Sea cucumber species found in Soft-bottom of Wulan Estuary-Demak, Central Java

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Abstract. Indonesia has been known to have a high diversity of sea cucumber, but data and information are mostly on high-economic-value species. Sea cucumber living in soft-bottom substrates is less studied and unexploited. Wulan estuary located in the Demak Regency of Central Java was experiencing high sedimentation, which was consisted of fine material, and acted as a habitat for many macrozoobenthos, amongst others sea cucumbers. The objective of the present research was to identify the species of sea cucumber in the soft bottom of the Wulan estuary. The collection of sea cucumber specimens was done using a dredge. A total of 132 specimens were collected, examined, and identified through their morphological characters. The holothuroids found in the soft-bottom of the Wulan estuary represent five genera (Acaudina, Colochirus, Holothuria, Paracaudina, Phyllophorus, Phyllophorus) in four families (Caudinidae, Cucumariidae, Holothuriidae, and Phyllophoridae) belonging to three orders (Molpadida, Dendrochirotida, and Aspidochirotida). The species were Acaudina sp., A. molpadioides, Colochirus quadrangularis, Holothuria cf. impatients, Paracaudina sp., Paracaudina chilensis, P. australis, and Phyllophorus spiculata. A. molpadioides is presented as the most frequently found species. Although sea cucumber found in the Wulan estuary has not been exploited, it still needs to be managed to sustain its population.

Keywords: Acaudina, Colochirus, Paracaudina, Phyllophorus, Soft-bottom

1. Introduction

The Wulan estuary, located in the Demak Regency of Central Java, is surrounded by a fertile mangrove area that supplies nutrients to land and sea and is also well known for experiencing high sedimentation which built a delta (named as Delta Wulan) [1]. The seafloor of the Wulan estuary has soft-bottom sediment, including clay, silt, and sandy. Clay and silt are usually grouped as mud, and tidal current moved about these particles [2]. In the estuary, most of the soft sediment consists of fine material. Through the tidal activity, the sediment was settled and formed a habitat for many macrozoobenthos, among the other sea cucumbers [3]. As a benthic organism, sea cucumbers have very important roles not only to stabilize sediment but also as bioturbators to mix the sediment layers so become aerobic and could be useful for the habitat of other organisms.

Sea cucumbers belonging to the class Holothuroidea are one of the marine invertebrates that are currently widely exploited. Indonesia has been known to have a high diversity of sea cucumber, but data and information are mostly on high-economic-value species. Low-value species belong Malpodida is unexploited therefore is less studied. Sea cucumbers inhabit a wide range of depths and can be found in
a variety of habitats, such as mudflats to rocky reefs. They prefer to live in certain characters of habitat which is related to their feeding and shelter [4]. Therefore, the objective of the research was to identify the species of sea cucumber in the soft-bottom of the Wulan estuary. Understanding the species biodiversity in a particular habitat will help to enhance the management of sea cucumber populations and will allow more precise stock assessments.

2. Materials and Methods
Collection of sea cucumber specimens from the seabed was done using a dredge at 11 sites in the Wulan estuary from depths between 2-20 m (Figure 1). Before being fixed and preserved in 70% denatured ethanol, specimens were anesthetized in a 7.5 percent magnesium chloride solution and live color was observed and noted wherever feasible. A total of 132 specimens were collected, examined, and identified through their morphological characters [5]. Identification was performed according to the following literature [6–14]. Sediment samples of 100 g from each station were also taken, sieved, and weighed to determine their grain size composition.

![Figure 1. The sampling site of sea cucumber in the soft bottom of the Wulan Estuary, Demak, Central Java.](image)

3. Results and Discussion
The Wulan estuary is located in the Demak’s northern region (Figure 1). In this estuary, the sedimentation process from the Wulan River formed the delta. The recharge area of this river is located on the volcanic cone of Muria, Kendeng Hills, and Rembang (which feature karst landforms and partially denuded hills) which are all prone to erosion. The erosion may cause a huge volume of sediments and debris being conveyed by the Wulan River. Due to low wave and current energy, this material is also easily deposited near the mouth of the Wulan River. As a result, the river’s mouth continues to prograde, forming the Wulan Delta, which grows in size every year [6]. The result of grain
size analysis is shown in Figure 2, the content of silt the bottom sediment mostly more than 90%, except the Station 3.

Sea cucumbers, commonly known as holothurians, are members of the class Holothuroidea. The majority of economically harvested species are tropical and belong to the order Aspidochirotida, especially the families of Holothuroidea and Stichopodidae. Commercial fishing is also conducted on a few species belonging to the family Cucumariidae in the ordo of Dendrochirotida [5]. The species sea cucumbers belong to ordo of Apodida, Dactylochirotida, and Elasipodida are not economically fished, while Molpadida species are fished in East Java (Gresik and Surabaya), Madura (Indonesia), and Malaysia for human consumption [15].

The holothuroids found in soft-bottom of the Wulan estuary represent five genera (Acaudina, Colochirus, Holoturia, Paracaudina, and Phyllophorus) in four families (Caudinidae, Cucumariidae, Holothuriidae, and Phyllophoridae) belonging to three ordos (Aspidochirotida, Dendrochirotida, and Molpadida) (Table 1). The species were Acaudina sp., A. molpadioides, Colochirus quadrangularis, Holoturia cf. impatiens, Paracaudina sp., Paracaudina chilensis, P. australis, and Phyllophorus spiculata (Figure 2). The station where the species of sea cucumber were found shown in Table 2.

| No. | Ordo             | Family         | Genus        | Species                  | No. ind. found |
|-----|------------------|----------------|--------------|--------------------------|----------------|
| 1   | Molpadida        | Caudinida      | Acaudina     | Acaudina sp.             | 12             |
| 2   | Molpadida        | Caudinida      | Acaudina     | Acaudina molpadioides    | 34             |
| 3   | Molpadida        | Caudinida      | Paracaudina  | Paracaudina sp.          | 23             |
| 4   | Molpadida        | Caudinida      | Paracaudina  | Paracaudina chilensis    | 15             |
| 5   | Molpadida        | Caudinida      | Paracaudina  | Paracaudina australis    | 18             |
| 6   | Aspidochirotida  | Holoturoiida   | Holoturia    | Holoturia cf. impatiens  | 9              |
| 7   | Dendrochirotida  | Cucumariida    | Colochirus   | Colochirus quadrangularis| 12             |
| 8   | Dendrochirotida  | Phyllophorida  | Phyllophorus | Phyllophorus spiculata   | 9              |

**Tabel 1.** Sea cucumbers from the soft-bottom of Wulan estuary, Demak, Central Java.

| Species                       | Station |
|-------------------------------|---------|
| Acaudina sp.                  | +       |
| Acaudina molpadioides         | +       |
| Colochirus quadrangularis     | -       |
| Holoturia cf. impatiens       | -       |
| Paracaudina sp.               | +       |
| Paracaudina chilensis         | +       |
| Paracaudina australis         | +       |
| Phyllophorus spiculata        | -       |

**Tabel 2.** The species found in each station in Wulan Estuary, Demak, Central Java.
Figure 2. Sea cucumber species sea cucumber found in the soft-bottom of Wulan estuary, Demak (A. *Paracaudina* sp., B. *Paracaudina chilensis*, C. *Paracaudina australis*, D. *Holothuria cf. impatiens*, E. *Acaudina* sp., F. *Acaudina molpadioides*, G. *Phyllophorus spiculata*, H. *Colochirus quadrangularis*).

Figure 3. The percentage of fine sand, silt, and clay in the bottom sediment of sea cucumber sample in Wulan Estuary, Demak.

The species of *Acaudina* sp., *A. molpadioides*, *P. chilensis*, *P. australis*, *Paracaudina* sp. were the member of family Caudinidae and ordo Molpadida. Molpadid sea cucumbers have a fusiform body, narrowing posteriorly to form a conspicuous tail. It has respiratory trees and anal papillae. The ordo Molpadida Haeckel, 1896 has 15 digitate tentacles and a stout body, tapering posteriorly to a tail [16]. It lacks tube feet, although it does have anal papillae, tentacle ampullae, and respiratory trees. The tentacle of the family Caudinidae Heding, 1931 lacks a terminal digit and has one or two pairs of lateral digits; the tail is sometimes hidden [17]. Family Caudinidae contains small to medium sausage-shaped sea cucumbers with a thin body wall and lacking tube feet.[18]. The genus *Acaudina* H. L. Clark, 1908 has a robust and spindle-shaped body with a flattened, thin body wall (Figure 2E). It also has 15 pinnate tentacles were, each with a lateral digits pair. Five sets of anal papillae were formed, each with two to four delicate finger-like papillae [19]. *Acaudina* sp., also called or Sea potato or Smooth sea
cucumber found in soft-bottom of Wulan estuary were 10-15 cm long. The body was cylindrical and smooth, slimy and slippery. One end of its body is usually pointed with short and stubby feeding tentacles in the anterior part. It commonly has a uniform white, purplish, or light orange body, with spots and dull flecks. This Sea potato showed similarity with Acaudina sp. from Surabaya [20]. The sea cucumbers which have pink, smooth, and almost translucent body were also found in the soft bottom of the Wulan Estuary and were identified as A. molpadioides, Semper, 1868 (Figure 2F). The small specimens (juveniles) are transparent. The body of this species is fusiform with a more tapering posterior end compared to the anterior end leading to a clear separation from other sea cucumbers. It has 15 tentacles, because it has not got any tube feet, its body secrets a mucus to collect and stick the food such as debris and other sand particles. Commonly their max length is 15.0 cm [21] but the samples taken from Wulan estuary were up to 20 cm in length. This species of sea cucumbers are easily found in countries of East Asia [22], also around India, and in the Andamans, Pak Bay, and the Gulf of Mannar [23]. This species commonly inhabit the intertidal areas and are rarely found buried in sediment. A. molpadioides is also called Sweet Sea Potato. It has a uniform flesh color body but this color will fade when it is taken out from the water.

Three species of sea cucumbers under the Genus Paracaudina Heding, 1932 were present, i.e. Paracaudina sp., P. chilensis J. Müller, 1850 and P. australis Semper, 1868. The body of Paracaudina sp. is cylindrical with a wrinkled or smooth body wall (Figure 2A). It has got 15 tentacles and a long caudal taper or discrete thin tail in the posterior end of the body. P. chilensis or rat-tailed fusiform sea cucumber has a thin body wall with around 2 mm wide wrinkled long thin tail in its posterior end (Figure 2B). The tail length is approximately one-third of the total body. P. chilensis is a white sea cucumber with a purple cast near the posterior end [19]. It is a small to medium-sized species (to 200 mm). P. australis Semper, 1868 from the Wulan Estuary is a white sea cucumber with a pink cast (Figure 2C). It is a small to medium (50-150 mm), cylindrical species with a tapering caudal appendage. It has short stubby feeding tentacles [18]. The cylindrical and sausage-like body is thin, soft, and smooth tegument. It lacks tube feet, the skin is thin and transparent. The two stripes of muscles that run along the length of the body, as well as its internal organs, may be seen. Because of its slippery and transparent character, P. australis has also been named See-through sea cucumber. The only member of Phyllodocidae Oestergen, 1907 family and ordo of dendrochirotida found in the Wulan Estuary is P. spiculata Chang, 1935 (Figure 2G). This small to medium-sized sea cucumbers has more than 10 tentacles arranged in one to three rings [18]. Its outer tentacles are usually longer and useful for feeding. Its inner ones were shorter used for cleaning. The genera of Phyllophorus Ludwig, 1874 has a brown to grey color [24]. It is a small (25-75 mm), firm species with scattered tube feet. It has 20 tentacles in two rings. P. spiculata is a brownish-grey, small sea cucumber that has irregular papillae. Its tentacles are 20 and arranged in two rings. The appearance resembles with Terung from Kenjeran Waters, Surabaya, which showed similarity to Phyreilla sp. [25].

C. quadrangularis belong to the genus Colochirus Troschel, 1846, Cucumariidae Ludwig, 1894 family, and ordo Dendrochirotida Grube, 1840. This ordo was characterized by branched (dendritic) tentacles and its anterior end of the body was introverted which is associated with retractor muscles [26]. Cucumariidae family is commonly tiny to medium-sized sea cucumbers. It has 10 branching tentacles (Figure 2H). They are filter feeders, catching microorganisms with their tentacles and passing them to their mouths.

The body color of Colochirus is mixed with orange-pink and green. Its body has a thick wall with irregularly quadrangular in the transverse section. Each radius has a single row of conspicuous papillae on the dorsolateral and ventrolateral sides. Tube feet are limited on ambulacral regions of the ventral trivium [19]. C. quadrangularis found in the Wulan estuary was a medium-sized sea cucumber with a length in the range of 6-10 cm. The four longitudinal ridges on the approximately cylindrical body give it a square cross-section and a flat base. Along these ridges, its papillae have irregular, thorn-like, soft projections. Calcareous spike-like features, which comprise basket-shaped spicules and perforated ellipsoids in this species, strengthen the leathery body wall. Around the mouth is a ring of huge, branching feeding tentacles. On the underside, there are three rows of red tube feet, and the body tapers.
C. quadrangularis has a 6-10cm long body, squarish to quadrangular in cross-section with a distinct upper and underside [27]. The below part of its body is flat and has three short-red rows of tube feet. The upper side has soft, harmless conical projections. It also has five small teeth-like projections around the anus. The body is brilliant red or orange, with shades of grey and green or bluish lines running along its length. Feeding tentacles are yellow with tiny brown speckles and red or orange branched tips [28].

C. quadrangular is sometimes is identified as Cercodemas anceps but the body of the latter species has low, warty protuberances rather than thorny projections [29]. The same species was firstly reported in Surabaya waters [30]. Papilla was found on the dorsal surface (bivium) and tube feet were found on the ventral surface (trivium). Specimens found in the Wulan estuary have 5 anal teeth and no tail. Generally, color morphology was identical with the specimen from Camden Sound in northwest Australia [31].

H. cf. impatiens inhabit a soft-bottom substrate of Wulan Estuary is a member of family Holothuriidae and ordo Aspidochirotiota (Figure 2D). Aspidochirotiota holothurians commonly have 15-30 shield-shaped tentacles. The body wall is thick and has respiratory trees. Longitudinal muscles are arranged into five double bands. This sea cucumber usually occurs in exposed shallow-water environments [32].

Body dome-shaped in cross-section with trivium (or sole) is usually flattened and dorsal bivium convex and covered with papillae. Tentacular ampullae are present, long, and slender. While the Holothuriidae family has flattened trivium in the ventral side and convex dorsal bivium [33]. The body wall of the genus Holothuria was thin to thick, with podia distributed irregularly on the bivium and scattered papillae on the trivium.

H. cf. impatiens is a pink and brown sea cucumber with various dark and light transverse color bands as its most frequent pattern. It has a cylindrical and strong flexible tegument body with conspicuous papillae, in ranges of 150 to 400 mm in length. It also has got cuverian tubules which can be expelled [18]. This species is commonly inhabited under the rocks on the flat reef but is somewhat found in Wulan Estuary with the soft-bottom substrate with sand of more than 5% (Figure 2). Further identification has to be made to confirm the species. Preliminary biological information on sea cucumbers species is important in developing their management and conservation [34].

This research was the first attempt to identify the sea cucumber species in a soft-bottom habitat, especially in Wulan Estuary. Bottom sediment properties are one of the most important factors influencing sea cucumber habitat choice [35]. Sea cucumber habitat preferences have been observed to differ between species and even between life stages within the same species [35, 36]. Wulan estuary was experiencing sedimentation which comes from suspended sediments affected by hydrodynamic conditions [1], such as wind, waves, currents, tides, and runs off from Wulan River. The concentration of the suspended sediments from 2016 to 2018 was varied between 60 to 180 mg/l. The development of Delta Wulan followed their distribution, that is, leftward (southwest-south), where the sample of sea cucumbers was taken using a dredge. The species of Acaudina sp., A. molpadioides, C. quadrangularis, H. cf. impatiens, Paracaudina sp., P. chilensis, P. australis, and P. spiculata were successfully identified through their morphological characteristics. Those species were commonly inhabited in soft-bottom areas. The order Malpodiida usually burrow in soft sediment or sand [16]. They extract organic food from the ingested substrate. As a member of this ordo, sluggish sea cucumber of the family Caudinidae burrows in soft sediments. Their attenuate caudal region often was extended to the surface, presumably for respiration for they possess respiratory trees [18]. Acaudina sp. is frequently discovered half appeared on sand bars close to seagrasses [37] but in Wulan estuary they were found in soft-bottom. In Peninsular and Langkawi Island, Malaysia A. molpadioides lives in muddy shores [21, 37, 38]. A. molpadioides or Sea potatoes as benthic organisms live in slightly less saline waters and even could be inhabited in a depth range of 0-330 m [21]. They may be found in a reef, estuarine, and muddy environments, where they serve an important ecological function in cleaning up the seabed by moving, eating, and mixing marine sediments in the same way as earthworms do [22]. The environment where A. molpadioides thrives is unique since the mudflats can be anoxic or have very low levels of soluble oxygen [21]. When the samples of sea cucumber were taken, the black color of the mud and the smell of hydrogen sulfite
indicate an anoxic situation appeared. When it is dissected, its digestive system contains the same black mud. From family Caudinidae, Paracaudina sp., P. chilensis, and P. australis were found in the soft-bottom of the Wulan Estuary with a silt content of more than 90% (Figure 2). According to [39] the area where Paracaudina sp. found mostly consisted of clay and silt. While P. chilensis is a coastal species, buried 10-20 cm below sandy mud [18], in the muddy sand bottom [40] or as infaunal of soft, sandy sediment in the depth of 0–10 m [17]. While P. australis was also found buried in soft intertidal sediments. This species can also be found buried in the sand near seagrasses [18]. It burrows and eats in soft ground, breathing through its anus, which protrudes from the surface [41]. P. australis was fished in Socah Waters (Bangkalan, Madura) [42] and also found in the mudflat and seagrass bed of Pelawan and Tanjung Melolo Waters of Karimun regency of Riau Archipelago Province in the depth of 1 meter [43], and also found buried in soft intertidal sediment of Kenjeran Wares, Surabaya [39, 44]. P. australis was also live floating or partially buried on sand bars in seagrass meadows on the estuarine northern beaches of Singapore and at the mouth of the Johor River [14]. A Tennis-ball sea cucumber, P. spiculata, was found in the soft bottom of Wulan Estuary. As benthic sea cucumbers, they live in the depth range of 0-30 m [45], are aggregated at low tide marks on sandy muddy substrates. It is seen to be partially buried and connected to buried stones or pebbles by its tube feet [24]. Apart from coral reefs, seagrass meadows also serve as one of the important habitats that harbor a large diversity of marine organisms especially sea cucumbers [46]. C. quadrangularis are rarely seen on coral reefs but generally found on sand and gravel substrate of deep water [26], was existed in Socah waters (Bangkalan, Madura) [42], and it also inhabits in soft-bottom of the Wulan estuary. The same species were also observed to predominantly populate in the seagrass bed of Merambong Shoal in the southern tip of Peninsular Malaysia [29]. It is distributed from the temperate waters of Australia and extends to the tropic waters [47] in deeper waters (up to 40m) [48]. This species is generally found on the bottom, where it uses its tube feet to cling to seagrass, tube worm casings, or other projections [41]. C. quadrangularis is a suspension feeder, catching phytoplankton and other organic particles by raising its anterior end and extending its feathery tentacles. The tentacles are subsequently withdrawn one by one, and the food particles are scraped away by the mouthparts [26]. The sea-bottom of Wulan Estuary has the same characteristic as Kenjeran Waters or some area of Madura Strait where seven species of sea cucumbers were found, such as C. quadrangularis, Holothuria sp., H. sanctori, H. forskali, H. turriscelsa, Phyllophorus sp., and P. australis [49, 50]. Of seven species, C. quadrangularis, Phyllophorus sp., and P. australis were dominantly found. The majority of tropical fisheries are multispecies and operated on a small scale or for subsistence. After populations of highly valuable species were exhausted in certain situations, catching sea cucumber has the target to low-value species [5]. Not like other sea cucumbers which generally harvesting is for export [51, 52], the species found in the Wulan estuary have not been processed and sold in the market, but it still needs to be managed to sustain their population.

4. Conclusion
The holothuroids found in soft-bottom of Wulan estuary represent five genera (Acaudina, Colochirus, Holothuria, Paracaudina, and Phyllophorus,) in four families (Caudinidae, Cucumariidae, Holothuriidae, and Phyllophoridae) belonging to three ordos (Aspidochirotida, Dendrochirotida and, Molpadida). The species were Acaudina sp., A. molpadioides, Colochirus quadrangularis, Holothuria cf. impatiens, Paracaudina sp., Paracaudina chilensis, P. australis, and Phyllophorus spiculata. A. molpadioides presented as the most frequently found sea cucumber, it might be related to the substrates.

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