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THE OCCURENCE & DISTRIBUTION OF TWO BLACK SEA CUCUMBER SPECIES IN POMBO ISLAND, CENTRAL MALUKU (INDONESIA)

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ABSTRACT

The so called "black sea cucumber" are found in Indonesia as several species including *Holothuria atra, H. leucospilota, H. coluber, H. excellens* and *H. turriscelsa*. The local community of Wainure village near Pombo Island in central Maluku had reported that most sea cucumbers inhabiting the island are the black sea cucumbers or locally known as "*teripang hitam*." They are occasionally consumed but not exploited excessively by the locals. The goals of this study are to identify the species of black sea cucumbers inhabiting Pombo Island and map their distribution to understand the microhabitats of black sea cucumber. Two field surveys conducted in March and April 2014 collected more than 550 individuals of black sea cucumbers that belong to two species −*Holothuria (Halodeima) atra* Jaeger, 1833, and *Holothuria (Mertensiothuria) leucospilota* Brandt, 1835. Furthermore, distribution maps of these two species show that they are found only along the SE to SW coast of the island. Such distribution may relate to the availability of marine vegetation, as well as boulders and stones that provide shelters to the organism. The distribution maps also show that *H. atra* has a wider distribution than *H. leucospilota* in Pombo Island. This may be due to the semi-cryptic habit of *H. Leucospilota*'s (i.e. hiding its posterior body under rocks or crevices), making its distribution restricted to areas that provide ample shelters.

Key words: *Holothuria atra, Holothuria leucospilota,* distribution, Pombo Island.

INTRODUCTION

A number of black sea cucumbers are found in Indonesia including *Holothuria atra* Jaeger, 1833; *H. leucospilota* Brandt, 1835; *H. coluber* Semper, 1868; *H. excellens* Ludwig, 1875; and *H. turriscelsa* Cherbonnier, 1980 (Purwati, 2005; Purwati & Wirawati, 2009; Setyastuti, 2009; Setyastuti et al., 2014; Setyastuti & Purwati, 2015). The first three species are the most common black sea cucumber species in Indonesian intertidal waters, while the last two species have only been recorded in Spermonde and Situbondo (Massin, 1999; Setyastuti et al.., 2014). Studies have shown that black sea cucumbers are widespread across the Indo-West Pacific region (Fig. 1; Purcell *et al*., 2012; Setyastuti *et al*., 2014). With the exception of *H. excellens* and *H. turriscelsa* that have limited distributions. However, it is probable that these two species are more widely distributed than have been reported. But high morphological resemblance with other holothuroidea species might have caused misidentification of these two species during field observations.

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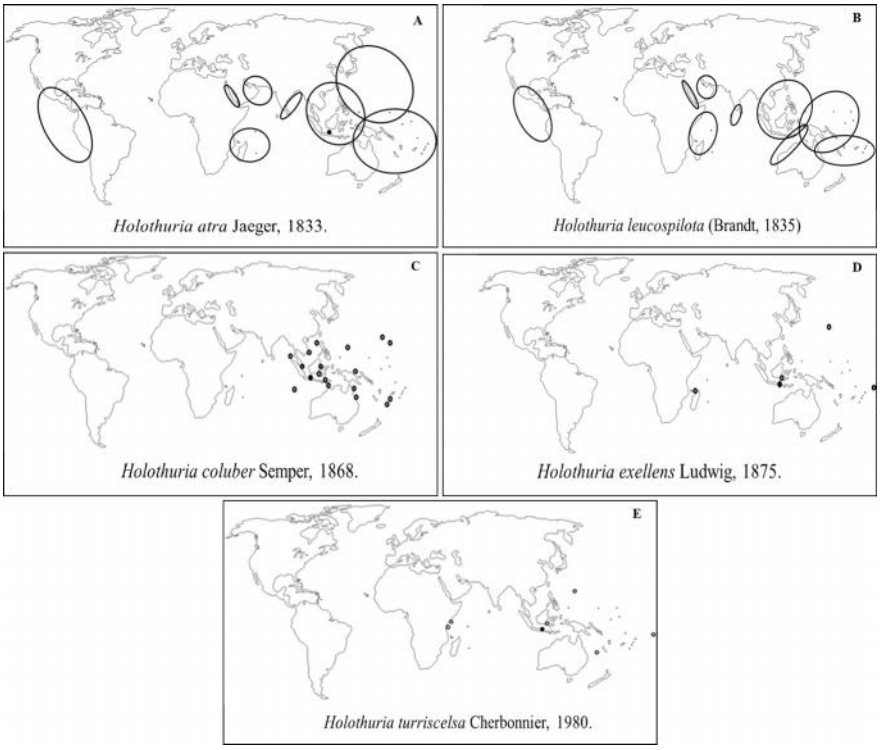


Figure 1. Geographic distribution of black sea cucumber. Data taken from Setyastuti et al. (2014) for Figures 1A-D; and Setyastuti (2009) and Purcell et al. (2012) for Figure 1E.

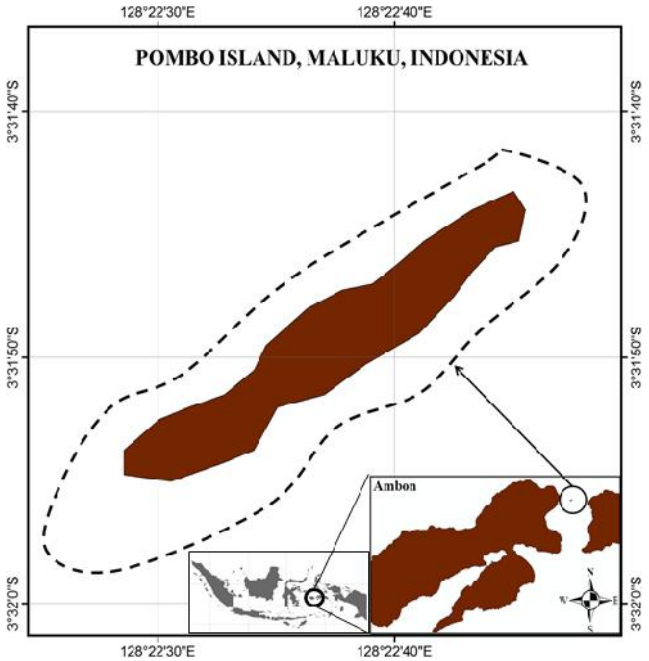


Figure 2. Study site. Pombo Island is situated on the Haruku Strait, between Ambon and Haruku Islands in the central Maluku. Dashed line shows the studied area during field observations.

Figure 3. Satellite image of the atoll surrounding the Pombo Island. Image taken from: http://wikimapia.org/#lang=en&lat=-3.529184&lon=128.377476&z=16&m=bh)

Massin (1996) states that Ambon Island is in a zone where the marine fauna is the richest in the Indo-Pacific region. Geologically, Ambon together with the islands of Pombo, Haruku and Saparua form a group of islands. This may imply that the possibility of finding more species is relatively high in these islands.

Pombo Island is located on the Haruku Strait, between the islands of Ambon and Haruku (Fig. 2). Administratively it is part of the Central Maluku Regency. In 1973, Pombo was established as a marine park sanctuary by a decree of the Ministry of Agriculture. The conservation area covers 1000 hectares of an uninhabited area including the island, reef flats and lagoons. The island spans northeast to southwest, with the Seram Sea lies to its north and the Banda Sea to its south (Fig. 3). The intertidal zone on the north coast is the only open area of white sandy substrate without any vegetation. The east coast area is characterized by a dead coral reef flat with white sandy substrates, boulders and rocks. The only vegetation found in this section is patches of *Sargassum* sp. seaweed. Intertidal area on the south coast has a similar geomorphology with the east coast but it is more extensive and vegetated by *Sargassum* sp. as well as *Padina* sp., (Fig. 4).

The local community near Pombo Island (Wainuru village) had reported that most sea cucumbers inhabiting Pombo Island. are black sea cucumbers called "*teripang hitam.*" Black sea cucumbers are occasionally consumed but not exploited excessively by the locals.

This paper presents an evidence that two species of black sea cucumbers inhabit Pombo Island and maps of their distribution to further understand their specific microhabitats. These information serves as important data for biodiversity studies as well as sustainable management of black sea cucumbers in the marine park.

MATERIALS AND METHODS

The black sea cucumbers studied herein were those inhabiting the intertidal zone of Pombo Island (Fig. 2). Surveys were conducted twice in 2014, specifically on March 20-21 and April 15-16.

Figure 4. Types of the intertidal zone of Pombo Island. A: Northwest coast, B: East coast, C: South coast, D: Southeast coast.

Species identification

Samples of sea cucumber were identified by observing the characteristics of their external bodies and examining the ossicles of their body wall, tentacle, dorsal papillae and ventral tube feet. The ossicles were isolated prior to examination. Small pieces (1-5 mm^2) of each body part were rinsed, put on a slide and dipped in several drops of NaClO for 5-10 minutes. Afterward, they were rinsed (4-7 times) with several drops of distilled water, and then with 70% ethanol - ready to be observed under a compound microscope.

Distribution mapping

The method used to develop distribution maps was modified from Visual Encounter Surveys (Heyer *et al.*, 1994) and is similar to previous works (e.g. Purwati, 2006; Purwati & Syahailatua, 2008; Purwati et al., 2008). It involved walking along the beach around the island to cover areas exposed at low tide while concurrently mapping the positions of individual black sea cucumbers using a Global Positioning System or GPS unit (Garmin 60CS). This method would avoid double-counting a same individual as specific locations of each organism are documented. While tracking the sea cucumber individuals, other information was also collected including species identity, the body length of each individual, substrate type, water temperature and salinity.

The GPS coordinates for each sea cucumber were analyzed and mapped using ArcGis 10.1

RESULTS

The black sea cucumbers at Pombo Island belong to two species: *Holothuria atra* and *Holothuria leucospilota*. These two species can be distinguised from each other by several characteristics as shown in Table 1, Fig. 5 and Fig. 6.*H. atra* is black in color and usually covers itself with a coating of coral sand that is held in place by its podia. The integument is thick and firm. *H. atra* lacks a cuvierian organ and thus can be handled without the annoyance of adhesive threads as described by Bonham & Held (1963). It frequently extrudes its internal

Figure 5. *Holothuria (Halodeima) atra* Jaeger, 1833.

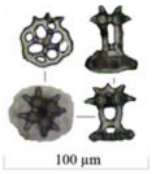
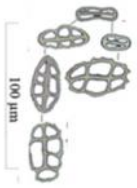
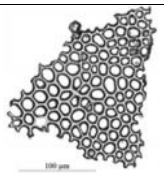
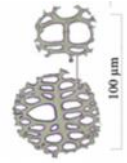
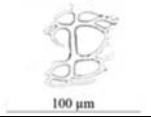
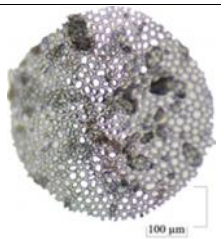
Figure 6. *Holothuria (Mertensiothuria) leucospilota* Brandt, 1835.

organs when stressed. *H. leucospilota* is almost black in color and does not cover itself in sand. The integument is softer with fine protuberances giving a prickly appearance. It quickly expels its cuvierian organ during hand contact. The ossicles in the integument

(dorsal and ventral) of the two species are different. The tables are tall and have no buttons for *H. atra*; while the tables are short and squat, and there are a lot of buttons for *H. leucospilota* (Rowe, 1969; Clark & Rowe, 1971; Cannon & Silver, 1986; Cherbonnier, 1988; Massin, 1996; Massin, 1999; Samyn et al., 2006; Setyastuti, 2009; Setyastuti, 2013). *Holothuria atra* and *H. leucospilota* are common species inhabiting the shallow water of Pombo Island. They occupy the intertidal area where beach rocks and dead corals are present, as well as pools of water that are a few centimeters to about a meter deep during low tide. The two species were found only along the intertidal zone of the east to south coasts of Pombo Island. No *H. atra* or *H. leucospilota* were found on the north to west coasts of the island during the surveys.Pombo Island forms an atoll with a narrow deep pool (with an approximate depth of more than 8 meters) located on its the northwestern side (Fig. 3). The pool is more like a sand valley as there was only white sandy substrates with no stone, boulder or vegetation. This is also the general condition in the NW side of the island (Fig. 4A). The habitat along the east to south coast of the island is fairly different, where the presence of a reef flat with dead corals and white sandy substrates is prominent. Several species of marine vegetation such as *Sargassum* spp. and *Padina* spp. Were also found in patches (Fig. 4B-D). Details on the number of species found in the studied areas, the size and local distributions are presented in Table 2 and Fig. 7-9.

Table 1. Morphology and behavior differences between *Holothuria atra* Jaeger, 1833 and *Holothuria leucospilota* Brandt, 1835. BW: body wall.

	External morphology	*Holothuria atra*	*Holothuria leucospilota*
1.	Fresh BW color	Uniformly black	Uniformly ash-grey to black
2.	Preserved BW color	Uniformly black	Uniformly brown
3.	Cross section (live only)	Cylindrical	Cylindrical
4.	Lateral appearance	Straight	Straight
5.	Body wall texture	Soft, smooth	Soft, smooth
6.	Average thickness of BW	<5 mm	<10 mm
7.	Tentacle size	Short	Long
8.	Tentacle shape	Peltate, indentions shallow	Peltate with branches
9.	Number of tentacles	15-20	20
10.	Position of mouth	Ventral	Ventral
11.	Position of anus	Terminal	Terminal
12.	Collar around mouth	Absent	Absent, but prickly oral papillae made them looks like a collar around mouth
13.	Tube feet	Present	Present
14.	Arrangement of ventral tube feet	Overall spreading (distributed over the ventral side, not in rows)	Mostly in radial areas, but some also spread in interadial areas
15.	Arrangement of dorsal papillae	Distributed over the dorsal side	Distributed over the dorsal side

	Ossicles	Dorsal BW	Ventral BW	Dorsal BW	Ventral BW
1.	Tables				
2.	Rosettes		Absent	Absent	Absent
3.	Buttons	Absent	Absent		
4.	Rods	Absent	Absent		Absent
5.	Perforated plates	Absent			
6.	Pseudo plates	Absent		Absent	Absent
7.	Large perforated plates	Absent	Absent	Absent	

Note on behaviour			
1	Body covering with sand	Usually with distinctive bare spots	Sometimes
2	When capture	Usually in open area	Usually with anterior part exposed and the posterior part under a rock or dead coral/crevices.
3	Solitary/aggregation	Usually found individually	Solitary and sometimes in an aggregation
4	When stressed	Expel internal organ	Expel cuvierian tubulus
5	Reproduction	Sexual and asexual through fission	Sexual and asexual through fission

Table 2. The number of black sea cucumbers in Pombo Island during surveys.

	Survey Time	
	20-21 March 2014	22-23 April 2014
Holothuria (Halodeima) atra Jaeger, 1833	158 individuals	319 individuals
Holothuria (Mertensiothuria) leucospilota Brandt, 1835	65	24
Total	223	343

Table 3. Physical parameters at Pombo Island during surveys.

	Survey Time	
	20-21 March 2014	22-23 April 2014
Temperature	30°C	29-30°C
Salinity	34-35‰	33-35‰

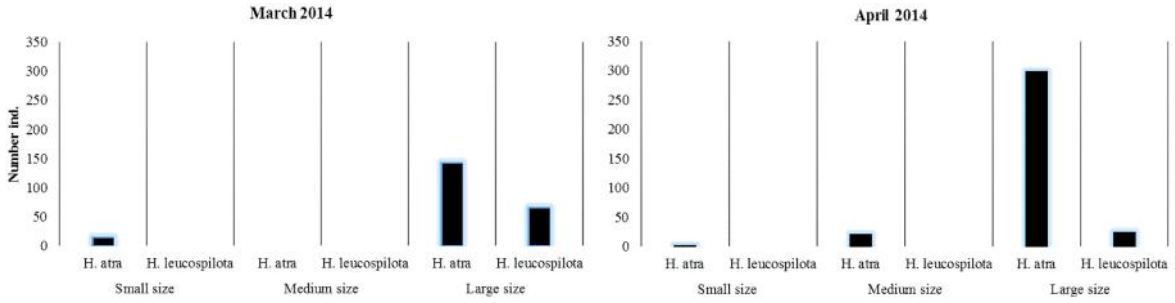


Figure 7. Size distribution of both species *Holothuria atra* Jaeger, 1833 and *Holothuria leucospilota* Brandt, 1835. Size categorization are based on Setyastuti (2014): Small class (0-9.9 cm); Medium class (10-30.99 cm) and Large class (≥ 31 cm).

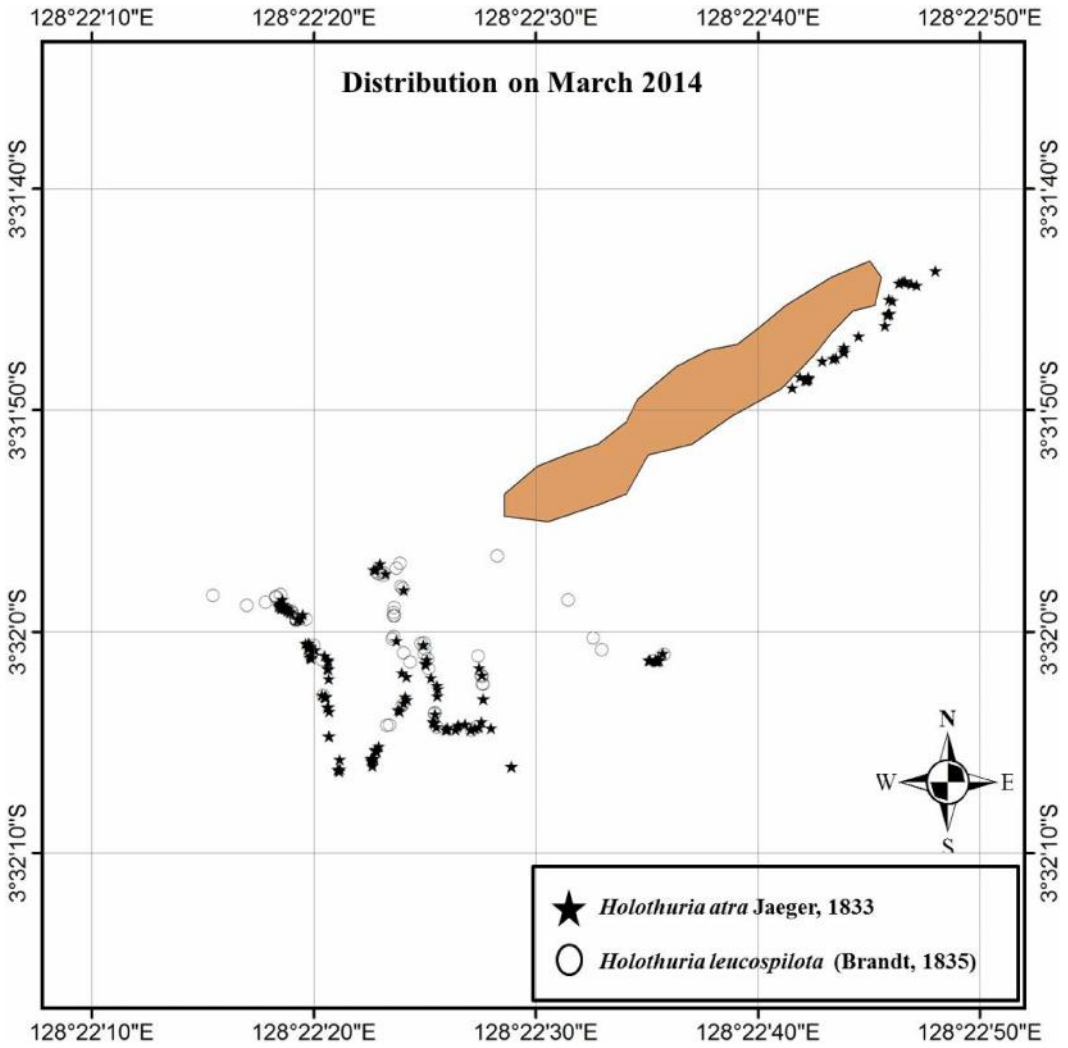


Figure 8. Geographical positions of *Holothuria atra* Jaeger, 1833 (158 individuals) and *Holothuria leucospilota* Brandt, 1835 (65 individuals) on Pombo waters in March 2014.

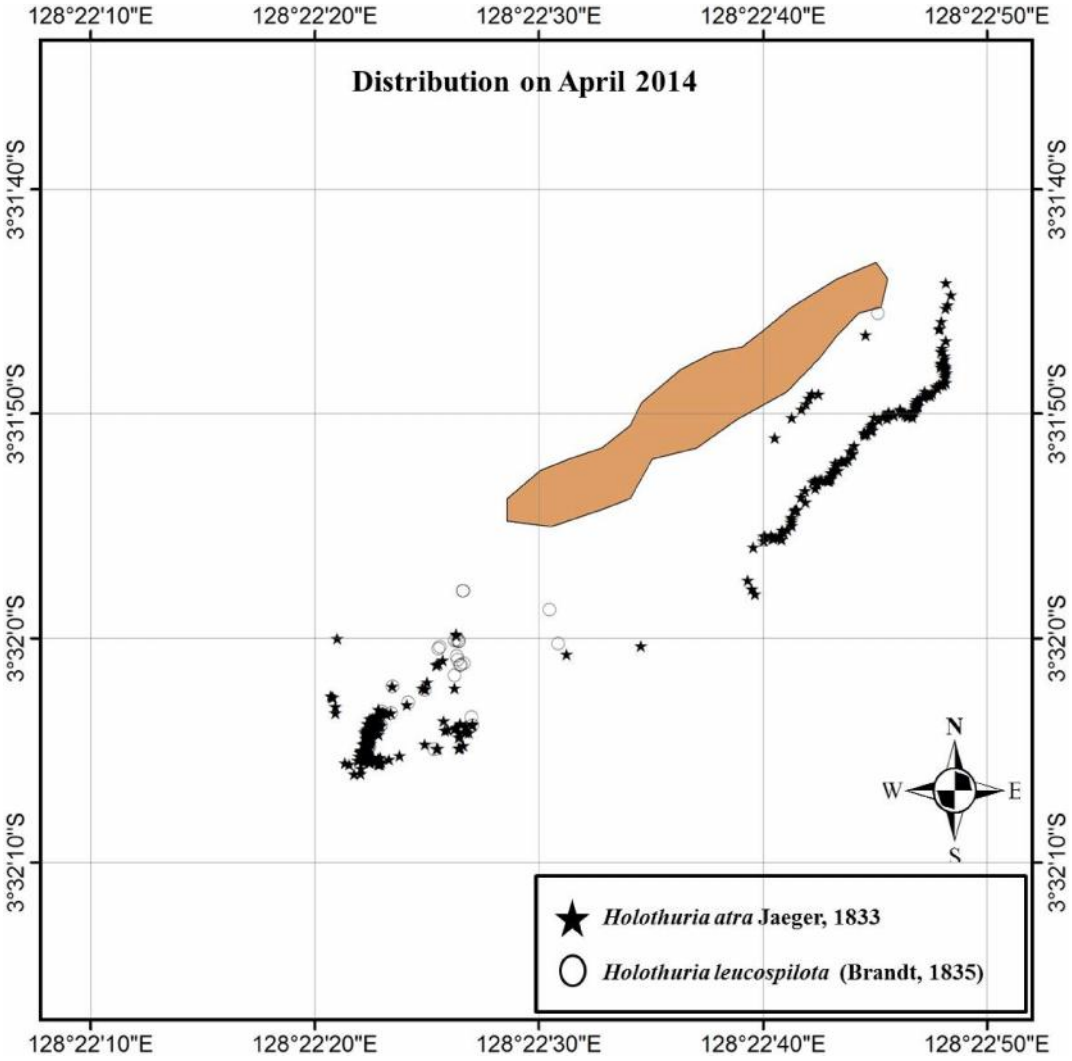


Figure 9. Geographical positions of *Holothuria atra* Jaeger, 1833 (319 individuals) and *Holothuria leucospilota* Brandt, 1835 (24 individuals) on Pombo waters in April 2014.

DISCUSSION

Species identification

Holothuria atra Jaeger, 1833 and *Holothuria leucospilota* Brandt, 1835 have morphological resemblances such as body color, body shape and size. Furthermore, they are frequently found together in the same habitat particularly in intertidal areas. In addition, they are described as benthic, deposit feeder, detritus feeder, inshore and tropical organisms (Rowe & Gates, 1995). However, the detailed observations showed that they could be distinguished based on their morphologies and behaviors (Table 1).

Distribution mapping

Regarding the absence of both *H. atra* and *H. leucospilota* on the NE coast of Pombo Island. some possible reasons are: the lack of shelter, strong current and low organic materials. These reasons were also suggested in previous works by Bonham & Held (1963), Massin & Doumen (1986), Conand &

Mangion (2002), Slater & Jeffs, (2010), Dissanayake & Stefansson (2011). Shelter areas such as shelves of rock along the beach give an insulating effect by cooling water temperature during hot days and providing protection from high waves. Based on field observation, the NE coast has no shelter such shelves, rocks or dead corals, with only white sandy substrates present. In addition, this side is directly exposed to northerly winds coming from the Seram Sea that bring high wave energy on the sandy beach. However, there is no quantitative measurement of the current, although it was observed during the surveys that the current at this side is stronger than the opposite side (SE coast). The fact that the NE side has no shelter area that could reduce wave energy from the ocean may also explain the absence of marine vegetation particularly seagrass. In turn, the lack of seagrass might impact the amount of organic material deposits in the intertidal area. No specific measurement was undertaken to quantify the level of organic material during the surveys. However, literatures on the habitat preferences of sea cucumbers conclude that the presence of organic material is one of the most important factors controlling sea cucumbers abundance (Dissanayake & Steffansson, 2011; Purcell et al., 2009; Purcell, 2004; Conand & Mangion, 2002; Conand, 1990). And, higher levels of organic material are influenced by the presence of seagrasses, because they can trap nutrients at their base making the accumulation of particulate matter and detritus higher (Komatsu *et al*., 2004; Dissanayake & Steffansson, 2011). And studies

All individuals of black sea cucumber were found along the SE to SW coast. The argument for this distribution pattern must be the reverse of the reason for the absence of black sea cucumbers on the NE coast. Geomorphologically, the SE and SW coasts offer a better protection from high wave energy and strong current because most of this area is made up of a reef flat with dead corals. The flat is extensive with many patches of marine vegetation. Therefore, despite being directly exposed to the Banda Sea, which is known to have high wave energy, conditions there may offer a suitable condition to reduce the strong current. This condition is similar with the result of Zhou & Shirley (1996) that observed high density of sea cucumber on the rock walls of Barlow Cove, SE Alaska.

Most *H. atra* found during the surveys covered their bodies with white sandy substrate or rubble, consistent with previous observations. It has been suggested that the sand coating could reflect light, thus enabling *H. atra* to have a slightly lowered body temperature (Aziz, 1995). Furthermore, the mapping of *H. atra* shows that they are only found along the SE to SW coast of Pombo Island (Fig. 7-8). Specifically, the highest abundance was found in open areas with sand or beach rocks with *Sargassum* spp. and *Padina* spp., with some inhabited pools of water at low tide. These habitat preferences as well as the aggregation of *H. atra* could be their self-defense mechanism against waves and currents since they mostly dwell in the intertidal area (Bonham & Held, 1963; Massin & Doumen, 1986; Conand & Mangion, 2002). *H. atra* protects itself from the waves and currents by maintaining its position in depressions and holding onto the relatively smooth reef flat or beach rock using its tube feet (Bonham & Held, 1963).

Similar behavior was also displayed by all individuals of *H. leucospilota* in this study, which were found underneath rocks or holes on the reef floor. This result confirms the finding of Massin & Doumen (1986) who never found this species on dry surface, living corals or other sites with high water turbulence. They also noted this species anchoring its posterior under shelter and described it as a semi-cryptic habit.

The number of *H atra* in April 2014 was more than twice than that of March 2014. This can be explained by several possible reasons. More small to medium size individuals were captured in April than in March (Fig. 7). Careful observation shows that those small-medium size individuals were showing signs of having undergone asexual reproduction through fission. These observed individuals only had its anterior part (A) or only had its posterior part (P), and were only separated from each other by a

short (less than 0.5 m) distance. The other small size individuals were captured as Ap specimens (showed signs of regenerating of their posterior part) or Pa specimen (showed signs of regenerating their anterior part) – and were separated by a farther (about 1-1.5 m) distance. Similar observation was obtained by previous authors (Conand et al., 1997; Jaquemet et al., 1999; Purwati, 2001); Conand & Mangion, 2002; and Dwiono et al., 2008. Another reason for explaining the higher number of *H atra* in April 2014 is that the rising abundance of seaweed may take effect on sea cucumber population only after a couple of months.

In contrast to *H. atra*, the number of *H. leucospilota* in April 2014 was fewer than in March 2014. The reasons are unclear. But the most likely reason may be directly related to the hiding behavior of this species under the boulders/stones/rocks and crevices as shelter areas. The individuals might have moved to other shelter areas that were not well observed during the surveys. These findings of *H. leucospilota*'s behavior and type distribution were similar to Purwati (2006)'s observation in West Lombok, Indonesia. The distribution mapping (Fig. 8, 9) shows that *H. atra* was distributed more extensively than *H. leucospilota*. The possible reason may be that suitable living areas for *H. atra* are more extensive than for *H. leucospilota*. *H. atra* do not hide like *H. leucospilota* so they do not need a specific place to live. On the contrary, *H. leucospilota* always anchors its posterior under a stable rock or a hole on the reef floor, making its distribution more limited to specific places. This finding is similar to the work of Bonham & Held (1963) and Massin & Doumen (1986) that were conducted at Rongelap Atoll and the reef flat of Laing Island, Papua New Guinea, respectively, where *H. atra* has a broader distribution and higher abundance than *H. leucospilota*. Other works, by Dissanayake & Stefansson (2011) and Conand & Mangion (2002), also suggest that *H. atra* are more able to live over a broader area in the intertidal zone than any other Holothurian species.

CONCLUSION

Pombo Island has two dominant species of black sea cucumber: *Holothuria atra* Jaeger, 1833 and *Holothuria leucospilota* Brandt, 1835. Those two species have a morphological resemblance, but detailed observation shows they are quite different. The presence of *H. atra* was higher with wider distribution than those of *H. leucospilota*. *H. atra* were found in a broader area on the reef flats with or without the presence of boulders/rocks, while *H. leucospilota* was found only in areas where there were many rocks or holes in the reef floor. Both *H. atra* and *H. leucospilota* were found along the SE to SW coast of Pombo Island. This is an evidence that the availability of shelter influences the distribution of sea cucumbers in Pombo Island.

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REFERENCES

Aziz, A. 1995. Beberapa catatan tentang teripang bangsa Aspidochirotida. *Oseana*, 20(4):11-23.

Bonham, K. and Held, E.E. 1963. Ecological obervation on the sea cucumbers *Holothuria atra* and *H. leucospilota* at Rongelap Atoll, Marshal Island. *Pacific science* vol. XVII: 305-314.

Brandt, J.F. 1835. Prodomus descriptionis animalium ab H. Mertensio in orbis terrarium circumnavigatione observatorium. *Petropoli*. I: 1-75, 1 pl.

Cannon, L.R.G and H. Silver. 1986. *Sea Cucumber of Northern Australia*. QLD. Museum, Brisbane: 60 pp.

Cherbonnier, G. 1980. Holothuries de Nouvelle-Caledonie. *Bull. Mus. Natn. Hist. nat. Paris 4eme ser., 2*. Section A (3): 615-667.

Cherbonnier, G. 1988. *Faune de Madagascar. 70. Echinodermes: Holothurides*. Institut Francais De Recherche Scientifique Pour Le Developpement en Cooperation. Paris: 292 pp.

Clark, A.M and F.W.E. Rowe. 1971. *Monograph of shallow water Indo-Pacific Echinoderm.* Trust. Br. Mus. Nat. Hst. London: 238 pp.

Conand C. and Mangion P. (2002) Sea cucumbers on La Réunion Island fringing reefs: diversity, distribution, abundance and structure of the populations. *SPC Bêche-de-Mer Information Bulletin* 17, 27–32.

Conand, C. 1989. Les Holothuries Aspidochirotes du lagon de Nouveelle-Caledonie. Biologie, ecologie et exploitation. *These de Doctorat*, Brest: 1-393.

Conand, C. 1990. The fishery resources of Pacific Island countries. Part 2 Holothurians. *FAO Fisheries Technical Paper*, No. 272. FAO-Rome. 2–143pp.

Conand, C., Morel, C. and Mussard, R. 1997. A new study of asexual reproduction in holothurians: fission in *Holothuria leucospilota* on Reunion Island in the Indian Ocean. *SPC Beche-de-mer Information Bulletin*, 9: 5-11.

Dissanayake, D.C.T. and Stefansson, G. 2011. Habitat preference of sea cucumbers: *Holothuria atra* and *Holothuria edulis* in the coastal waters of Sri Lanka. *J. Mar. Biol. Assoc.*, 92: 581-593. doi: 10.1017/S0025315411000051

Dwiono, S. A. P., P. Purwati, V. Fahmi and L. F. Indriana. 2008. Reproduksi Aseksual pada *Holothuria atra* (Echinodemata) di Teluk Medana, Lombok Barat. *Jurnal Penelitian Perikanan Indonesia*: Vol 14 No. 4: 415-421.

Heyer, W.R., Donnelly M.A., McDiarmid, R.W., Hayek, L.C. & Foster, M.S. 1994. Measuring and monitoring biological diversity: standard methods for amphibians. Smithsonian Institute Press. Washington: 364 pp.

Jaeger, G. F. 1833. *De Holothuriis*: 1-40 pls. 3. Turici.

Jaquemet, V.S. Rousset, V. and Conand, C. 1999. Asexual reproduction parameters and the influence of fision on a *Holothuria atra* sea cucumber population from a fringing reef on Reunion Island (Indian Ocean). *SPC Beche-de-mer Information Bulletin*, 11: 12-18.

Komatsu, T., Y. Umezawa, M. Nakakoka, C. Supanwand, and Z. Kanamoto. 2004. Water flow and sediment in Enhalus acoroides and other sea grass beds in the Andaman Sea, off Khao Bae Na, Thailand. *Coastal Marine Science*, 29(1):63-68.

Ludwig, H. 1875. *Beitrage zur kenntniss der Holothurien*: 77-118, pls. 6-7.

Massin, C. 1996. Result of The Rhumpius Biohistorical Expedition to Ambon (1990). Part. 4. The Holothurioidea (Echinodermata) collected at Ambon during the Rumphius Biohistoritical Expedition. *Zoologische Verhandelingen* vol. 307. National

Natuur historisch Museum. Leiden: 53 pp.

Massin, C. 1999. Reef-dwelling Holothuroidea (Echinodermata) of the Spermonde Archipelago (South-West Sulawesi, Indonesia). *Zoologische verhandelingen vol. 329*. National Museum of Natural History, Leiden: 144 pp.

Massin, C. and C. Doumen. 1986. Distribution and feeding of epibenthic holothuroids on the reef flat of Laing Island (Papua New Guinea). *Marine Ecology Progress Series*, 31: 185-195.

Purcell, S.W. 2004. Criteria for release strategies and evaluating the restocking of sea cucumbers. In: Lovatelli, A., C. Conand, S.W. Purcell, S. Uthicke, J.F. Hamel, and A. Mercier (eds.). Advances in sea cucumber aquaculture and management. *FAO Fisheries and Aquaculture Technical Paper No. 463*. FAO-Rome. 181-189pp.

Purcell, S.W., H. Gossuin, and N. S. Agudo. 2009. Changes in weight and length of sea cucumbers during conversion to processed beche-de-mer: filling gaps for some exploited tropical species. *SPC Beche-de-mer Information Bulletin*, 29:3-6.

Purcell, S.W., Samyn, Y. and Conand, C. 2012. *Commercially important sea cucumbers of the world-FAO species catalogue for fishery purpose No. 6*. Rome, FAO: 150 pp. 30 color plate.

Purwati P. 2005. Teripang Indonesia: Komposisi jenis dan sejarah perikanan. Oseana 30 (2):11–18.

Purwati, P. 2001. Reproduction in a fissiparous holothuria, *Holothuria leucospilota* Clark, 1920 (Echinodermata: Holothuroidea) in tropical waters of Darwin, Northern territory, Australia. *Thesis*. Northern Territory University: 147 pp.

Purwati, P. 2006. Teripang, Biodiversitas, dan Permasalahan di Indonesia. *Laporan Akhir Tahunan*. Jakarta (ID): Program Penelitian dan Pengembangan IPTEK, Riset Kompetitif LIPI.

Purwati, P. and I. Wirawati. 2009. Holothuriidae (Echinodermata, Holothuroidea, Aspidochirotida) perairan dangkal Lombok Barat. Bagian I: Genus Holothuria. *Jurnal Oseanologi* No. 2(1/2): 1-25.

Purwati, P. and Syahailatua, A. 2008. *Timun laut Lombok Barat*. Jakarta: Ikatan Sarjana Oseanologi (ISOI): 71 pp.

Purwati, P., P. Widianwari, and S.A.P. Dwiono. 2008. Timun laut Teluk Medana, Lombok Barat: pola sebaran dan kelimpahan. Jurnal Ilmu Kelautan: 219-226. doi: 10.14710/ik.ijms.13.4.219-226.

Rowe, F.W.E and J. Gates, 1995. Echinodermata. In: A. Wells (ed), *Zoological Catalogue of Australia*: vol. 33, i-xiii. CSIRO Australia, Melbourne: 510 pp.

Rowe, F.W.E. 1969. A Review of the Family Holothuriidae. (Holothurioidea: Aspidochirotida). *Bulletin of the British Museum (Natural History) Zoology Vol. 18 No.4*: London: 119-169.

Samyn, Y., Vandenspiegel. And Degreef, J. 2006. *ABC TAXA une Série de Manuels Dédiés aux Renforcements des Capacités en Taxonomie et en Gestion des Collections*. Produit avec le soutien financier de la Direction générale de la Cooperation au Développement, Belgique. Belgia: 130 pp.

Semper, C. 1868. *Reisen im Archipel und Philipinen*. Holothurien.2. Wissenschaftliche Resultate. Leipzig: i-x, 1-288, 40 pls.

Setyastuti, A. 2009. Sea cucumber (Echinoderms: Holothurioidea: Stichopodidae, Holothuriidae, Synaptidae) of West Seram, Maluku, Indonesia, collected during July 2007. *Oseanologi dan Limnologi di Indonesia*, 35 (3): 369-396.

Setyastuti, A. 2013. Taxonomy study on trepang collected from Karimunjawa, Situbondo, Spermonde and Ambon. *Thesis*: 122 pp.

Setyastuti, A. 2014. Echinodermata, *Holothuria atra*, in an intertidal seagrass bed off The Bama beach,

Baluran National Park, East Java, Indonesia. Jurnal Ilmu dan Teknologi Kelautan Tropis, VOl. 6, No. 1: 31-39.

Setyastuti, S. and P. Purwati. 2015. Species list of Indonesian trepang. *SPC Beche-de-mer Information Bulletin*, 35: 19-25.

Setyastuti, S., NP. Zamani, and P.Purwati. 2014. Teripang dari Karimunjawa, Situbondo, Spermonde dan Ambon. *Oseanologi dan Limnologi di Indonesia*, 40 (2): 133-142.

Slater, M.J. and Jeffs, A.G. 2010. Do benthic sediment characteristics explain the distribution of jouveniles of the deposits-feeding sea cucmber *Australostichopus mollis*?. *Journal of Sea Research* 64: 241-249. doi: 10.1016/j.seares.2010.03.005

Zhou, S. and T.C. Shirley. 1996. Habitat and depth distribution of the red sea cucumber *Parastichopus californicus* in a Southeast Alaska Bay. *Alaska Fisheries Research Bulletin* 3 (2): 123-131.