INDO PAC J OCEAN LIFE
Volume 8, Number 2, December 2024
Pages: 112-121

P-ISSN: 2775-1961
E-ISSN: 2775-1953
DOI: 10.13057/oceanlife/o080206

Structure and composition of Ophiuroidea (Echinodermata) at three beaches in Gunungkidul, Yogyakarta, Indonesia

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Manuscript received: 31 March 2024. Revision accepted: 31 December 2024.

Abstract. *Yap CK, Putri RRA, Manullang RH, Andrianto R, Salsabila S, Nugroho GD, Setyawan AD. 2024. Structure and composition of Ophiuroidea (Echinodermata) at three beaches in Gunungkidul, Yogyakarta, Indonesia. Indo Pac J Ocean Life 8: 112-121.* Ophiuroidea (Echinodermata) contribute significantly to species diversity, abundance, and biomass of the world's marine fauna. The study aimed to determine the composition structure of Ophiuroidea in the coastal area of Gunungkidul, Yogyakarta, Indonesia. It was conducted in March 2024 at Pringjono Beach, Torohudan Beach, and Dadap Ayam Beach, at low tide with a sampling area of about 1,000 m^2 on each beach. We recorded the name of the species, the number of individuals, and description of visible characteristics as well as pH, Dissolved Oxygen (DO), and seawater temperature. The data were analyzed using the density, Shannon-Wiener diversity index (H'), evenness index (E), and richness index (R). We found five species from two families, Ophiocomidae, with *Breviturma dentata* (Müller and Troschel, 1842); *Ophiocoma schoenleinii* (Müller and Troschel, 1842); *Ophiocoma scolopendrina* (Lamarck, 1816); *Ophiocoma erinaceus* (Müller and Troschel, 1842); and Ophiomyxidae, with only one species, *Ophiarachna affinis* (Lütken, 1869). *Breviturma dentata* was the most dominant species, with 495 individuals. Pringjono Beach had the highest density, followed by Torohudan Beach and Dadap Ayam Beach. Then, for H' and E were low, but R was moderate. Water temperature, pH, and DO may affect species density in these areas.

Keywords: Echinodermata, ecosystem, environment, Gunungkidul, Ophiuroidea

INTRODUCTION

Indonesia is an archipelago that is rich in biological resources, this can be seen from the diversity of marine biota (Hasan et al. 2023; Helmiyani et al. 2024). One example of the diversity of marine life in Indonesia is Echinodermata (Nurcahyo et al. 2024; Mustagfirin et al. 2021; Horman et al. 2024; Rindriawaty et al. 2025), especially the Ophiuroidea class. The presence of Echinodermata can be an indicator in determining the balance of marine ecosystems (Hermosillo-Núñez 2020; Patech et al. 2021). In general, Echinodermata reach their highest diversity on coral reefs and shallow beaches because their larvae are pelagic and swim long distances to expand their distribution (Deaker and Byrne 2022; Pereira and Pardal 2024). Echinodermata habitats are influenced by physical and chemical factors (Lawrence 2020; Lestari et al. 2020). These factors include substrate conditions, water quality, and the presence of predators and competitors in the surrounding environment (South et al. 2022).

The Ophiuroidea class is one of the two most species-rich Echinodermata classes (Lessios and Hendler 2022). The Ophiuroidea class is usually found around soft sediments, rocks, corals, sponges, sand, macroalgae, and dead corals (Suwartimah et al. 2017; Nugroho et al. 2018). These habitats provide shelter and food for Ophiuroidea species, allowing them to survive and reproduce. Ophiuroidea distribution diversity can be influenced by environmental factors such as temperature, light, and substrate characteristics (Post et al. 2017). Interactions between these factors often create conditions that favor the survival of different species in different ecosystems.

Echinodermata in Indonesia can be classified into about 1,600 species (Ringvold et al. 2021). A wide variety of Echinodermata species are found in Indonesia, a country that has high biodiversity as it is located at the center of the world's coral regions (Anahau and Ina 2023). Indonesia's strategic position provides ecological benefits in the form of access to global marine biota distribution pathways. The distribution of Echinodermata species is most commonly found on the beaches in Gunungkidul, especially Ophiuroidea species. This is influenced by favorable environmental factors such as water temperature, Dissolved Oxygen (DO), and water pH (Lopo et al. 2023). These stable environmental conditions are the main reason why the area is a favorite habitat for Ophiuroidea. The beaches in Gunungkidul have characteristics of rocky shores, which are suitable as a habitat for Ophiuroidea, which is one of the typical living creatures of rocky shores (Nugroho et al. 2018). According to Buyami et al. (2020), Ophiuroidea is

also found on beaches that have tidal zones, such as the beaches in Gunungkidul. This zone provides dynamic conditions that allow organisms to adapt to environmental changes.

Research on Echinodermata, especially Ophiuroidea in Gunungkidul beaches, has been conducted previously in various locations, such as in the waters of Krakal Beach (Suwartimah et al. 2017), Indrayanti Beach (Nugroho et al. 2018), and Watu Kodok Beach (Tarigan et al. 2020). This research was conducted because the location taken was different from previous studies. This effort aims to complement biodiversity data that has not been thoroughly documented. The beaches are remote and difficult to reach (Nurzaman et al. 2020), making it difficult for researchers to carry the necessary equipment and logistics (Natalia et al. 2020). Another reason is the lack of understanding of the biodiversity, ecology and role of Ophiuroidea in marine ecosystems (Suprapto et al. 2022). In addition, the lack of research on Ophiuroidea in Gunungkidul can also be caused by several factors, including limited resources, lack of researcher interest, or a focus on other species that are considered more important or better known scientifically. However, it is important to remember that each species has a specific role in its ecosystem, including Ophiuroidea. As a result, knowledge of Echinodermata (Ophiuroidea) populations in this region still needs to be improved (Pakpahan et al. 2020). Every ecosystem is unique and interesting to study (Bohnsack et al. 2024). Such ecosystem studies not only provide scientific insights but also contribute to better conservation efforts. The purpose of this study is to determine the composition structure of Echinodermata (Ophiuroidea) in Gunungkidul, namely Pringjono Beach, Torohudan Beach, and Dadap Ayam Beach, Kanigoro Village, Saptosari Sub-district, Gunungkidul, Yogyakarta, Indonesia.

MATERIALS AND METHODS

Study area

Sampling was conducted in March 2024 at Pringjono Beach, Torohudan Beach, and Dadap Ayam Beach, Kanigoro Village, Saptosari Sub-district, Gunungkidul District, Yogyakarta, Indonesia (Figures 1 and 2). Pringjono Beach is located at 8°07'03"S 110°29'57"E, Torohudan Beach at 8°07'20"S 110°30'58"E, and Dadap Ayam Beach at 8°07'13"S 110°30'26"E (Figures 2.A-C; Table 1). Gunungkidul's extraordinary natural beauty is defined by its unique karst landscapes, limestone formations, and extensive cave systems. The region boasts rich biodiversity with rare and endemic species, and features unique hydrological elements like underground rivers and springs. Its distinctive climate shapes the ecosystem, while striking topography includes hills, valleys, and coastal cliffs. Gunungkidul, geographically bordered by Sleman District to the north, the Indian Ocean to the south, Wonogiri District to the east, and Bantul District to the west, exhibits significant natural attractions. These geographic and environmental features contribute to its appeal as a tourist destination, drawing visitors from various regions (Fujiwara et al. 2018).

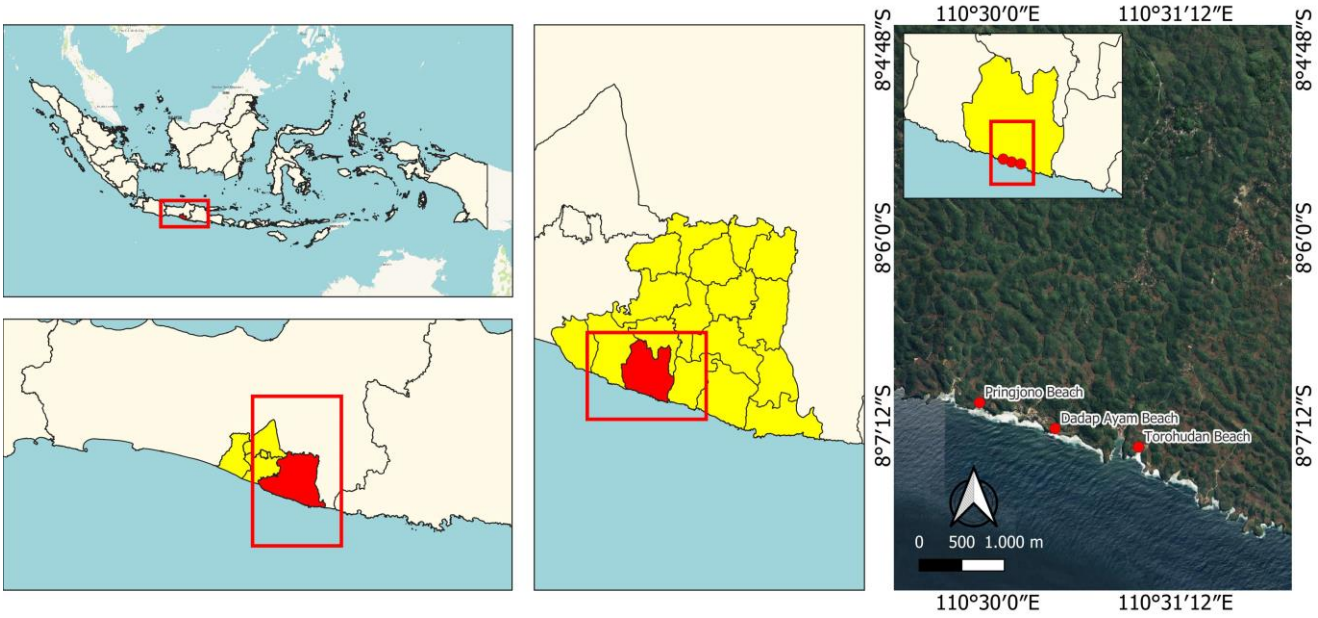

Figure 1. Map of the research location. The research locations were Pringjono Beach, Torohudan Beach, and Dadap Ayam Beach, Kanigoro Village, Saptosari Sub-district, Gunungkidul District, Yogyakarta, Indonesia

Figure 2. Echinodermata (Ophiuroidea) sampling areas: A. Pringjono Beach, B. Torohudan Beach, and C. Dadap Ayam Beach, Kanigoro Village, Saptosari Sub-district, Gunungkidul District, Yogyakarta, Indonesia

Table 1. Location of beach administration

Beach	Coordinates	Administrative location
Pringjono Beach	-8° 7' 4.306" S, 110° 29' 58.146" E	Kanigoro Village, Saptosari District, Gunung Kidul District, Yogyakarta Province, Indonesia
Torohudan Beach	8° 7' 21.226" S, 110° 30' 58.666" E	Kanigoro Village, Saptosari District, Gunung Kidul District, Yogyakarta Province, Indonesia
Dadap Ayam Beach	-8° 7' 13.738" S, 110° 30' 26.809" E	Kanigoro Village, Saptosari District, Gunung Kidul District, Yogyakarta Province, Indonesia

Pringjono Beach has a wide shoreline of soft white sand and is surrounded by coral cliffs formed from andesite and limestone rocks, creating an ideal habitat for a variety of marine species, including the snaking star that is often found among the corals. Torohudan Beach, characterized by steep cliffs and more rugged coral formations, provides rich biodiversity and shelter for fish and marine invertebrates. Dadap Ayam Beach, on the other hand, is known for its more gently sloping and wide beaches, and the presence of more lush coastal vegetation, creating an ecosystem that supports shorebirds and other organisms. The main difference lies in the geologic structure; Pringjono with flat corals, Torohudan with steep cliffs, and Dadap Ayam with a more visitor-friendly sloping beach. All three sites serve as important habitats for the snaking star, which utilizes the crevices between the rocks to hide from predators and find food.

Data collection

Ophiuroidea diversity was observed physically at low tide in a sampling area of about 1,000 m^2 on each beach (Aulia et al. 2021). Sampling, and data collection were carried out in the plot. The sampling procedure involved walking along the beach at low tide, starting from the sandy shore and extending to the farthest observable boundary about 1,000 m^2, employing direct observation. Data collected consisted of the number of Ophiuroidea species found directly in the field, as well as measuring water abiotic factors such as pH, temperature, and Dissolved Oxygen (DO) at each location. Each specimen collected on the beach was counted and documented. The identification of Ophiuroidea was conducted by considering terminology, species, and genus levels (Suwartimah et al. 2017; Setiawan et al. 2019; Tarigan et al. 2020; Tavares et al. 2021).

Data analysis

The data obtained were analyzed using density, diversity index, evenness index, and richness index. Then, value ranges and categories for each index can be seen in Table 2.

Density

Density is the density or number of individuals of a species per unit area (Setiawan et al. 2018). The density formula can be written as follows:

$$Density\ (K) = \frac{number\ of\ individuals}{plot\ area}$$

Shannon Wiener diversity index (H')

The diversity index is a measurement used to calculate the magnitude of species diversity in sampling (Azhari et al. 2018). The diversity index used is the Shannon-Wiener index using the formula:

$$H' = -\Sigma pi \times \ln pi$$

Where:
H': Diversity index
pi: Relative abundance of species
ln: Natural logarithm

Table 2. Value range and categories of diversity, evenness, and richness indices

Index	Value range	Category
Diversity (H')	H'<1.0	Low
	1.0<H'<3.0	Medium
	H'> 3.0	High
Evenness (E)	0.00<E<0.50	Low
	0.50<E<0.75	Medium
	0.75<R<1.00	High
Richness (R)	0.00<R<0.50	Low
	0.50<E<0.75	Medium
	0.75<R<1.00	High

Evenness index (E)

The evenness index describes the number of individuals between species in an invertebrate community (Pertiwi et al. 2020). The more even the distribution of individuals between species, the more ecosystem balance increases. The evenness index was analyzed using the following index:

$$E = H'/\ln S$$

Where:
E: Evenness index
H': Diversity index
ln S: Number of species with E values ranging from 0-1

Richness index (R)

Richness index is a measure of species richness that depends on the direct relationship between the number of species and the logarithm of the sampling area (Dewi et al. 2023). The richness index used is the Margalef richness index with the formula:

$$R = (S - 1)/(\ln (N))$$

Where:
R: Richness index
S: Total number of species
N: Total number of individual

RESULTS AND DISCUSSION

This study found five species from to families, Ophiocomidae and Ophiomyxidae, each displaying unique characteristics and adaptations that enable them to thrive in diverse marine environments (Tables 3; Figure 4). The most dominant family is Ophiocomidae, with the species *Breviturma dentata* (Müller and Troschel, 1842), *Ophiocoma schoenleinii* (Müller and Troschel, 1842), *O. scolopendrina* (Lamarck, 1816), and *O. erinaceus* (Müller and Troschel, 1842). The Ophiomyxidae family is represented by only one species, *Ophiarachna affinis* (Lütken, 1869).

In Table 3, one class was found to be distributed across all three beaches: Ophiuroidea, with a total of five identified species. The species within the class Ophiuroidea: *B. dentata*; *O. schoenleinii*; *O. scolopendrina*; *O. erinaceus*; and *O. affinis* (Figure 3). The Echinodermata identified in this study consist of five species from two families: Ophiocomidae and Ophiomyxidae. The most dominant from three beachs is *B. dentata* with 495 individuals and the lowest density is *O. scolopendrina* with 7 individuals.

Table 3. Echinodermata (Ophiuroidea) species are found in Pringjono Beach, Torohudan Beach, and Dadap Ayam Beach, Kanigoro Village, Saptosari Sub-district, Gunungkidul District, Yogyakarta, Indonesia

Family	Species	Density (ind/1,000m^2)
Ophiocomidae	*Breviturma dentata* (Müller and Troschel, 1842)	495/1,000m^2
Ophiocomidae	*Ophiocoma schoenleinii* (Müller and Troschel, 1842)	71/1,000m^2
Ophiocomidae	*Ophiocoma scolopendrina* (Lamarck, 1816)	7/1,000m^2
Ophiocomidae	*Ophiocoma erinaceus* (Müller and Troschel, 1842)	55/1,000m^2
Ophiomyxidae	*Ophiarachna affinis* (Lütken, 1869)	21/1,000m^2

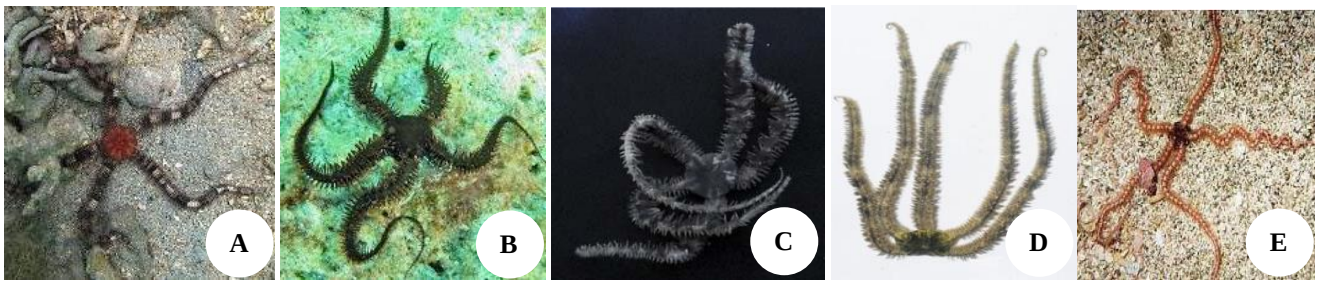

Figure 3. Echinodermata (Ophiuroidea) in this research: A. *Breviturma dentata* (Source: Luthfi 2021); B. *Ophiocoma schoenleinii* (Source: Lesawengan et al. 2019); C. *O. erinaceus* (Source: Triana et al. 2015); D. *O. scolopendrina* (Source: Setiawan et al. 2019); E. *Ophiarachna affinis* (Source: Suwartimah et al. 2017)

The calculation results of the ecological index are grouped into three categories: diversity index, evenness index, and species richness index. In Table 4, the analysis results indicate that the diversity levels at the three beaches are relatively low. The diversity index values for each beach are as follows: Pringjono Beach is 0.63, Torohudan Beach is 0.57, and Dadap Ayam Beach is 0.74. Furthermore, in Table 5, the analysis results reveal that the evenness levels at the three beaches are also relatively low. The evenness index values for each beach are: Pringjono Beach is 0.46, Torohudan Beach is 0.43, and Dadap Ayam Beach is 0.41. Additionally, based on Table 6, the three beaches exhibit moderate species richness levels. The species richness index values in Pringjono Beach is 0.52, Torohudan Beach is 0.55, and Dadap Ayam Beach is 0.66, respectively.

In Table 7, the research locations at the three beaches included measurements of several abiotic environmental parameters based on the diversity of brittle stars. The results of this study were obtained through measurements of water temperature, pH, and Dissolved Oxygen (DO) at the three beaches serving as research sites. The water temperature measurements at the three beach locations showed the following results: Pringjono had a water temperature of 27-30.8°C, Torohudan recorded 28-30.3°C, and Dadap Ayam measured 28-30.1°C. Next, the pH measurements at the sampling locations were as follows: 6.98-7.92 at Pringjono, 8.26-8.55 at Torohudan, and 8.26-8.38 at Pantai Dadap Ayam. The DO measurements for the samples were 0.70-2.31 mg/L at Pringjono, 0.30-0.49 mg/L at Torohudan, and 0.49-1.70 mg/L at Dadap Ayam. The measurements of these abiotic environmental parameters were conducted using appropriate tools for each parameter being measured.

Discussion

Species found

The species *B. dentata* is distinguished by its circular disc shape, which is dorsally flattened and covered with small, rounded granules that obscure the underlying scales and radial shields (Pillai and Biju Kumar 2019). According to Setiawan et al. (2018), *B. dentata* is found in tropical and subtropical waters around the world and is known for its ability to inhabit a variety of habitats, ranging from coral reefs to rocky shores (O'Hara et al. 2019). The species *O. schoenleinii* has unique morphological characteristics, including a distinctive pattern of spines on its body. *Ophiocoma schoenleinii* species is found in the Indo-Pacific region and is known for its ability to inhabit deep sea environments. The species *O. scolopendrina* is characterized by its dark dorsal body and light ventral body (Biserova et al. 2023). This species is known for its ability to inhabit crevices or beneath the margins of intertidal reef platforms. *Ophiocoma scolopendrina* can also reproduce throughout the year and is known to have a symbiotic relationship with other organisms The habitat of *O. scolopendrina* is restricted to intertidal environments in the Indo-Pacific (Triacha et al. 2021). Like *O. scolopendrina*, *O. erinaceus* species are also found in tropical and subtropical waters. The species *O. erinaceus* may have a unique way of gathering food and reproducing. *Ophiocoma erinaceus* has a unique way of collecting food by using its long, slender arms equipped with cilia to capture food particles from the surface of the substrate (Byrne et al. 2024). In addition, *O. erinaceus* prefers habitats with bottom substrates of mixed mud and fine sand (Nurdiansah and Supono 2017). The family Ophiomyxidae is represented by one species, *O. affinis*, which is characterized by its unique body shape and is longer than other species in this class. The species *O. affinis* is found in the tropical and subtropical waters, especially in the Indian Ocean and western Pacific Ocean. This species usually lives on coral reefs, rocky bottoms, and sometimes in sandy areas at varying depths (Lawere et al. 2023). They often hide in rock crevices or under coral during the day and become more active at night.

Table 4. Diversity index (H')

Location	Diversity index value (H')	Category
Pringjono Beach	0.63	Low
Torohudan Beach	0.57	Low
Dadap Ayam Beach	0.74	Low
Total	0.24	Low

Table 5. Evenness index (E)

Location	Evenness index (E)	Category
Pringjono Beach	0.46	Low
Torohudan Beach	0.43	Low
Dadap Ayam Beach	0.41	Low
Total	0.15	Low

Table 6. Richness Index (R)

Location	Richness index (R)	Category
Pringjono Beach	0.52	Medium
Torohudan Beach	0.55	Medium
Dadap Ayam Beach	0.66	Medium
Total	0.62	Medium

Table 7. Environmental parameter results

Location	Water temperature (°C)	pH of water	DO water (mg/L)
Pringjono Beach	27-30.8	6.98-7.92	0.70-2.31
Torohudan Beach	28-30.3	8.26-8.55	0.30-0.49
Dadap Ayam Beach	28-30.1	8.26-8.38	0.49-1.70

Species density

The highest number of individuals per 1,000 m^2 was *B. dentata,* with 495 individuals per 1,000 m^2, while *O. scolopendrina* had the lowest, with seven individuals per 1,000 m^2. Factors such as water temperature, and water quality are known to affect the health and survival of Ophiuroidea, thus explaining the low number of individuals on the three beaches. Although starfish do not have many well-defined sense organs, they are sensitive to touch, light, temperature, orientation, and the status of the water around them (Rahman et al. 2018). Density also affects the physical and chemical properties of materials and has important implications in various materials applications. Species density is obtained by counting the number of individuals of a species present in a given area, usually in units such as hectares, and dividing it by the area. Species density in a given area can vary based on its locational conditions (Pretzsch and del Río 2020). Species density and the number of species in a plot are of a fixed size and will increase with the total habitat area in the local landscape surrounding the plot (Watling et al. 2020).

Morphology description (Figure 3)

Breviturma dentata (Müller and Troschel, 1842) (Figure 3.A)

The body of *B. dentata* is flat and round, featuring five long and slender arms. The central disk measures between 1 to 2 cm in diameter, while the arms can extend up to 10 cm in length. The color ranges from light brown to black, often adorned with spots or stripes. Its surface is rough, entirely covered with short, blunt spines. *Breviturma dentata* exhibits radial pentamerous symmetry similar to that of a typical starfish, but with a harder texture. This hardness is due to the presence of calcareous plates containing calcium carbonate and magnesium carbonate, making its texture more rigid compared to that of a regular starfish. The pentamerous radial symmetry is clearly visible, with sharp grooves between the five parts, ensuring that damage to one part does not affect the others. The arrangement of the body parts in *B. dentata* is consistent, with spines distributed evenly, each being short, blunt, and hard (Luthfi 2021).

Ophiocoma schoenleinii (Müller and Troschel, 1842) (Figure 3.B)

Ophiocoma schoenleinii, or often known as the snake star, is a species of Ophiuroid that has distinctive characteristics that differentiate it from other members. In general, *O. schoenleinii* has a flat, pentagonal body shape (like a pentagonal star) with five long, slender, and flexible arms, which can reach up to 30 cm. The size of the disk can reach up to 2-3 cm in diameter, while the arms can extend up to 10 cm. The arms are covered with small scales that give a rough texture to the surface of the body. Its body color varies, usually consisting of a combination of white, brown, gray, and yellow, which functions as camouflage among the substrate where it lives. The center of the body, or disk, is usually round and has a smaller diameter than the arms, with gaps that facilitate movement. The surface of the body is coarse-grained on top, with small, blunt spines covering the entire body. The species *O. schoenleinii* is also known for its extraordinary regeneration abilities, allowing them to repair limbs lost due to predators or injury. Its natural habitat includes coral reef areas and rocky substrates in tropical waters, where it functions as a detritus feeder, filtering food from passing water. The existence of this species in the ecosystem is very important because it helps maintain the balance of the marine environment (Lesawengan et al. 2019).

Ophiocoma erinaceus (Müller and Troschel, 1842) (Figure 3.C)

This starfish is characterized by a disc with a diameter of about 2-3 cm covered with black grains on the aboral part. In the mouth there are dental papillae and a series of oral papillae. This starfish has five simple arms with cigar-shaped upper arm bones, slender and up to 12 cm long. The species *O. erinaceus* has two tentacle scales on the ventral side. This sea star sample was found to be medium sized and black with brown spots. Its surface is covered with small, sharp spines. The classification of this marine biota is: Kingdom Animalia, Phylum Echinodermata, Class Ophiuroidea, Order Ophiurida, Family Ophiocomidae, Genus *Ophiocoma*, Species *O. erinaceus* (Figure 3.C). The distribution of *O. erinaceus* includes Saipan, Maldives, eastern India, Indian Ocean, Mascarene, Madagascar, Arabia, northern Australia, Philippines, China, southern Japan, southern Pacific, Hawaii, Indo-Pacific Ocean, and Red Sea (Triana et al. 2015).

Ophiocoma scolopendrina (Lamarck, 1816) (Figure 3.D)

Ophiocoma scolopendrina, known as the spotted snake star or scaly snake star, is a member of the class Ophiuroidea. It has five arms up to 15 cm long with short, pointed spines for protection and movement on the rocky seabed. Its body is small, disc-shaped with a diameter of 1-2 cm, and has a striped color pattern for camouflage. This animal is able to regenerate lost arms and has high mobility to find food and avoid danger. As detritivores, they feed on small organic particles in marine sediments. Its habitat is in the intertidal zone to several meters deep, often under rocks or coral reef crevices. Advanced sensory systems allow them to detect environmental changes, making them a successful and widespread species of star snake in tropical and subtropical marine areas (Lestari et al. 2020).

Ophiarachna affinis (Lütken, 1869) (Figure 3.E)

Ophiarachna affinis has a cream-colored base and spines on the arms, which are usually white and gray extending to the ventral spines. The arm length reaches up to 9 cm with a disc diameter of 2.5 cm. The arm pattern is cream and gray with dark stripes, and it is a benthic animal (Sloan et al. 1979). Its habitat is found in shallow waters in coral rubble areas. The distribution ranges in tropical waters, in the Pacific Ocean up to a depth of 25 m, the Red Sea, Eastern Pacific, Eastern India, the Philippines, South Pacific, and Australia (Nurafni et al. 2019).

Ecological index

Diversity index (H')

Diversity index (H') value for each beach location has a low category value (Table 4). Pringjono Beach has a value of 0.63, Torohudan Beach with 0.57, and Dadap Ayam Beach with 0.74. Meanwhile, the three beaches combined had a value of 0.24 (low). The main cause of the low diversity category in all locations is likely due to factors that limit species diversity in these areas. It could be due to environmental disturbances, habitat degradation, or pressures from human activities such as pollution and global warming. Research by Budiman et al. (2014) showed that the number of species or individuals influences the high or low diversity index (H') of species, the presence of abundant species, substrate homogeneity, and the condition of three important ecosystems in coastal areas such as seagrass beds, coral reefs, and mangrove forests as habitat for aquatic biota. In addition, research by Jiao et al. (2019) also showed that the diversity index (H') has a high value if all individuals come from different genera or species, while the lowest value occurs if all individuals come from one genus or species with an even distribution. Therefore, irregularity in the distribution of individuals can lead to low diversity.

Evenness index (E)

The evenness index (E) values for Pringjono Beach, Torohudan Beach, and Dadap Ayam Beach are 0.46, 0.43, and 0.41, respectively, with all three in the low category (Table 5). If calculated in total from the 3 beaches, it also produces a value that is included in the low category, namely 0.15. Research conducted by Soliha and Rahayu (2018) shows that the uneven distribution of individuals of each species causes the low evenness index in habitats. It is because there is only one species that lives very abundantly in the number of individuals on the three beaches; the most dominating is *O. dentata*. If the species found in a community have an unequal number of individuals of each species, then the evenness in the community is low. The unevenness of the Ophiuroidea species is thought to be caused by the distribution of the number of individuals of each species not spreading evenly or caused by physical-chemical environmental factors (Kambey et al. 2015).

Another factor that supports *B. dentata* species as the most commonly found species compared to other species is the ecological and habitat conditions that support the needs of this species (Pakpahan et al. 2020). *Breviturma dentata* is a brittlestar species that is usually found in areas with hard substrates, such as boulders, bedrock, and gravel, in areas exposed to water with some water movement (Kaharudin et al. 2023). This species was also found in moderate areas exposed to water with some water movement. This condition is in accordance with the needs of this species, which requires a hard substrate to live and is exposed to water with some water movement. The beaches used as research sites also have substrate characteristics in the form of sand and dead coral beds that are overgrown with macroalgae (Komala et al. 2024).

Richness index (R)

Richness index (R) value for each beach location has a medium category value, namely: Pringjono Beach with a value of 0.52; Torohudan Beach with a value of 0.55, and Dadap Ayam Beach has a richness index (R) value of 0.66 (Table 6). The total of three beaches have a richness index (R) value of 0.62, which is also included in the medium category. Research conducted by Dharma et al. (2019) showed that the moderate Richness Index in marine animals was due to several factors. First, the richness index (R) is influenced by the value of diversity, which in some studies, as in this study, is in the medium category. Second, the richness index is also influenced by the dominance value. However, if the dominant species at each point is a relatively rare species, then the richness index can be in the moderate category. In addition, the richness index is also influenced by the distribution pattern of the species. If the distribution pattern is not too homogeneous, then the richness index can be in the medium category. In general, species richness in a community is strongly influenced by various interrelated factors, especially by environmental quality, both physically and chemically (Binambuni et al. 2019).

As well as research conducted by Jalaluddin and Ardeslan (2017) found that Ophiuroidea consists of one species with 76 individuals. The species found was *O. erinaceus*, and the research was conducted in the coastal waters of Sembilan Village, West Simeulue Sub-district, Simeulue District, Indonesia. This area is known to have a variety of habitats, such as coral reefs, rocks, and sand. In addition, in research conducted by Lestari et al. (2020) in Seupang Beach, Lebak District, Banten, Indonesia, two species of Ophiuroidea were found, namely *O. scolopendrina* and *O. nigra*, with the number of individuals totaling 803 and 216, respectively. In the last study conducted by Turner et al. (2021), the research and sampling locations were at Tebing Beach, Indonesia, where two species were found, namely *O. erinaceus* and *O. scolopendrina*, with the number of individuals being six and one, respectively. When compared to the research at Pringjono Beach, Torohudan Beach, and Dadap Ayam Beach, five species of Ophiuroidea were found, including *O. dentata*, *O. affinis*, *O. schoenleinii*, *O. erinaceus*, and *O. scolopendrina*, with a total number of individuals of 495, 21, 71, 7, and 55, respectively, spread across the three Gunungkidul beaches. These findings indicate significant species diversity in the region, which may expand the understanding of the geographical distribution and abundance of these species and try to understand the environmental factors that influence the presence of the five species.

Environmental factors

The study was conducted at three beaches that had several abiotic environmental parameters measured. The physicochemical parameters of the waters have a major impact on the presence of species in the ecosystem. From the data listed in Table 7, the results of temperature measurements at the three beaches show that Pringjono Beach has a temperature of 27-30.8°C, Torohudan Beach has a temperature of 28-30.3°C, and Dadap Ayam Beach

has a temperature of 28-30.1°C. This finding is in line with research by Olsen et al. (2015), which states that the optimal water temperature for Ophiuroidea life ranges from 25 to 30°C. Based on temperature parameters, the three beaches are still suitable as habitats for Ophiuroidea despite being in extreme environmental conditions, with the highest tolerance limit reaching 35°C. If the water temperature exceeds 35°C, marine animals are likely to experience stress.

Other environmental factors that affect Ophiuroidea growth, such as water pH, were also measured in this study (Malik et al. 2023). Water pH is important to measure because it affects many aspects of aquatic ecosystems, including the health and growth of organisms. In addition, water pH can affect the solubility and availability of nutrients as well as the toxicity of dangerous chemicals (Alengebawy et al. 2021). The pH measurement results showed that Pringjono Beach had a pH of 6.98-7.92, Torohudan Beach had a pH of 8.26-8.55, and Dadap Ayam Beach had a pH of 8.26-8.38. According to Sahetapy et al. (2014), Ophiuroidea can live in seawater with a pH range between 7 and 8.5. Therefore, the pH in the three beaches is considered normal for Ophiuroidea growth. In addition, Dissolved Oxygen (DO) levels were measured. Pringjono Beach has a DO of 0.70-2.31, Torohudan Beach has a DO of 0.30-0.49, and Dadap Ayam Beach has a DO of 0.49-1.70. Based on Sutisna's research (2018), Ophiuroidea requires a minimum DO level of around 4 to 6 mg/L to maintain health and survival. The measurement results show that DO conditions on the three beaches are far below the threshold required for Ophiuroidea life, which is likely to be a contributing factor to the limited number of species in this study.

In conclusion, this study identified five species of Ophiuroidea from two families, Ophiocomidae and Ophiomyxidae. The five species found were *B. dentata, O. affinis, O. schoenleinii, O. erinaceus,* and *O. scolopendrina.* The species *B. dentata* was observed to be the most dominant species, with 495 individuals per 1,000 m^2. Pringjono Beach had the highest density, followed by Torohudan Beach and Dadap Ayam Beach. Ophiuroidea in the three beaches had diversity index (H') and evenness index (E), which were classified as low, while the richness index (R) was classified as moderate. Environmental factors such as water temperature, water pH, and DO may affect species density in these areas. In the future, it is important to continuously monitor and understand the complex interactions between organisms and their environment for the preservation of a balanced coastal ecosystem.

REFERENCES

Alengebawy A, Abdelkhalek ST, Qureshi SR, Wang MQ. 2021. Heavy metals and pesticides toxicity in agricultural soil and plants: Ecological risks and human health implications. Toxics 9 (3): 42. DOI: 10.3390/toxics9030042.

Anahau SR, Ina AT. 2023. Keanekaragaman jenis landak laut kelas Echinoidea di Pantai Kadahang Kabupaten Sumba Timur. Bioscientist: Jurnal Ilmiah Biologi 11 (1): 412-420. DOI: 10.33394/bioscientist.v11i1.7477. [Indonesian]

Aulia ED, Muzaki FK, Saptarini D, Setiawan E, Setiamarga D, Lutvianti ID, Rosyidah SK, Muhammad NA. 2021. Diversity of sea cucumber from intertidal area of Pacitan and Bangkalan, East Java, Indonesia. Biodiversitas 22 (4): 2136-2141. DOI: 10.13057/biodiv/d220463.

Azhari A, Kamal S, Agustina E. 2018. Keanekaragaman spesies burung di kawasan Taman Hutan Raya Pocut Meurah Intan Aceh Besar. Prosiding Seminar Nasional Biologi, Teknologi dan Kependidikan 5 (1): 180-186. DOI: 10.22373/pbio.v5i1.2141. [Indonesian]

Binambuni P, Langoy M, Katili DY. 2019. Keanekaragaman jenis bintang laut di Pantai Bahowo Kecamatan Bunaken Kota Manado Sulawesi Utara. Pharmacon 8 (1): 65-72. DOI: 10.35799/pha.8.2019.29238. [Indonesian]

Biserova NM, Kutyrev IA, Saitov VR, Kolesnikov IA. 2023. The neuro-exocrine secretion: A new type of gland in tapeworms? Zoology 160: 126119. DOI: 10.1016/j.zool.2023.126119.

Bohnsack R, Rennings M, Block C, Bröring S. 2024. Profiting from innovation when digital business ecosystems emerge: A control point perspective. Res Policy 53 (3): 104961. DOI: 10.1016/j.respol.2024.104961.

Budiman CC, Maabuat PV, Langoy ML, Katili DY. 2014. Keanekaragaman Echinodermata di Pantai Basaan Satu Kecamatan Ratatotok Sulawesi Utara. Jurnal MIPA 3 (2): 97-101. DOI: 10.35799/jm.3.2.2014.5859. [Indonesian]

Buyami B, Suratno S, Prihatin J. 2020. Diversity of Asteroidea on Gili Ketapang Beach Probolinggo Regency and its use as popular scientific book. Pancaran Pendidikan 9 (4): 31-38. DOI: 10.25037/pancaran.v9i4.312.

Byrne M, Cisternas P, O'Hara T, Selvakumaraswamy P. 2024. Evo-devo in the ophiuroid family Ophiocomidae. Invertebr Biol 143 (2): e12432. DOI: 10.1111/ivb.12432.

Deaker DJ, Byrne M. 2022. Crown of thorns starfish life-history traits contribute to outbreaks, a continuing concern for coral reefs. Emerg Top Life Sci 6 (1): 67-79. DOI: 10.1042/ETLS20210239.

Dewi MAK, Aurina DM, Faturrahman AD, Fatikha LA, Rachmalia F, Ainaya FA, Kinanthi A, Rohman CM, Fadzilah FPA, Pramudita DA, Ramadhan MF, Mahajoeno E, Nugroho GD, Sujarta P, Dadiono MS, Yap CK, Rahim KABA, Setyawan AD. 2023. Ecological index and economic potential of Mollusks (Gastropods and Bivalves) in Ayah Mangrove Forest, Kebumen District, Indonesia. Biodiversitas 24 (2): 1231-1241. DOI: 10.13057/biodiv/d240265.

Dharma A, Lestari F, Susiana S. 2019. Struktur komunitas dan sebaran bintang laut di perairan Desa Pengudang Kabupaten Bintan. Jurnal Akuatiklestari 3 (1): 31-35. DOI: 10.31629/akuatiklestari.v3i1.973. [Indonesian]

Fujiwara T, Awang SA, Widayanti WT, Septiana RM, Hyakumura K, Sato N. 2018. Socioeconomic conditions affecting smallholder timber management in Gunungkidul District, Yogyakarta, Indonesia. Small-Scale For 17: 41-56. DOI: 10.1007/s11842-017-9374-1.

Hasan V, Baptista Y, Mamat NB, Vieira LO, Ottoni FP, South J. 2023. First records of Segura's throatspine gudgeon *Belobranchus segura* Keith, Hadiaty & Lord 2012 (Gobiiformes: Eleotridae) in Sumatra, Indonesia. CYBIUM Intl J Ichthyol 47 (4): 473-475. DOI: 10.26028/cybium/2023-013.

Helmiyani NA, Suryanti S, Purwanti F. 2024. Community structure of sea cucumber (Echinodermata: Holothuroidea) resources in the Kepulauan Seribu National Park, Indonesia. Biodiversitas 25 (1): 344-354. DOI: 10.13057/biodiv/d250140.

Hermosillo-Núñez BB. 2020. Contribution of echinoderms to keystone species complexes and macroscopic properties in kelp forest ecosystems (northern Chile). Hydrobiologia 847 (3): 739-756. DOI: 10.1007/s10750-019-04134-8.

Horman CA, Manu GD, Sangari JR. 2024. The abundance of sea cucumber species in the waters of the wet laboratory of East Likupang, North Minahasa. Jurnal Ilmiah PLATAX 12 (1): 70-75. DOI: 10.35800/jip.v12i1.53189.

Jalaluddin J, Ardeslan A. 2017. Identifikasi dan klasifikasi phylum Echinodermata di Perairan Laut Desa Sembilan Kecamatan Simeulue Barat Kabupaten Simeulue. J Biol Educ 6 (2): 81-97. DOI: 10.32672/jbe.v6i2.435. [Indonesian]

Jiao S, Li Q, Zai X, Gao X, Wei G, Chen W. 2019. Complexity of bacterial communities within the rhizospheres of legumes drives phenanthrene degradation. Geoderma 353: 1-10. DOI: 10.1016/j.geoderma.2019.06.019.

Kaharudin HA, Ananda GA, Prasetya WH, Wibisono MW, Yuwono JSE. 2023. Hunter-gatherers in labyrinth karst: An early Holocene record

from Gunung Sewu, Java. Archaeol Res Asia 33 (1): 2352-2267. DOI: 10.1016/j.ara.2022.100427.

Kambey AG, Rembet UNWJ, Wantasen AS. 2015. Komunitas Echinodermata di daerah intertidal perairan Pantai Mokupa Kecamatan Tombariri Kabupaten Minahasa. Jurnal Ilmiah Platax 3 (1): 10-15. DOI: 10.35800/jip.3.1.2015.13212. [Indonesian]

Komala R, Isfaeni H, Rizal M, Setyasih BR, Angelita D. 2024. The correlation between abundance of macroalgae and echinoderms at Sepanjang beach, Gunungkidul-Yogyakarta. AIP Conf Proc 2982: 050007. DOI: 10.1063/5.0183832.

Lawere MS, Kaligis EY, Lumuindong F, Darwisito S, Ompi M, Mamangkey NFG. 2023. Identifikasi jenis dan keanekaragaman Echinodermata di rataan perairan sekitar Desa Tambala Kecamatan Tombariri Kabupaten Minahasa. Jurnal Pesisir dan Laut Tropis 11 (3): 243-254. DOI: 10.35800/jplt.11.3.2023.53706. [Indonesian]

Lawrence JM 2020. Mass mortality of echinoderms from abiotic factors. In: Jangoux M (eds.). Echinoderm Studies 5 (1996). CRC Press, Boca Raton. DOI: 10.1201/9781003077909-3.

Lesawengan S, Langoy ML, Wahyudi L. 2019. Keanekaragaman bintang mengular (Ophiuroidea) di perairan Desa Mokupa, Kecamatan Tombariri, Kabupaten Minahasa. Pharmacon 8 (3): 607-611. [Indonesian]

Lessios HA, Hendler G. 2022. Mitochondrial phylogeny of the brittle star genus *Ophioderma*. Sci Rep 12 (1): 5304. DOI: 10.1038/s41598-022-08944-0.

Lestari Y, Munarti M, Kurniasih S. 2020. Inventarisasi keanekaragaman Echinodermata di Pantai Seupang sebagai media pembelajaran biologi. J Biol Educ Res (JBER) 1 (1): 33-40. DOI: 10.55215/jber.v1i1.2634. [Indonesian]

Lopo MY, Djalo A, Sepe FY. 2023. Keanekaragaman keanekaragaman jenis Echinodermata di zona litoral Pantai Oesina Kecamatan Kupang Barat Kabupaten Kupang. JBIOEDRA: Jurnal Pendidikan Biologi 1 (2): 101-111. [Indonesian]

Luthfi MJF. 2021. Morphology and anatomy histology of brittle star (*Ophiocoma dentata*). Proc Intl Conf Sci Eng 21 (4): 115-118

Malik A, Minsaris LOA, Anzani L. 2023. Pengaruh perbedaan modul transplantasi karang terhadap pertumbuhan karang di Pulau Pramuka. Juvenil: Jurnal Ilmiah Kelautan dan Perikanan 4 (2): 90-103. [Indonesian]

Mustagfirin M, Wijayanti DP, Subagiyo S. 2021. Reproductive activity and morphometric assessment of three commercial species of sea cucumber (Echinodermata) from Karimunjawa National Park, Indonesia. Biodiversitas 22 (8): 3333-3341. DOI: 10.13057/biodiv/d220829.

Natalia CY, Karini NMO, Mahadewi NPE. 2020. Pengaruh aksesibilitas dan fasilitas terhadap kepuasan wisatawan ke Broken Beach dan Angel's Billabong. Jurnal IPTA 8 (1): 10-17. DOI: 10.24843/IPTA.2020.v08.i01.p02. [Indonesian]

Nugroho PER, Purnomo PW, Suryanti S. 2018. Biodiversitas Echinodermata berdasarkan tipe habitatnya di Pantai Indrayanti, Gunungkidul, Yogyakarta. Manag Aquat Resour J (MAQUARES) 6 (4): 409-414. DOI: 10.14710/marj.v6i4.21330. [Indonesian]

Nurafni N, Muhammad SH, Sibua I. 2019. Keanekaragaman Echinodermata di Perairan Pulau Ngele Ngele Kecil, Kabupaten Pulau Morotai. Jurnal Ilmu Kelautan Kepulauan 2 (2): 74-83. [Indonesian]

Nurcahyo FD, Zen HM, Husna'putri NA, Nugroho GD, Ramdhun D, Yap CK, Indrawan M, Setyawan AD. 2024. The community structure of Echinodermata (Echinoidea and Holothuroidea) on seagrass ecosystem in Gunungkidul, Yogyakarta, Indonesia. Biodiversitas 25 (11): 4561-4571. DOI: 10.13057/biodiv/d251155.

Nurdiansah, Supono. 2017. Keanekaragaman bintang mengular Ophiuroidea di Perairan Pulau Talise, Sulawesi Utara. Jurnal Ilmu dan Teknologi Kelautan Tropis 9 (2): 709-716. DOI: 10.29244/jitkt.v9i2.19303. [Indonesian]

Nurzaman A, Shaw R, Roychansyah MS. 2020. Measuring community resilience against coastal hazards: Case study in Baron Beach, Gunungkidul District. Progress Dis Sci 5: 100067. DOI: 10.1016/j.pdisas.2020.100067.

O'Hara TD, Hugall AF, Cisternas PA, Boissin E, Bribiesca-Contreras G, Sellanes J, Paulay G, Byrne M. 2019. Phylogenomics, life history and morphological evolution of ophiocomid brittlestars. Mol Phylogenet Evol 130: 67-80. DOI: 10.1016/j.ympev.2018.10.003.

Olsen TB, Christensen FEG, Lundgreen K, Dunn PH, Levitis DA. 2015. Coelomic transport and clearance of durable foreign bodies by starfish (*Asterias rubens*). Biol Bull 228 (2): 156-162. DOI: 10.1086/BBLv228n2p156.

Pakpahan HL, Irwani I, Widowati I. 2020. Komposisi dan kelimpahan Ophiuroidea dan Echinoidea di Perairan Pantai Pok Tunggal, Gunungkidul, Yogyakarta. J Mar Res 9 (2): 109-118. DOI: 10.14710/jmr.v9i2.26101. [Indonesian]

Patech LR, Dewi KR, Zulhalifah Z, Syukur A, Jamaluddin. 2021. The perceptions of local community's about diversity of mangrove ecological potential for ecotourism development in the south coast of Lombok Island, Indonesia. Jurnal Biologi Tropis 21 (2): 480-495. DOI: 10.29303/jbt.v21i2.2741.481.

Pereira L, Pardal MA. 2024. Introductory chapter: General overview on oceanography. In: Pereira L, Pardal MA (eds.). Oceanography-Relationships of the Oceans with the Continents, Their Biodiversity and the Atmosphere. InTechOpen, London.

Pertiwi W, Bahri S, Rokhim S, Firdhausi NF. 2020. Keanekaragaman dan kemerataan jenis Collembola gua di kawasan karst Malang Selatan. Biotropic: J Trop Biol 4 (2): 134-139. DOI: 10.29080/biotropic.2020.4.2.134-139.

Pillai DR, Biju Kumar A. 2019. Four new records of Ophiuroids (Ophiuroidea: Echinodermata) from the southwest coast of India. J Aquat Biol Fish 7: 50-58.

Post AL, Lavoie C, Domack EW, Leventer A, Shevenell A, Fraser AD, NBP 14-02 Science Team. 2017. Environmental drivers of benthic communities and habitat heterogeneity on an East Antarctic shelf. Antarct Sci 29 (1): 17-32. DOI: 10.1017/S0954102016000468.

Pretzsch H, del Río M. 2020. Density regulation of mixed and mono-specific forest stands as a continuum: a new concept based on species-specific coefficients for density equivalence and density modification. For: Intl J For Res 93 (1): 1-15. DOI: 10.1093/forestry/cpz069.

Rahman MA, Molla MHR, Megwalu FO, Asare OE, Tchoundi A, Shaikh MM, Jahan B. 2018. The sea stars (Echinodermata: Asteroidea): Their biology, ecology, evolution and utilization. SF J Biotechnol Biomed Eng 1 (2): 1-8.

Rindriawaty, Ramli M, Nur AI. 2025. Kondisi ekosistem lamun pada zona pemanfaatan kawasan konservasi daerah Teluk Moramo Provinsi Sulawesi Tenggara. JSIPi (Jurnal Sains dan Inovasi Perikanan) 9 (1): 61-72. [Indonesian]

Ringvold H, Guðmundsson G, Andersen T. 2021. Starfish (Asteroidea, Echinodermata) from Iceland; spatial distribution and abundance. Deep Sea Res I: Oceanogr Res Pap 176: 103605. DOI: 10.1016/j.dsr.2021.103605.

Sahetapy JM, Latuihamallo M. 2014. The growth of abalone (*Haliotis squamata*) in net floating cage at Hulaliu Waters, Central District of Moluccas. Aquac Indones 15 (1): 21-25. DOI: 10.21534/ai.v15i1.28.

Setiawan R, Atmowidi T, Widayati KA et al. 2018. Preferensi habitat spesies Ophiuroidea di zona intertidal Pantai Pancur Taman Nasional Alas Purwo. Jurnal Kelautan: Indones J Mar Sci Technol 11 (2): 151-166. DOI: 10.21107/jk.v11i2.4741. [Indonesian]

Setiawan R, Ula FA, Sijabat SF. 2019. Inventarisasi spesies bintang mengular (Ophiuroidea) di Pantai Bilik, Taman Nasional Baluran, Jawa Timur. Jurnal Kelautan: Indones J Mar Sci Technol 12 (2): 192-200. DOI: 10.21107/jk.v12i2.5838. [Indonesian]

Sloan NA, Clark AM, Taylor JD. 1979. The echinoderms of Aldabra and their habitats. British Museum (Natural History), London.

Soliha E, Rahayu SS. 2018. Kualitas air dan keanekaragaman plankton di Danau Cikaret, Cibinong, Bogor. Ekologia: Jurnal Ilmiah Ilmu Dasar dan Lingkungan Hidup 16 (2): 1-10. DOI: 10.33751/ekol.v16i2.744. [Indonesian]

South PM, Delorme NJ, Skelton BM, Floerl O, Jeffs AG. 2022. The loss of seed mussels in longline aquaculture. Rev Aquac 14 (1): 440-455. DOI: 10.1111/raq.12608.

Suprapto PK, Husna IR, Meylani V, Basukriadi A, Wibowo AA, Nurdin E. 2022. Spatial models of suitable sandy substrates for brittle star community conservation in Sancang Coast, West Java, Indonesia. Indo Pac J Ocean Life 6 (2): 87-93. DOI: 10.13057/oceanlife/o060204.

Sutisna A. 2018. Penentuan angka dissolved oxygen (DO) pada air sumur warga sekitar industri CV. Bumi Waras Bandar Lampung. Jurnal Analis Farmasi 3 (4): 246-251. DOI: 10.33024/jaf.v3i4.2816. [Indonesian]

Suwartimah K, Wati DS, Endrawati H, Hartati R. 2017. Komposisi Echinodermata di rataan litoral terumbu karang Pantai Krakal, Gunung Kidul, Yogyakarta. Buloma: Buletin Oseanografi Marina 6 (1): 53-60. DOI: 10.14710/buloma.v6i1.15743. [Indonesian]

Tarigan RS, Hartati R, Widowati I. 2020. Diversity of brittle star and sea urchin (Echinoderm: Ophiuroidea, Echinoidea) of Krakal and Watu Kodok beach, Gunungkidul, Yogyakarta. IOP Conf Ser: Earth Environ Sci 530 (1): 012042. DOI: 10.1088/1755-1315/530/1/012042.

Tavares MR, Franco ACS, Ventura CRR, Santos LN. 2021. Geographic distribution of *Ophiothela* brittle stars (Echinodermata: Ophiuroidea): substrate use plasticity and implications for the silent invasion of *O. mirabilis* in the Atlantic. Hydrobiologia 848 (9): 2093-2103. DOI: 10.1007/s10750-020-04505-6.

Triacha ZIEC, Pertiwi MP, Rostikawati T. 2021. Echinoderms diversity in Cibuaya Beach Ujung Genteng, West Java. Jurnal Ilmu Dasar 22 (1): 9-18. DOI: 10.19184/jid.v22i1.18899.

Triana R, Elfidasari D, Vimono IB. 2015. Identifikasi Echinodermata di selatan Pulau Tikus, Gugusan Pulau Pari, Kepulauan Seribu, Jakarta. ros Sem Nas Masy Biodiv Indon 1 (3): 455-459. DOI: 10.13057/psnmbi/m010313. [Indonesian]

Turner RL, Boucher JM, O'Neill BO, Becker NW. 2021. Brittlestars with a bite: A new kind of pedicellaria in echinoderms. Zoomorphology 140: 505-525. DOI: 10.1007/s00435-021-00542-4.

Watling JI, Arroyo-Rodríguez V, Pfeifer M, Baeten L, Banks-Leite C, Cisneros LM, Fang R, Hamel-Leigue AC, Lachat T, Leal IR, Lens L. 2020. Support for the habitat amount hypothesis from a global synthesis of species density studies. Ecol Lett 23 (4): 674-681. DOI: 10.1111/ele.13471.