Jurnal ILMU DASAR (JID)
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Echinodermata Community Structure in Seagrass Ecosystem at Sijile Beach Baluran National Park

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Article info

Keywords
Baluran National Park; Echinodermata; Diversity; Seagrass, Sijile Beach

Article history
Received 24-07-2025
Accepted 30-09-2025

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ABSTRACT

Seagrass ecosystems represent one of the most important coastal ecosystems due to their crucial ecological role in maintaining marine environmental balance.This study aims to identify and analyze the community structure of Echinodermata from the classes Ophiuroidea, Echinoidea, and Holothuroidea in the seagrass ecosystem of Sijile Beach, Baluran National Park. Sampling was conducted using a systematic transect-plot method across 10 transects and a total of 100 plots. The results revealed seven Echinodermata species, with *Ophiocoma scolopendrina* being the most dominant (6.15 ind/m²). The Shannon-Wiener diversity index (H') was 0.98, indicating low species diversity. This low diversity is attributed to the dominance of specific species and uneven individual distribution. Although seagrass serves as a crucial habitat supporting Echinodermata survival, environmental conditions and species-specific adaptations play key roles in shaping the community structure. These findings highlight the importance of ecological studies for the conservation and management of coastal resources.

INTRODUCTION

Seagrass ecosystems represent one of the most important coastal ecosystems due to their crucial ecological role in maintaining marine environmental balance (Lestariningsih et al., 2023). Seagrasses are flowering plants (Angiosperms) adapted to grow in shallow marine environments, with root systems capable of stabilizing sediments (Sari et al., 2023). The primary productivity of this ecosystem is considered high, producing substantial biomass that plays a key role in the coastal energy cycle. In addition, seagrass meadows contribute to substrate stabilization, reduce current velocity, and enhance dissolved oxygen availability in the water column. These functions make seagrass ecosystems one of the main structural components of tropical coastal ecosystems. The community structure of organisms associated with seagrass meadows generally exhibits high complexity. Among these, the phylum Echinodermata is closely associated with seagrass ecosystems. This phylum comprises five major classes: Asteroidea, Ophiuroidea, Echinoidea, Holothuroidea, and Crinoidea (Tala et al., 2021). However, three classes most found in seagrass ecosystems are Ophiuroidea, Echinoidea, and Holothuroidea. Their presence not only enhances the diversity of benthic fauna but also provides functional contributions to the ecological balance of seagrass ecosystems.

The class Ophiuroidea, commonly known as brittle stars, functions primarily as detritivores and benthic microorganism predators. Their feeding activities accelerate the decomposition of organic matter, thereby facilitating nutrient cycling. The class Echinoidea, which includes sea urchins, generally acts as herbivores consuming epiphytic algae as well as seagrass fragments and predators (Sasongko et al., 2021). This activity has a positive impact by controlling excessive alga growth that could otherwise smother seagrass leaves and reduce photosynthetic efficiency. The class Holothuroidea, or sea cucumbers, such as *Holothuria atra*, play an important role in bioturbation, namely the reworking of sediments through feeding and body movements and sea cucumbers play an important role as deposit feeders and suspension feeders. According to (Bachmid et al., 2020), bioturbation by Holothuroidea enhances sediment fertility by enriching surface layers with nutrients previously trapped in deeper sediments. The ecological role of echinoderms, particularly the three classes, is strongly linked to the stability and productivity of seagrass meadows. In addition, according to (Sasongko et al., 2021), it plays a role as a deposit eater and suspension feed. Moreover, echinoderm communities hold great potential as bioindicators of seagrass ecosystem health. This is due to their relatively narrow environmental tolerance and high sensitivity to changes in physical and chemical parameters of seawater.

Factors such as substrate type, seagrass density, depth, and water quality significantly influence species abundance and distribution (Indah et al., 2018). For instance, Holothuroidea tend to thrive in fine sandy to muddy substrates suitable for foraging, while Echinoidea are more frequently found in hard or mixed sand–coral substrates. Ophiuroidea, due to their high mobility, are often encountered in open sandy areas within seagrass stands. As reported by (Yunita et al., 2020), echinoderm community structure exhibits significant variation in coastal areas under environmental stress. Their response to disturbance is generally reflected in shifts in species composition and distribution, with tolerant species becoming dominant while sensitive ones decline or disappear. Consequently, the analysis of echinoderm community structure can provide valuable insights into the overall condition of seagrass ecosystems. Indonesia possesses extensive seagrass meadows, including those within conservation areas. One region with considerable seagrass potential is Baluran National Park in East Java. While the park is widely recognized for its terrestrial biodiversity, its coastal ecosystems, particularly seagrass meadows, also hold high ecological value.

Sijile Beach is one of the coastal areas in Baluran characterized by a relatively diverse expanse of seagrass meadows (Nike, 2016). However, scientific information regarding the echinoderm community structure in this area remains scarce. Furthermore, research focusing on the relationship between echinoderm community structure and the physical–environmental conditions of Baluran's coastal waters is still limited, despite its importance for providing a more comprehensive understanding of ecosystem dynamics in this conservation site. Studies on echinoderm community structure also carry an additional dimension in terms of resource utilization. Several Holothuroidea species are economically valuable, both as food commodities and as raw materials for pharmaceuticals. Likewise, certain Echinoidea species are of economic importance in various coastal regions. Baseline information on the population structure and distribution of economically significant species is essential to prevent overexploitation and to support sustainable utilization practices. Beyond economic aspects, echinoderms also have educational and research potential, as their unique morphology and physiology make them highly valuable marine biology study objects. Deeper understanding of this group can enhance ecological literacy among coastal communities and strengthen conservation awareness.

In summary, seagrass ecosystems are closely linked to the presence of echinoderms, particularly the classes Ophiuroidea, Echinoidea, and Holothuroidea. These groups not only contribute to maintaining ecosystem balance through their specific ecological functions but also serve as bioindicators of seagrass ecosystem health. Conservation efforts based on the understanding of echinoderm community structure are expected to provide dual benefits: sustaining the ecological functions of seagrass ecosystems while protecting economically valuable species from overexploitation. Thus, research on seagrass ecosystems and echinoderm communities has both ecological and strategic significance in supporting the sustainable management of marine resources in Indonesia. Accordingly, this study aims to identify and analyze the community structure of echinoderms within seagrass ecosystems at Sijile Beach, Baluran National Park, as a foundation for conservation and sustainable management initiatives.

MATERIALS AND METHODS

Research Implementation and Methods

This research was conducted from June to September 2024. Data collection took place at Sijile Beach, Baluran National Park (Figure 1). Data analysis was carried out at the Biology Laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences, University of Jember.

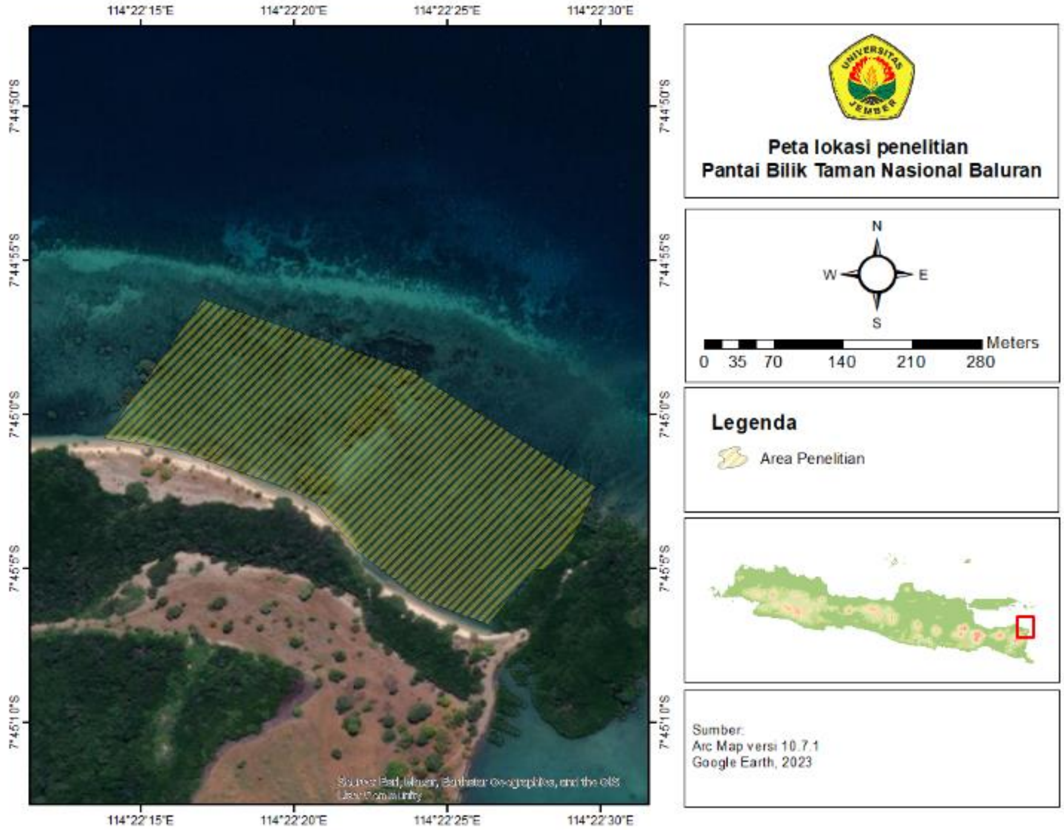

Figure 1: Map of the research location

Sampling Tools and Materials

The tools and materials used in this research included 1 × 1 m transects, sample jars, raffia string, plastic bags, stationery, labeling paper, measuring tape, permanent markers, GPS, pH meter, DO meter, refractometer, identification books, camera, scissors, forceps, Echinodermata samples, 70% alcohol, and distilled water.

Data Collection Method

Echinodermata sampling was conducted using the transect-plot method systematically placed along the shoreline transects. This research employed ten transects, each 100 m in length (Figure 2). The transects were arranged parallel to each other, with distance of 25 m between each transect. Each transect was positioned perpendicular to the shoreline, determined using a Garmin GPSMAP 64s compass. Within each transect, plots measuring 1 × 1 m² were placed at 10 m intervals. The first plot on the first transect was marked with a Garmin GPSMAP 64s as the starting point of the transect, while the last plot on the tenth transects served as the endpoint. The boundaries of Sijile Beach were also determined using the Garmin GPSMAP 64s Echinodermata sampling was conducted using the transect-plot method systematically placed along the shoreline transects. This research employed ten transects, each 100 m in length. The transects were arranged parallel to each other, with distance of 25 m between each transect. Each transect was positioned perpendicular to the shoreline, determined using a Garmin GPSMAP 64s compass. Within each transect, plots measuring 1 × 1 m² were placed at 10 m intervals. The first plot on the first transect was marked with a Garmin GPSMAP 64s as the starting point of the transect, while the last plot on the tenth transects served as the endpoint. The boundaries of Sijile Beach were also determined using the Garmin GPSMAP 64s.

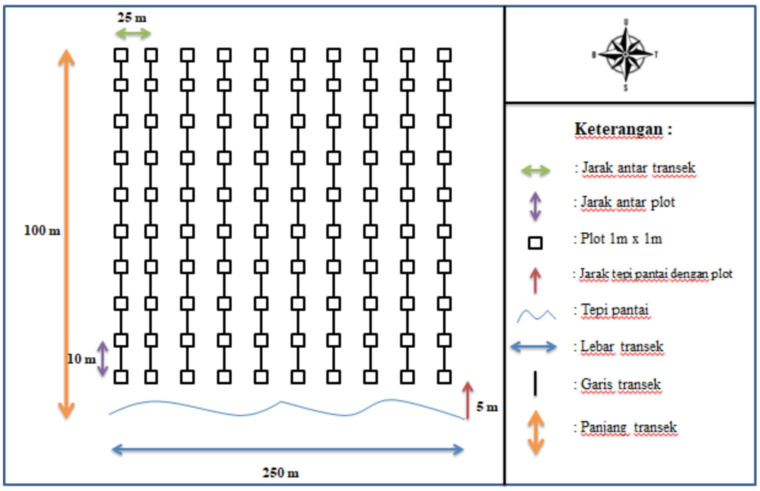

Figure 2. Plot Placement Scheme

Data Analysis

a. Species Composition and Abundance

The composition of seagrass species represents the list of seagrass taxa observed in the study area. Species identification was carried out in situ during data collection, and the taxonomic classification was further organized into genus, family, and order. Likewise, the Echinodermata species recorded from the classes Echinoidea, Holothuroidea, and Ophiuroidea were identified in the field. These taxa were compiled into tables, with taxonomic hierarchy provided up to genus, family, and order. Species abundance of Echinodermata was determined by summing the number of individuals of species i (ni) found within the plots, divided by the total sampled area (A), following Odum (1993): Data on species abundance were tabulated in table.

K_i (ind_i/m^2) = $ni\ /A$ ....(Odum, 1993)

b. Diversity Index

The diversity of Echinodermata was calculated using the Shannon-Wiener Diversity Index (Odum, 1994): s

H' = -$\sum ni/N\ ln\ ni/N$ ....(Odum, 1994)

where H' is the diversity index, ni is the number of individuals of species i, and N is the total number of individuals across all species. The criteria for Shannon-Wiener Diversity Index (H') according to Odum (1994) are as follows:

H' < 1 : Low diversity, low number of individuals per species, unstable community, heavily polluted condition.

1 < H' < 3 : Moderate diversity, moderate distribution of individuals among species, moderately polluted conditions.

H' > 3 : High diversity, even distribution of individuals among species, unpolluted conditions.

RESULTS AND DISCUSSION

Composition and Abundance of Echinodermata Species

A total of seven echinoderm species were recorded at Sijile Beach, with their composition summarized in Table 1. The most dominant species was *Ophiocoma scolopendrina* (6.15%), while the least abundant species was *Echinometra mathaei* (0.17%). *Ophiocoma scolopendrina* was predominantly located within dense seagrass patches. Such vegetation provides optimal microhabitats for refuge, protection from predators, and abundant organic particulate matter that supports the species' microphagous and suspension feeding strategies. In comparable intertidal reef settings, *O. scolopendrina* is known to engage in rapid surface-film feeding, sweeping the air–water interface using 2–4 arms during tidal influxes (flooding tide), followed by prolonged suspension feeding, with fewer instances of bottom feeding (Oak & Scheibling, 2006). This feeding behavior enables efficient exploitation of neustonic and detrital particles, positioning *O. scolopendrina* as a vital trophic conduit between primary producers and higher trophic levels.

Conversely, *Echinometra mathaei* a rock-boring sea urchin was minimally represented in this study area. This species typically adopts a burrowing lifestyle within hard substrates, emerging to graze nocturnally, and contributing significantly to bioerosion of coral reef structures. The low prevalence of *E.*

mathaei in a seagrass dominated, soft sediment environment likely reflects the unsuitability of the habitat for its ecological requirements. According to (Alwi et al., 2020) sea urchins are generally found in coral reef flat, sandy rocky, sandy rock habitats. Research conducted by (Budiman et al., 2014) states that in coral flats there is a high density of sea urchins.

Table 1. Species Composition of Echinodermata at Sijile Beach

Family	Genus	Species	Abundance (ind/m2)
Ophiocomidae	Ophiocoma	*Ophiocoma scolopendrina* (Lamarck, 1816)	6,15
Ophiocomidae	Ophiocoma	*Ophiocoma erinaceus* (Müller & Troschel, 1842)	0,35
Diadematidae	Diadema	*Diadema setosum* (Leske, 1778)	0,56
Echinometridae	Echinometra	*Echinometra mathaei* (Blainville, 1825)	0,03
Synaptidae	Opheodesoma	*Opheodesoma grisea* (Semper, 1867)	0,69
Synaptidae	Synapta	*Synapta maculata* (Chamisso & Eysenhardt, 1821)	0,36
Holothuriidae	Holothuria	*Holothuria atra* (Jaeger, 1833)	0,17

Diversity Index

The high abundance of *Ophiocoma scolopendrina* influenced the diversity index value at the study site. The diversity index at Sijile Beach was relatively low (H' = 0.98), with their composition summarized in Table 2. This low diversity value was attributed to the uneven distribution of species, as only a few species were able to dominate and adapt effectively to the prevailing environmental conditions at Sijile Beach. *O. scolopendrina* demonstrated high tolerance to substrate types and environmental variables such as temperature, salinity, and pH, enabling it to dominate the echinoderm assemblage (Nugroho et al., 2014; Simatupang et al., 2017).Emphasized that, in addition to species richness, the distribution of individuals among species is also a key factor influencing diversity index values. Imbalances in the number of individuals within species can be associated with various adaptive strategies shaped by substrate availability, food resources, and surrounding environmental conditions (Nugroho et al., 2018). This indicates that diversity is not solely determined by the number of species present, but also by how individuals are distributed and adapted to their respective habitats. This condition is closely linked to the presence of seagrass beds, which represent one of the most important habitats for echinoderms. Seagrasses provide a stable substrate, protection from currents, and abundant food resources, thereby supporting the successful establishment of species such as *O. scolopendrina*. However, if only one or two species are able to optimally exploit seagrass habitats, such dominance may ultimately reduce the overall diversity index. Thus, although seagrass ecosystems play a crucial role in supporting echinoderm populations, species variation and distribution remain strongly influenced by the adaptive capacity of individual species to the microhabitat conditions within the seagrass ecosystem.

Table 2. Echinodermata diversity

Species	H'
O. scolopendrina	0,223
O. erinaceus	0,133
D. setosum	0,181
E. Mathaei	0,020
O. Grissea	0,209
S. maculata	0,135
H. atra	0,079
	0,981

CONCLUSIONS

This study revealed that the echinoderm community within the seagrass ecosystem of Sijile Beach comprised seven species, with Ophiocoma scolopendrina being the dominant species. The diversity index

(H' = 0.98) was classified as low, primarily due to the uneven distribution of species and the dominance of a single species. The presence of seagrass contributes significantly as a critical habitat; however, community structure is strongly influenced by environmental factors such as substrate type, vegetation density, and species-specific adaptations. Therefore, the condition of the echinoderm community can serve as an indicator of seagrass ecosystem health. Further studies with broader spatial coverage and periodic monitoring are required to observe the dynamics of echinoderm communities. In addition, the conservation of seagrass ecosystems must be strengthened to ensure the sustainability of biodiversity in coastal areas, particularly within Baluran National Park.

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