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Diversity and distribution patterns of Sea Urchins (echinoidea) in the waters of Doreng Beach, Sikka Regency, Indonesia

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ABSTRACT

Echinoidea is a marine biota with many important roles in life. Echinoidea can be found in various sea and water areas, one of which is in the waters of Doreng Beach. The rampant exploitation activities and minimal efforts to conserve Echinoidea in the waters of Doreng Beach have caused the diversity of Echinoidea to decline. This study aimed to identify the types of Echinoidea and analyze their abundance and distribution patterns in the waters of Doreng Beach. This research was conducted on October 1 -November 1, 2022. The type of research conducted was qualitative descriptive research with a field observation approach. The method used was the quadrat sampling method. Observations were carried out at three stations, each with 15 quadrat plots measuring 1 x 1 m2. The results of the study showed that there were eight species in the waters of Doreng Beach, namely Echinometra mathei, Echinometra viridis, Diadema setosum, Diadema savignyi, Echinothrix calamaris, Echinothrix diadema, Tripneustes gratilla and Tripneustes Ventricosus. The highest abundance is from the species Echinometra mathei, with a value of 4.62 ind/m2, and the lowest is Diadema savignyi, with a value of 0.02 ind/m2. The distribution pattern of Echinoidea in Doreng Beach Waters is clustered with a moisten index value of 5.5.

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INTRODUCTION

Indonesia is an archipelagic country whose territory mostly consists of sea and water areas. Indonesian seas and waters have diverse and unique topographies with various types of substrates. These conditions cause Indonesian waters to have high biological resources and diversity, one of which is echinoderms (Kurniasari dkk., 2014; Latupono dkk., 2017).

Echinodermata, which can be interpreted as spiny-skinned animals, are one group of invertebrate animals whose habitat is found in almost all marine ecosystems. Echinodermata is included in the largest animal phylum, consisting of 6,000 species, an estimated 950 of which are Echinoidea (Toha dkk., 2022; Yusron, 2006). Echinoidea are divided into 15 orders, 46 families, and 121 genera, of which more than 84 species are spread across Indonesian waters (Yunita dkk., 2020). Echinoidea live and are spread across almost all coastal waters. Echinoidea can be found in intertidal areas and tidal zones in deep waters (Arhas dkk., 2018). Echinoidea is like clear waters with rather hard substrates, such as a mixture of dead coral fragments and sand. Echinoidea can be found in coral reefs, rocky beaches, and seagrass beds.

Echinoidea generally live in seagrass ecosystems and coral reef ecosystems. In these ecosystems, Echinoidea makes it a place to survive and find food and shelter from predators (Kurniasari dkk., 2014; Latupono dkk., 2017). Echinoidea eat algae living on coral reefs, so they are among herbivorous animals (Patech dkk., 2020). Echinoidea usually live in solitary or groups, depending on the type and habitat.

Echinoidea has important benefits and roles both ecologically and economically. Ecologically, Echinoidea can control the population of macroalgae in waters so that Echinoidea acts as keystone species in several marine ecosystems, such as coral reef ecosystems and rocky coastal ecosystems (Haurissa dkk., 2021). *Keystone species* are species that make a major contribution to the function of an ecosystem. Somma et al. (2017) stated that Echinoidea's diversity in water significantly influences the water's ecological balance. Echinoidea are detritus eaters and, in seagrass ecosystems, act as first-level consumers and prevent blooming (Meye dkk., 2023).

Doreng Beach has waters with sandy and coral substrates dominated by seagrass and coral reef ecosystems, making it rich in marine biota, one of which is Echinoidea. Doreng Beach has long been famous for its echinoidea and is therefore nicknamed "doreng weren gete" where echinoidea in the local language is known as weren. According to the people of Doreng Beach, Echinoidea has only been used for consumption. The large number of Echinoidea in the waters of Doreng Beach and its easy availability has caused Echinoidea to be increasingly exploited, and the absence of conservation efforts for Echinoidea has caused its population to decline.

Research on Echinoidea has been reported from several regions in Indonesia, including on Bangkalan Island, Central Sulawesi; seven types of Echinoidea were found and six species of Echinoidea were found (Diadema setosum, Diadema savignyi, Echinothrix diadema, Echinothrix calamari, Cenro Stephanus Rodgers and Echinometra mature in the waters of Iboih, Sukakarya District, Sabang City (Arhas,2015). A study on the diversity of types and distribution patterns of Echinoidea in the waters of Doreng Beach, Doreng District, Sikka Regency, to determine the diversity of Echinoidea species and distribution patterns so that they can be used as a reference for conservation policies and utilization of biological resources.

METHOD

The type of research used is descriptive qualitative with a field observation approach (Sugiyono, 2021). The research was conducted from October 1 to November 1, 2022, in the waters of Doreng Beach, Doreng District, Sikka Regency. The method used in this study is the Quadrat Sampling Technique. The quadrat method is one of the methods in ecological studies where observations or sampling are carried out in a box of a certain size whose area is measured in square units.

The study's location is divided into three stations: station 1, station 2, and station 3. Each station will have 15 square plots measuring 1 x 1 m2, for a total of 45 square plots. The square plots will be placed randomly in the station area without spacing.

Picture 1. Research design

The distribution pattern was analyzed using the distribution index developed by Morisita. (1962) in (Anwar, 2020) as follows :

$$Id = n \frac{\sum x2 - \sum x}{(\sum x)2 - \sum x} \quad (1)$$

Where Id is the Morisita Index, n is the number of quadrant plots, $\sum x$ is the number of individuals in each quadrant ($x1+ x2+ ....$), and $\sum x2$ is the number of individuals in each quadrant squared ($x12+ x22+ ....$), with the criteria if Id = 1 then the distribution pattern is random, Id < 1 then the distribution pattern is uniform and Id > 1 then the distribution pattern is clustered. The diversity index indicates the level of diversity of a species. The diversity index can be determined using the Shannon – Wienner formula (H') from Aimatuzzahro et al. (2020) as follows: H' = -∑ (ni/(N) In ni/(N)) (2). Where H' is the diversity index, ni is the number of individuals of the i-th species. N is the total number of individuals in the community, with the criteria that the diversity index is low if the value of H' <1 and the level of diversity is moderate if 1 <H' ≤ 3.

RESULT AND DISCUSSION

Echinoidea was found and identified in the waters of Doreng Beach, Doreng District, Sikka Regency, and there were three families, four genera, and eight species from a total of 384 individuals. The low diversity of echinoidea species is greatly influenced by anthropogenic factors. The results of interviews with several residents stated that people often exploit several Echinoidea species excessively, which greatly affects the number of these species. The number of echinoidea species that are not consumed is not directly influenced by community activities but is influenced by other factors (Tala dkk., 2021).

The type of substrate and the daily cycle of sea tides greatly determine the number and types of echinoidea in growth and development (Azwir dkk., 2019). The type of sea in the waters of Doreng Beach, Doreng District, Sikka Regency, which faces the open sea on the South coast, causes strong waves that greatly affect the existence of echinoidea species. The Echinometra mathei species are

often found in the research location because a suitable habitat with a rocky substrate type and coral reef fragments supports them. This group of echinoidea has a suitable habitat in open sea waters or coral reef ecosystems with strong currents, clear waters, and sufficient oxygen levels. In habitats like this, the echinoidea group protects itself from wave impacts (Binambuni dkk., 2019; Triacha dkk., 2021).

Tabel 1. Echinoidea species found in the waters of Doreng Beach, Doreng District, Sikka Regency

No	Family	Genus	Species	Research Station			Total
				I	II	III	Σ
1	*Echino metridae*	*Echino metras*	*Echinometra mathei*	79	26	103	208
2	*Ecihno metridae*	*Echino metras*	*Echinometra viridis*	42	19	75	136
3	*Diadem atidae*	*Diadema*	*Diadema setosum*	2	3	4	9
4	*Toxopneustidae*	*Tripneustes*	*Tripneustes gratilla*	3	6	-	9
5	*Toxopneustidae*	*Tripneustes*	*Tripneustes ventricosus*	1	6	2	9
6	*Echino metridae*	*Echinothrix*	*Echinothrix calamaris*	8	-	-	8
7	*Echino metridae*	*Echinothrix*	*Echinothrix diadema*	-	-	4	4
8	*Toxopne ustidae*	*Tripneustes*	*Diadema savignyi*	1	-	-	1
	Total Individu			136	60	188	384

Description and pictures of each species of Echinoidea found in the Doreng Coastal Waters are as follows:

1. Echinometra mathei

Echinometra mathei has a round, slightly oval shell and is brownish black; the dorsal part has an oral, and the ventral part has an anus; long, sharp, tapering spines cover the body, and the shell is black. Habitatnya di ekosistem padang lamun dan terumbu karang dan sering ditemukan pada substrat berbatu dan berkarang (Meye, 2023).

Picture 2. *Echinometra mathei*
(Private Document, 2022)

There are three types of Echinometra mathei found in the Doreng Coastal Waters, namely type B (brown spines), type C (blackish green spines) and type D (blackish brown spines) but the most commonly found is type B which has brown spines with whitish brown tips. Generally, there is

a white ring at the base. The primary spines are 8-13 mm long. At the research location, this type was found in areas with rocky substrates and coral reefs.

2. Echinometra *viridis*

The Echinometra viridis found has a round, oval, and slightly elongated body. Its shell is blackish brown. This species has primary spines that are not too long, thick and pointed. The spines are light brown, with the tips darker than the base. At the base, there is a white ring. The primary spines are 20-30 mm long. Its habitat is in coral crevices and under coral rocks.

Picture 3. *Echinometra viridis*
(Private Document, 2022)

3. Diadema *setosum*

Diadema setosum has a round and flat body shape and is pitch black on the shell and also the spine, the dorsal part has an eyeball that is sensitive to light, and the ventricle has an anus; the spine is long and sharp and poisonous, found chiefly on rocky substrates, its habitat is in seagrass and mangrove ecosystems with muddy sand. Diadena setosum has madreporite, no ambulacral, there are pedicellaria (Wahyuni, 2018). The spines tend to be black and consist of two types: primary and secondary. The primary spines are sharp, the tips are tapered and fragile, and are longer than the body, namely 50-100 mm. The abundance of species is closely related to the reproduction of the species. Research by Garrido et al. (2000) showed that the reproduction of Diadema antillarum was not affected by changes in seawater temperature.

Picture 4. Diadema setosum
(Private Document, 2022)

4. Diadema *savignyi*

Diadema savignyi has a round body shape; its shell and spines are black, with a blue ring on the central surface. D. savignyi has long spines that can stick more, plunging into the bottom of the *water* and protecting it from the pounding of sea waves. Its habitat is on a rocky substrate type (Thamrin dkk., 2012). During the study, this type was found on a rigid substrate, namely coral reefs and rock crevices. Certain species of the genus Diadema usually forage at night (Tuya dkk., 2004).

Picture 5. *Diadema savignyi*
(Private Document, 2022)

5. Echinothrix *calamaris*

Echinothrix calamari has a flat, pentagonal body. Its primary spines are 40–55 mm in size and black with white or striped ring patterns. The spines are thick, blunt, and brittle at the ends. Its secondary spines are light brown, smooth, brittle, very sharp, and poisonous, with a length of 20–40 mm. *Echinothrix calamaris* is generally found in coral reefs, coral rubble and under rocks at depths of 0 – 90 m.

Picture 6. *Echinothrix calamaris*
(Private Document, 2022)

6. *Echinothrix diadema*

The Echinothrix diadema was found to have a round shape and dark black color. It has long, rather significant, and pointed primary spines.

Picture 7. *Echinothrix diadema*
(Private Document, 2022)

The genus Echinotrix has a more rigid spine shape and a brighter color of the tip of the spine than the genus Diadema. The length of the primary spines in the genus Echinothrix ranges from 4.1-4.9 cm, with secondary spines located irregularly between the primary spines, which are 2.2-3.6 cm long. The body is round and flat, with a diameter ranging from 6.2-7.2 cm (Ristanto dkk., 2017). This

type is generally found in coral fracture areas, coral rocks and sandy corals which are dominated by seagrass and seaweed beds.

7. Tripneustes ventricosus

Tripneustes ventricosus has a round body shape and a 50-70 mm diameter. It is dark brown. This type has small, blunt, and irregular spines. The primary spines are 2-7 mm, while the secondary spines are 2-4 mm. This species is found on sandy substrates in seagrass vegetation. It covers its body with leaf lettuce and consumes seagrass and macroalgae.

Picture 9. *Tripneustes ventricosus*
(Private Document, 2022)

8. *Tripneustes gratilla*

Tripneustes gratilla has a blackish-brown shell and is round. The spines are short and not sharp. The primary spines are predominantly orange-brown and 2-5 mm in size, while the secondary spines on the oral part are white and 2-5 mm in size. This species is found living in groups and solitary in sandy substrate areas in seagrass ecosystems, but some live in coral reef areas at depths of 0.3 -20 m.

Picture 10. *Tripenustes gratilla*
(Private Document, 2022)

The Echinometra mother species is one type of Echinoidea in the Doreng Beach Waters, which has the highest abundance value compared to other types because it has a suitable habitat supported by the type of substrate found in the Doreng Beach waters in the form of coral whose coral communities grow better in the wave crash zone. Echinometra mathei is one type of echinoidea whose habitat is only found in rock crevices and coral debris. Echinometra mathei lives in association with coral crevices on rougher substrates. This echinoidea group likes areas protected and covered by coral frameworks (Haurissa dkk., 2021; Triacha dkk., 2021).

Echinometra mathaei has a vast color variation, which is then grouped into four types of E. mathaei sea urchins, namely types A, B, C, and D. Type C has the habit of burrowing and waiting for

food trapped in the burrow while type A has the habit of actively looking for food in the cave area overgrown with algae and seagrass (Moningkey, 2010). In the waters of Doreng Beach, Sikka Regency, three were found, namely types B, C, and D. The difference in the types of E. Nathalie lies in the size of the shell and the color related to the life and foraging strategy.

Table 2. Distribution patterns of Echinoidea in the waters of Doreng Beach, Doreng District, Sikka Regency

Echinoidea Species	Distribution patterns (Id)				
	N	Σx	Σx²	Id	Distribution patterns
Echinometra mathei	45	208	2546	2,4	Grouping
Echinometra viridis	45	136	1258	2,8	Grouping
Diadema setosum	45	9	17	5	Grouping
Tripneustes gratilla	45	9	13	2,5	Grouping
Tripneustes ventricosus	45	9	15	3,8	Grouping
Echinothrix calamaris	45	8	14	4,8	Grouping
Echinothrix diadema	45	4	10	22,5	Grouping
Diadema savignyi	45	1	1	0	Similar
Average Morisita Index				5,5	Grouping

The distribution pattern of Echinoidea in the waters of Doreng Beach is clustered on sandy beaches, coral reefs, and seagrass vegetation, with a moist index value of 5.5. The clustered distribution pattern means a specific type of individual is found in groups in a certain place according to its habitat preferences (Haurissa dkk., 2021). he abundance of a type of individual in the population causes the clustered distribution pattern. This happens because the habitat conditions allow Echinoidea to forage and reproduce, forming clusters or groups (gregarios) to avoid and defend themselves from predators. Organisms that live in groups are caused by biological factors from the organism itself to live in groups or because of environmental factors (Aimatuzzahro dkk., 2020; Meye dkk., 2023).

The diversity of a species can be used to describe the structure of a community. Echinoidea's distribution and its community's stability are classified as moderate, with a diversity index value of 1.107. The high and low diversity in a community depends on the number of species and individuals of each species (Eman dkk., 2021). A high diversity value indicates that the number of individuals between the species that comprise the ecosystem is not much different or is classified as the same (Toha dkk., 2012). A low diversity index value indicates that the location has high ecological pressure and its ecosystem is unstable. Ecological pressure can come from settlement or transportation activities around the location (Erlangga dkk., 2018). Another factor that causes low species diversity is a lack of food sources.

Table 3. Echinoidea diversity index in the waters of Doreng Beach, Doreng District, Sikka Regency

Species name Echinoidea	Diversity Index (H')				
	ni	N	ni/N	In ni/N	ni/N In ni/N
Echinometra mathei	208	384	0,542	-0,613	-0,332
Echinometra viridis	136	384	0,354	-1.038	-0,368
Diadema setosum	9	384	0,023	-3.753	-0,088
Tripneustes gratilla	9	384	0,023	-3.753	-0,088
Tripneustes ventricosus	9	384	0,023	-3.753	-0,087
Echinothrix calamaris	8	384	0,021	-3.871	-0,081
Echinothrix diadema	4	384	0,010	-4.564	-0,048
Diadema savignyi	1	384	0,003	-5.951	-0,015
H' = -∑(ni/N ln ni/N)					**1,107**

CONCLUSION

The structure of the echinoidea community in the waters of Doreng Beach is experiencing ecological pressure due to settlement activities that cause its ecosystem to become unstable. This condition is indicated by the diversity index value in the moderate category; only four (4) genera were found from eight (8) species of Echinoidea, namely Echinometra mathei, E. viridis, Diadema setosum, D. savignyi, Tripneustes gratilla, T. ventricosus, Echinothrix calamaris, and E. Diadema with a group distribution pattern. There needs to be a study on environmental conservation efforts to prevent the population of marine biological resources, including Echinoidea, in the waters of Doreng Beach, Doreng District, and Sikka Regency.

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