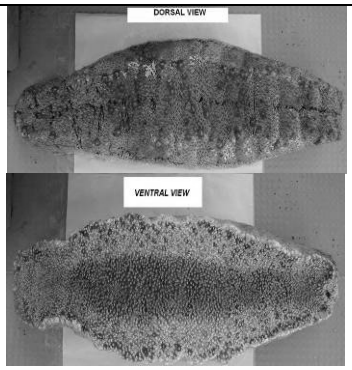
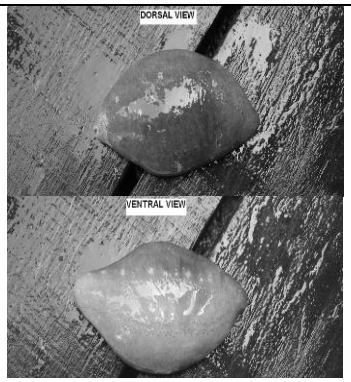
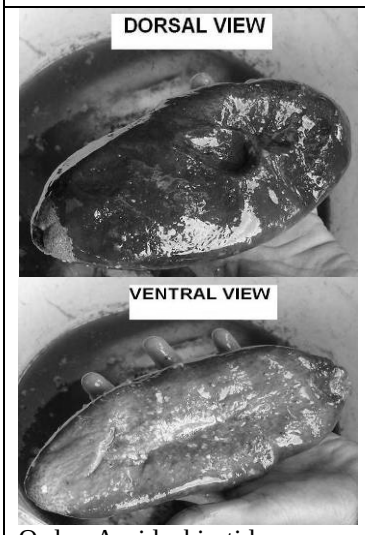
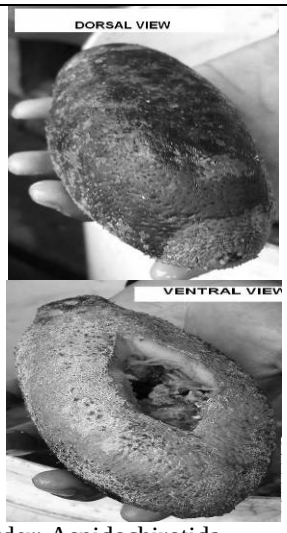
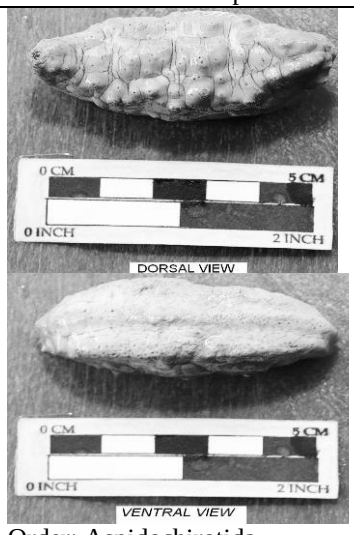
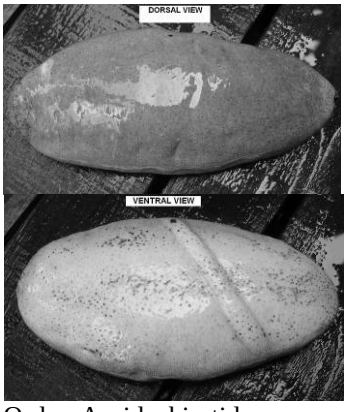
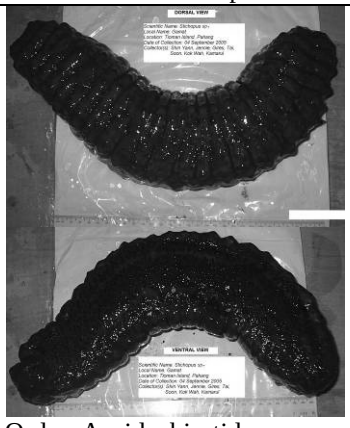
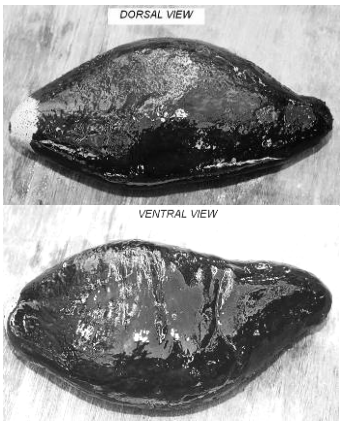
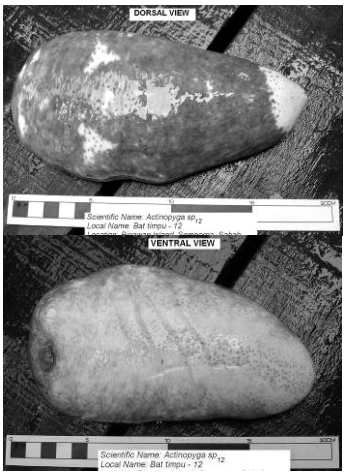
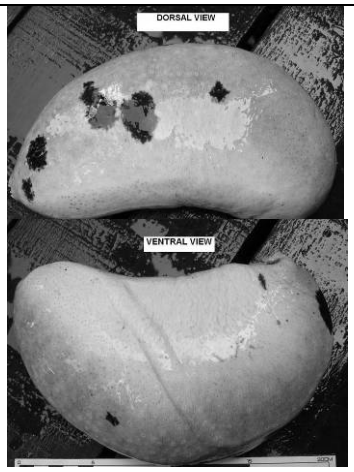
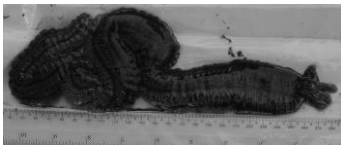
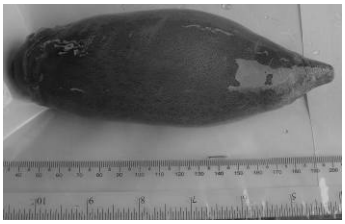
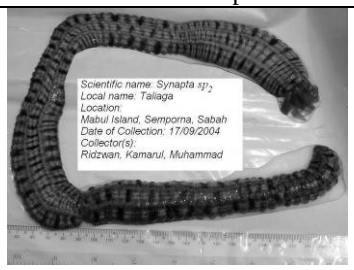
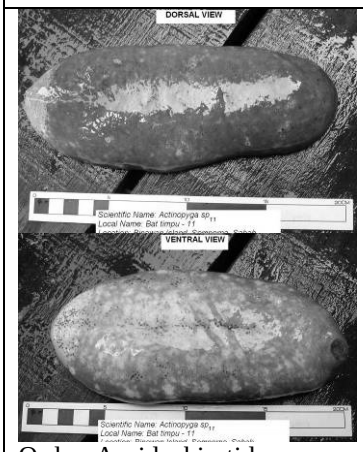
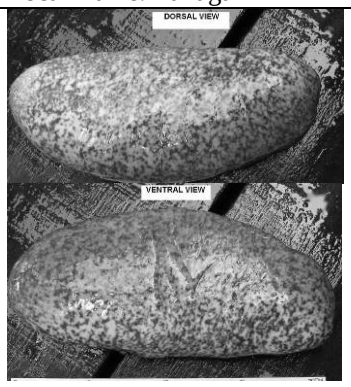
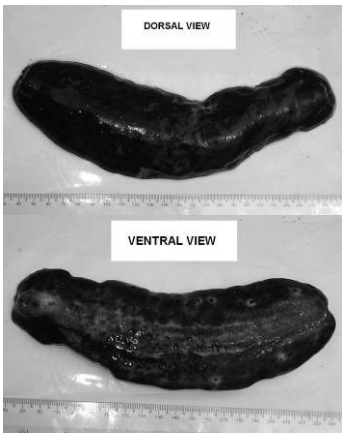
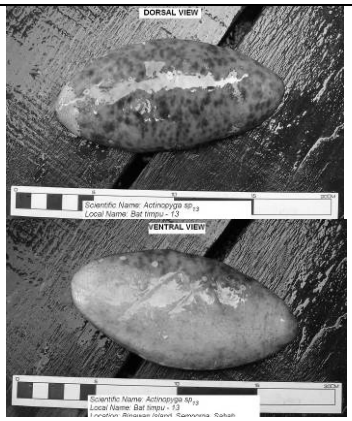
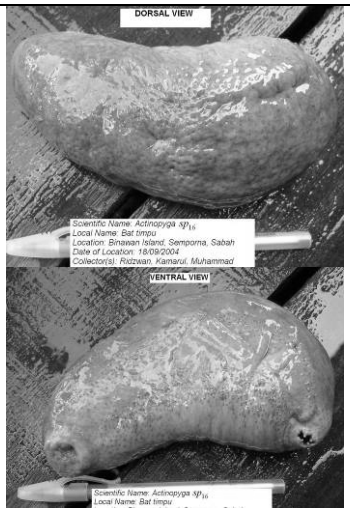
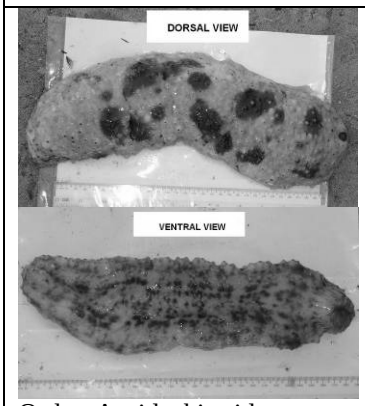
Order: Aspidochirotida Species: *Holothuria* sp.9 Local Name: *Bat*	Order: Aspidochirotida Species: *Holothuria* sp.11 Local Name: Bat	Order: Aspidochirotida Species: *Holothuria* sp.12 Local Name: Bat

 Order: Aspidochirotida Species*: Bohadschia* sp.2 Local Name: Bat	 Order: Aspidochirotida Species: *Stichopus* sp.3 Local Name: Gamat	 Order: Aspidochirotida Species: : *Actinopyga* sp.14 Local Name: Bat timpu
 Order: Aspidochirotida Species: *Actinopyga* sp.2 Local Name: Bat timpu	 Order: Aspidochirotida Species: *Actinopyga* sp.3 Local Name: Bat timpu	 Order: Aspidochirotida Species: *Stichopus* sp.6 Local Name: Bat
 Order: Aspidochirotida Species: *Actinopyga* sp.6 Local Name: Bat timpu	 Order: Aspidochirotida Species: *Stichopus* sp.7 Local Name: Gamat	 Order: Aspidochirotida Species: *Actinopyga* sp.7 Local Name: Bat timpu

 Order: Aspidochirotida Species*: Actinopyga* sp.15 Local Name: Bat timpu	 Order: Aspidochirotida Species: *Actinopyga* sp.12 Local Name: Bat timpu	 Order: Aspidochirotida Species: *Actinopyga* sp.8 Local Name: Bat timpu
 Order: Aspidochirotida Species: *Synapta* sp. 1 (s) Local Name: Taliaga	 Order: Aspidochirotida Species: *Molpadia* sp.1 Local Name: Buah hati/ Brunok	 Order: Aspidochirotida Species: *Synapta* sp. 2 (s) Local Name: Taliaga
 Order: Aspidochirotida Species: *Actinopyga* sp.11 Local Name: Bat timpu	 Order: Aspidochirotida Species: *Actinopyga* sp.5 Local Name: Bat timpu	 Order: Aspidochirotida Species: *Actinopyga* sp.10 Local Name: Bat timpu

 Order: Aspidochirotida Species*: Stichopus* sp.1 Local Name:Kumbatas	 Order: Aspidochirotida Species: *Actinopyga* sp.13 Local Name: Bat timpu	 Order: Aspidochirotida Species: *Actinopyga* sp.16 Local Name: Bat timpu
 Order: Aspidochirotida Species*: Stichopus* sp.2 Local Name: Kambatan	 Order: Aspidochirotida Species: *Actinopyga* sp.9 Local Name: Bat timpu	