

Study of diet composition in sea cucumber intestines in Socah Waters, Bangkalan Regency

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Abstract. Sea cucumbers, which belong to the Phylum Echinodermata, possess significant potential for cultivation. However, these invertebrates require further investigation concerning various aspects of their cultivation, including their feeding habits and diet composition. Research on the dietary requirements of sea cucumbers aims to identify their primary and supplementary food sources, which can serve as references for the provision of natural feed in future sea cucumber farming efforts. Data collection was conducted through random sampling in the Socah Waters, Bangkalan Regency. Observations of the food type found in the intestines of sea cucumbers revealed the presence of plankton, sediment, and detritus. The plankton species identified in the intestines include *Cyclotella kuantzingiana*, *Chaetoceros densus*, and *Thalassiosira fluviatilis*. The diet composition varied among the three sea cucumber species studied: *Paracaudina australis*, *Phyllophorus* sp., and *Colochirus quadrangularis*. In *Paracaudina australis*, the food composition consists of *Cyclotella kuantzingiana* (55%), *Thalassiosira fluviatilis* (30%), sediment (10%), and detritus (5%). For *Phyllophorus* sp., the composition consists of sediment (70%), detritus (15%), *Thalassiosira fluviatilis* (10%), and *Chaetoceros densus* (5%). In *Colochirus quadrangularis*, the diet comprised *Thalassiosira fluviatilis* (55%), *Cyclotella kuantzingiana* (20%), sediment (15%), and detritus (10%).

1 Introduction

Sea cucumbers, also known as holothurians, are marine invertebrates classified under the Phylum Echinodermata, Class Holothuroidea. They inhabit the sea floor with substrates such as sand, mud, or coral reefs, and exhibit very slow movement. Sea cucumbers may be found almost anywhere in the world's maritime ecosystems, from shallow to deep waters. Because they are benthic, sea cucumbers are found on the ocean floor. On the other hand, their larvae drift in the water with the currents because they are planktonic.

The body shape resembles that of a cucumber, which is why they are often referred to as "sea cucumbers." Different countries have various names for sea cucumbers; in Indonesia, they are commonly called 'teripang,' while in Thailand, they are known as 'plingkao,' in Japan as 'namako,' in China as 'haishen,' in Malaysia as 'trepong,' in France as 'beche de-mer,' and on the international market, they are referred to as 'sandfish' [1].

Although often perceived as unattractive, sea cucumbers play a crucial role in marine ecosystems and possess high economic value [2]. The economic value of a marine organism is partly determined by its nutritional content and the presence of active compounds. Generally, a higher economic value correlates with

greater nutritional and compound content. Sea cucumbers contain 82% protein, 1.7% fat, 8.9% moisture, 8.6% ash, and 4.8% carbohydrates when dried. They are also beneficial for health and pharmaceutical production due to their collagen content, which constitutes up to 80% of their body [3].

Sea cucumbers have a higher economic value compared to other species within the Phylum Echinodermata. They are reported to contain antimicrobial and antifungal substances. Alcohol extracts from holothurians have been shown to inhibit pathogens in humans and shrimp larvae [4], [5], [6]. Triterpene glycosides isolated from sea cucumbers commonly exhibit cytotoxic properties. In addition to cytotoxicity, these compounds also demonstrate antifungal, antiviral, and hemolytic activities [7]. Holothurian species have also been reported to possess antitumor, antifertility, ichthyotoxic, antiviral, antiradiation, and immunomodulatory activities [8], [9], [10].

This unique marine animal is widely distributed around the world and exhibits high species diversity. There is a significant demand for sea cucumbers in countries such as Japan, Korea, Malaysia, Singapore, and China, and the exploitation of these animals is increasing annually, leading to overfishing in certain regions of the Indo-Pacific. Sea cucumber farming could

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meet the rising market demand for beche-de-mer while also helping to boost the dwindling wild sea cucumber population [11], [12], [13]. Indonesia is recognized as the world's largest exporter of sea cucumbers. Sea cucumbers can be found throughout Indonesian waters, including in the waters of Socah, located in Socah Village, Bangkalan Regency, East Java, Indonesia. The species found in the Socah waters include *Paracaudina australis*, *Phyllophorus* sp., and *Colochirus quadrangularis*. These three species have significant potential for cultivation in controlled environments.

To date, the local community in Socah Village has been harvesting sea cucumbers directly from the wild. This practice poses a risk of population decline if exploitation continues without efforts to replenish stocks through cultivation. In fact, sea cucumber farming has been practiced for some time in China, India, and Japan [14]. Despite the variety of sea cucumber species found in Indonesia, many have yet to be cultivated. Since the early 1990s, Indonesia has initiated the breeding of the sandfish sea cucumber, scientifically known as *Holothuria scabra* Jaeger. Although this effort has successfully produced "seed" sea cucumbers, further research is still needed. Various observations and experiments are being conducted to improve the survival rates of larvae until they develop into juvenile sea cucumbers [15].

The process of transforming a wild species into a cultivated one is known as domestication. To master cultivation techniques, it is crucial to study various aspects of the species and its habitat. Hatchery production of tropical sea cucumbers, such as sandfish (*Holothuria scabra*), encounters numerous difficulties. Progress in culturing tropical species lags behind that of temperate ones, necessitating further study on genetic diversity, broodstock management, and spawning methods. Genetic risks emerge from using limited broodstock and artificial fertilization. Moreover, there is insufficient knowledge about the nutritional requirements and feeding strategies for larvae and juveniles. Hatcheries also face issues with diseases and parasites, and recent efforts have been directed at improving disease management and water quality to boost survival rates. Overall, additional research is essential to refine hatchery practices and tackle these technical and biological obstacles [16].

Food content analysis data can provide in-depth insights into the feeding ecology of the biota we are studying. In addition, it also provides information on the availability and demand of resources, potential competition and other aspects of the ecology and biology of the biota that are the objects of study [17].

For sea cucumbers to become a viable commodity, research on their dietary needs is essential. Therefore, studying the food types consumed by sea cucumbers in the Socah waters is crucial for understanding their nutritional requirements and developing effective strategies for sustainable cultivation. Knowledge of the primary food sources for sea cucumbers in Socah will not only support efforts to maintain natural populations but also provide a strong foundation for large-scale cultivation. This research outlines the findings on the

dietary preferences of sea cucumbers in their natural habitat, with the aim of offering valuable insights for the sustainable management of marine resources and the development of sea cucumber farming in controlled environments.

2 Material and methods

2.1 Sample collection

The research on types and composition of food in sea cucumber intestines in Socah Waters was conducted in August-September 2023. The method used in this research was a qualitative descriptive method. Samples of sea cucumbers, specifically *Paracaudina australis*, *Phyllophorus* sp., and *Colochirus quadrangularis*, with ten individuals of each species, were collected using random sampling in the waters of Socah, Bangkalan Regency. Water quality parameters at the habitat site of the sea cucumbers were measured in situ. The parameters measured included temperature, pH, salinity, and dissolved oxygen (DO).

2.2 Identification of food types

The identification of food types in sea cucumbers was carried out at the Marine Biology Laboratory of the University of Trunojoyo Madura. Sea cucumber samples were dissected, and their intestines were removed. The contents of the intestines were then observed using a microscope. Immersion oil was also required for this observation. The sea cucumber intestines were preserved in 10% alcohol for observation the following day.

2.3 Index of preponderance

The index developed by Natarajan & Jhingran in 1961 [18] provides a single value for each attribute based on the frequency of occurrence and quantity of various food types. The Preponderance Index offers a definite and measurable basis for evaluating different dietary elements [19]. The formula for the Preponderance Index used is as follows.

$$IPi = \frac{Vi \times Oi}{\sum Vi \times Oi} \times 100 \quad (1)$$

Description:

V_i is percentage of the volume of food item i

O_i is the percentage of occurrence of given food item i

2.4 Data analysis

All data obtained from interviews were processed using Excel. The percentage of each type of food found in the intestines of sea cucumbers data were then analyzed and described according to the actual conditions.

3 Results and discussion

3.1 Species descriptions

In the Socah Waters, Bangkalan Regency, there are 5 types of sea cucumbers, namely *Colochirus quadrangularis*, *Phyllophorus* sp., *Phyllophorella spiculata*, *Acaudina leucoprocta*, and *Paracaudina australis* [20]. The sea cucumber *Phyllophorus* sp. has a nearly perfect round body shape with a blackish-white color. Its entire body surface is covered with papillae, which results in a rough texture. Like other sea cucumber species, *Phyllophorus* sp. will expel its internal contents when stressed. This finding is consistent with the research by Putri et al. in 2023 [21], which reported that *Phyllophorus* sp. has a round shape, a blackish-white color, and a rough skin surface due to the presence of papillae.



Fig. 1. *Phyllophorus* sp.

Morphometrics of *Phyllophorus* sp., revealing that this species typically measures 3-7 cm in total length or body diameter and weighs between 110-198 grams. *Colochirus* sp. is characterized by its elongated form, reaching 6 to 10 cm in length, with a distinctive red and orange coloration and a body pattern of ridges with papillae. Additionally, the red sea cucumber has tentacles. *Paracaudina australis* also has an elongated shape but is transparent white with white and pinkish-red line patterns [22].



Fig. 2. *Paracaudina australis*.

3.2 Environmental conditions

The waters of Socah in Bangkalan Regency are commonly used by local fishermen to collect sea cucumbers, which are subsequently utilized by the community for various commercial products, such as sea cucumber crackers [22]. Water quality significantly affects the growth and survival of aquatic organisms. Generally, temperature is a key factor for growth, while salinity and dissolved oxygen tend to influence survival rates. The average salinity measured in the waters of Socah was 26.25 ppt. The average temperature of Socah

waters was found to be 31.3°C. Additionally, the dissolved oxygen (DO) level in Socah waters was 6.075 mg/l. The average pH of the Socah waters was 7.5, while the average water clarity was 57.25 cm, and the average depth was 108.5 cm.

The ideal environmental parameters for sea cucumber life are water temperature 27-29 C, salinity 26.2-32.7, DO 5-6 ml/l, pH 6-9, and the ammonia content of the water 70 mg to 430 mg/m³ [23], [24], [25]. Regarding water clarity, in general, sea cucumbers like clear and clean waters with a fine sandy base with protective plants, protected from the movement of the waves, in a detritus-rich environment [26]. The varied environments where sea cucumbers live can significantly impact their growth and survival. For instance, sea cucumber *Stichopus japonicus* thrives optimally at temperatures between 10-15°C, salinities of 28-34 ppt, depths of 5-10 meters, and on muddy stone substrates with less than 20% mud content [27]. Water quality parameters used for the development of the sea cucumber species *Isostichopus fuscus* from fertilization to 35 mm long juveniles included a salinity of 34-35, a temperature range of 22 to 29°C, a pH of 8.4-8.5, and dissolved oxygen levels between 5.4 and 6.1 mg/l [28].



Fig. 3. *Colochirus quadrangularis*.

Optimal salinity and temperature conditions are crucial for maintaining good feeding rates. Conversely, if salinity or temperature levels are too high or too low, sea cucumbers may retreat into deeper mud, cease feeding, and even experience mortality. For juvenile sand sea cucumbers, a salinity range of 29-34 ppt supports growth, survival, and immunity. Salinities of 39 and 44 ppt are not recommended as they make it difficult for sea cucumbers to maintain iso-osmotic balance and survive [29].

3.3 Diet composition

Based on the research conducted in the waters of Socah, Bangkalan Regency, Madura, the Index of Preponderance (IP) calculations for the three sea cucumber species were averaged. The results can be seen in the pie charts presented in Fig. 4 to 6.

The diet composition of these three sea cucumber species reflects their ecological role as both suspension and deposit feeders, which ingest sediment to absorb organic materials. Research shows that *Paracaudina australis*, the primary food source is the plankton *Cyclotella kuantzingiana* (55%), other sources consist of the plankton *Thalassiosira fluviatilis* (30%), sediment (10%), and detritus (5%) (Fig. 4). For *Phyllophorus* sp., Sediment is the most significant component (70%), followed by detritus (15%), *Thalassiosira fluviatilis*

(10%), and *Chaetoceros densus* (5%) (Fig. 5). In the case of *Colochirus quadrangularis*, the primary food is *Thalassiosira fluviatilis* (55%), followed by *Cyclotella kuatzingiana* (20%), sediment (15%), and detritus (10%) (Fig. 6).

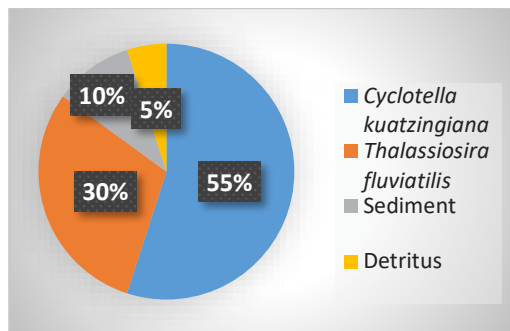


Fig. 4. Diet composition in the intestines of *Paracaudina australis*.

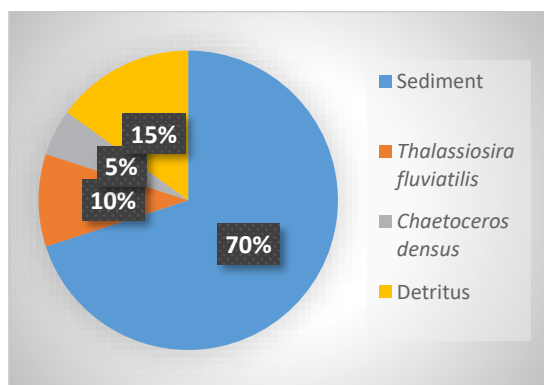


Fig. 5. Diet composition in the intestines of *Phyllophorus* sp.

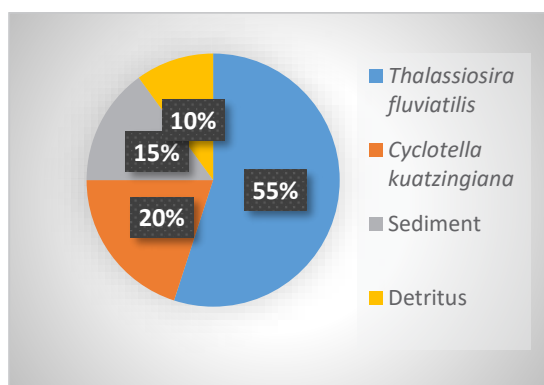


Fig. 6. Diet composition in the intestines of *Colochirus quadrangularis*.

The results show that plankton is the primary food source for sea cucumbers. Being benthic organisms, sea cucumbers consume significant amounts of sediment, which is evident from the sediment and detritus found in their intestines [30]. Most sea cucumbers are suspension or deposit feeders, which eat a lot of sediment and absorb organic material, which is then excreted [31]. To optimize their cultivation, it is essential to replicate their natural feeding environment by incorporating sediment into the cultivation ponds. Sea cucumber is known to feed on detritus and microorganisms found in sediments,

including bacteria and diatoms. The sediment in the sea cucumber habitat is characterized by fine to coarse grains and contains 4.21-6.03% organic matter, primarily detritus, which is crucial for the diet of sea cucumber [32]. National Wildlife Federation stated that as scavengers, sea cucumbers consume plankton floating in the water column and tiny food items found in the benthic zone, or seabed. Their food consists of waste particles, algae, and aquatic animals. Their lips are encircled by tube feet as they feed.

Research on the diets and feeding practices for the tropical sea cucumber larvae is currently inadequate. Although recommendations for using multiple microalgae species, such as *Chaetoceros muelleri*, *Rhodomonas salina*, and *Isochrysis galbana*, exist, recent findings suggest that sandfish larvae might thrive on single-species diets like *Chaetoceros muelleri* alone. This indicates the need for further replicated studies to determine whether simplified diets can be universally effective. Additionally, commercial paste mixes of microalgae, while potentially cost-saving, may settle quickly and require alternative feeding strategies to ensure effective nutrition. Further explanation regarding diets and feeding practices, research shows that lower stocking densities and good sediment management enhance juvenile growth, but cost-effective and scalable nursery methods need further development. Experiments with feeding strategies and enclosure types, both in ponds and at sea, are necessary to optimize growth and survival rates of sea cucumber juveniles [16].

4 Conclusion

Based on the research conducted in the waters of Socah, Bangkalan Regency, it can be concluded that the environmental conditions are highly supportive of sea cucumber life, which is a crucial resource for the local community, particularly for small-scale processed products such as sea cucumber crackers. Water quality measurements indicate that the salinity, temperature, dissolved oxygen, pH, clarity, and depth of Socah waters fall within the range suitable for sea cucumber habitation. Plankton, sediment, and detritus were identified as the primary food sources for sea cucumbers in their benthic habitat.

This study confirms that sea cucumbers in Socah waters tend to be deposit and suspension feeders, with sediment serving as a major organic source. These findings are consistent with previous research showing similar feeding tendencies in other sea cucumber species. Consequently, for the development of sea cucumber cultivation in controlled environments, it is important to consider adding sediment to the bottom of cultivation ponds. A thorough understanding of sea cucumber feeding habits is essential for designing effective and sustainable cultivation strategies.

Future research is expected to optimize sea cucumber cultivation conditions by addressing environmental factors such as food availability and water quality. This could enhance sea cucumber farming

yields and contribute positively to the local economy through the development of value-added sea cucumber products.

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