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Biodiversity of Sea Urchin in the Area of Sari Ringgung Beach, Pesawaran Regency, Lampung

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Abstract

Echinoderms have specific characteristic in the form of spines or protrusions on its body surface. The class of Echinoidea or commonly known as sea urchin is one of the extant members of Echinoderms with ecologically and economic pivotal roles. Habitat of sea urchin is a hard bottom with a mixture of coral reef ecosystems, seagrass beds, and sand with coral rubble. In the area of Sari Ringgung Beach, coral reefs and seagrass ecosystems are quite extensive. The purpose of this study was to investigate sea urchin species and analyze its population, relative abundance, diversity index, and dominance index. This research used purposive sampling method based on substrate type criteria. Two species of sea urchin were found and identified as Diadema sp. and Brissus sp. Individual abundance values ranged from 0-0.027 ind/m^2, relative abundance values ranged from 0-96.67%, sea urchin species diversity index was low, ranging from 0-0.5982, and was dominated by sea urchin types of Diadema sp. at station 2 of 0.9356.

Keywords: *Beach, Biodiversity, Lampung, Sari Ringgung, Sea urchin*

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INTRODUCTION

Echinoderms are marine invertebrate with spines or protrusions outside the body surface. The five extant taxonomic classes of Echinoderms are Asteroidea (starfish), Ophiuroidea (brittle stars), Crinoidea (sea lilies), Holuthuroidea (sea cucumbers), and Echinoidea (sea urchins) (Micael et al., 2009). According to their diverse body shapes, sea urchins are split into two groups: regular and irregular sea urchins. While irregular sea urchins have bilateral body symmetry and small spines, regular sea urchins have radial symmetry and long spines. The shape of the spine varies among species. The spines can have long and sharp pointed tips, short and blunt pointy tips, as well as hollow and brittle interiors. Sea urchins use their spines to move, hunt for food, and defend from potential predators (Afifa et al., 2017). Several species of sea urchins, including *Diadema, Echinothrix*, and *Taxopneustes pileolus*, have poisonous spines (Toha, 2006).

There are about 800 species of sea urchins and 84 of them are found in Indonesian marine waters (Akerina et al., 2015). Nearly all coastal waters, from the tidal zone to the

deep sea, are habitat to sea urchins (Toha et al., 2017). Sea urchins are mostly found in coral reef habitats, seagrass meadows, and sand substrates mixed with coral rubble (Alwi et al., 2020). In marine ecosystem, sea urchins play a crucial part in the food chain. Because they feed on different kinds of algae, sea urchins regulate the populations of algae. Sea urchins are preyed upon by other aquatic animals such as crabs, birds, and mammals (Sonico, 2018). Economically, sea urchins are highly valuable because they are both an exportable food source, particularly the gonads, and source of medicinal ingredients (Ferrario et al., 2020; Tupan & Silaban, 2017; Uneputty et al., 2017). Sea urchins have a significant potential as a natural antibacterial compound according to several studies (Hadinoto et al., 2017; Indrawati et al., 2018; Akerina et al., 2015).

Studies of the diversity and abundance of sea urchins in Indonesian waters have been conducted in several different locations, including Bali (Purnomo et al., 2019; Yudasmara, 2013), Manokwari (Haurissa et al., 2021), Morotai Island (Alwi et al., 2020), and Karimunjawa Islands (Afifa et al., 2017). In the waters surrounding Kelagian Lunik Island in Lampung, research on the variety of sea urchins had already been carried out. The findings showed that there were three distinct species of sea urchin, i.e. *Diadema* sp., *Brissus* sp., and *Echinotrix* sp. with low diversity index (Silaen, 2021). However, there are no reports of sea urchins (Echinoidea) species discovered in Sari Ringgung Beach in Lampung. Seagrass meadows and coral reef ecosystems can be seen in the waters off Sari Ringgung Beach in Pesawaran, Lampung. This demonstrates that Sari Ringgung Beach is a beach with the necessary qualities to serve as a sea urchin habitat. Because there are a lot of sea urchins in the area near the ocean, the findings of field studies and information from the community are also encouraging.

This research is important to be conducted to examine the diversity of sea urchins in Sari Ringgung area to take advantage of the sea urchins' potential for bioprospecting in the future. Therefore, the purpose of this research was to identify different species of sea urchins at Sari Ringgung Beach in Pesawaran, Lampung and to analyze individual and relative abundance as well as diversity and dominance index.

METHOD

Time and Location of Research

The study was conducted between December 2021 and February 2022. Sampling was conducted out in the seas of Sari Ringgung Beach (5˚32'56"S 105˚15'20"E) with a coastline length of 4.25 kilometers. Purposive sampling was used to determine the observation spots based on the substrate type criteria. Three stations were established at the sea urchin observation points: station 1 was muddy sand, station 2 coral reefs, and station 3 seagrass beds (Figure 1a), employing a line transect and a quadratic transect to sample at each station. Each station contains three line transects that extend 80 meters seaward from the shore. The line transects are 20 meters apart. Every line transect had 8 plots, each measuring 1x1 meter and placed 10 meters apart (Figure 1b). Sea urchin samples were identified at the Zoology Laboratory, Department of Biology, Institut Teknologi Sumatera.

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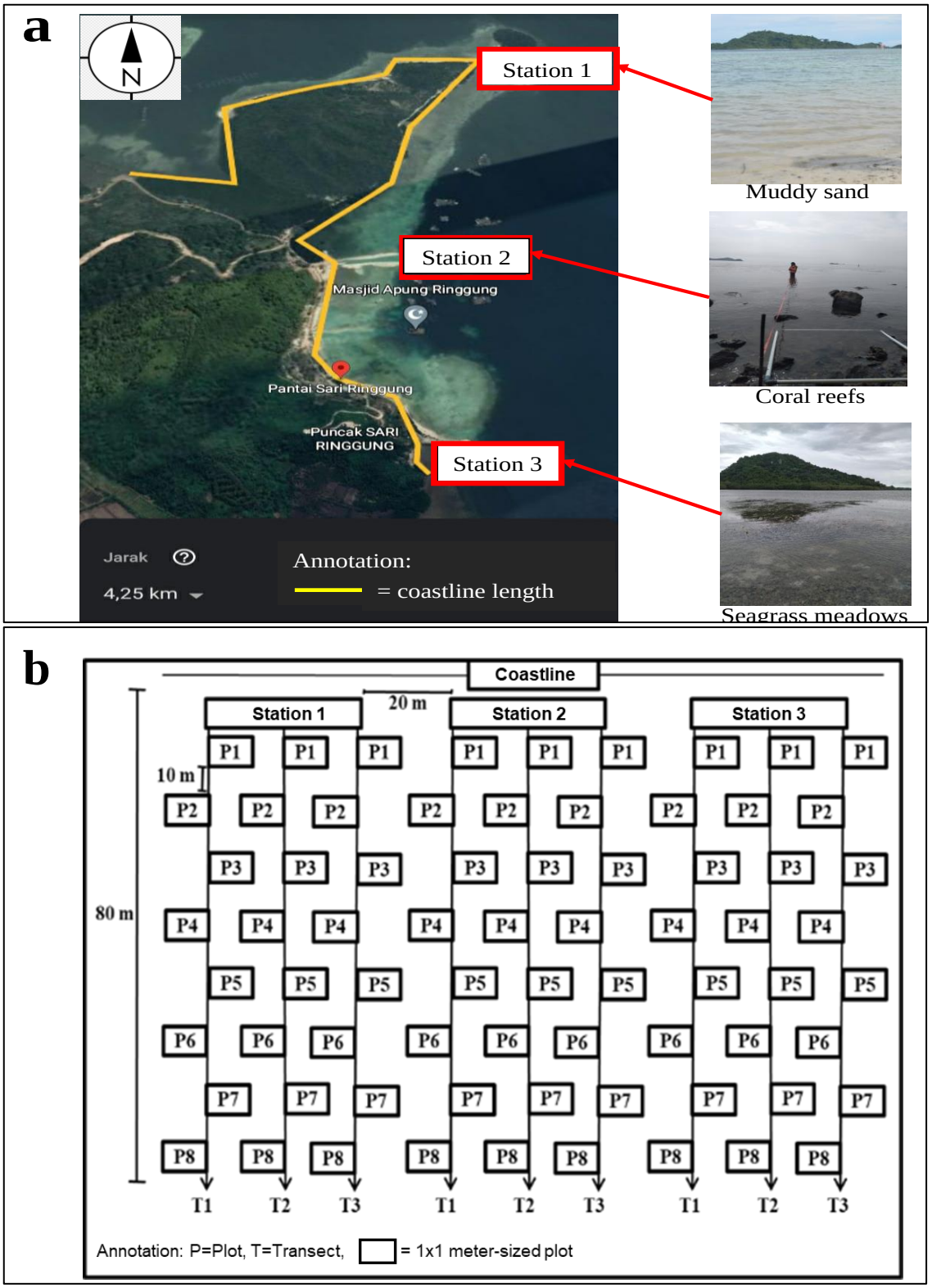

Figure 1. Research location in Sari Ringgung Beach, Lampung (a) Three observation stations; (b) Sampling method for sea urchin

Materials

The tools used during the study were a pH meter, thermometer, DO meter, refractometer, wooden stakes as the starting point of the transect, roll meter, rope to draw the transect line, camera, pipe (1x1 m plot) as an observation area, work stationery, and a jar to store the sea urchin specimens found. The materials used are sea urchins in the waters of Sari Ringgung Beach and 70% alcohol.

Sampling of Sea Urchins and Data Collection of Environmental Conditions

Sea urchins were observed inside each plot in a line transect. The quantity and types of sea urchins found in the plots were counted, identified, and stored in jars with 70% alcohol. Following their discovery, the sea urchins were identified for their morphological characteristics using a reference book and publications from related scientific journals, including Alwi et al. (2020); David et al. (2009); Nigam & Raghunathan (2017); and Suryanti et al. (2020). Individual abundance, relative abundance, Shannon-Wiener (H') diversity index, and dominance index were then used to examine the data.

Temperature, salinity, pH, and dissolved oxygen (DO) were among the environmental factors monitored at the three sampling locations. Based on the importance of water quality standards for sea urchin life, the results of measurements of environmental conditions were descriptively examined in relation to the variety of sea urchin species observed at Sari Ringgung Beach.

Data Analysis

Diversity Index

The diversity of species is demonstrated by how uniformly dispersed the individual proportions are within each species. The Shannon-Wiener Diversity Index (H') was used to determine the diversity of sea urchins (Odum, 1993).

$$H' = -\Sigma\ Pi(LnPi)$$

Where:
H' = Shannon-Wiener diversity index
Pi: ni/N = proportion of total sample represented by species

The diversity index criteria are as follows:
$H' < 1$ = Low diversity
$1 \leq H' \leq 3$ = Moderate diversity
$H' > 3$ = High diversity

Dominance Index

The Simpson equation generates the dominance index (C) value, which is used to define whether a species dominates a community (Magurran, 1988).

$$C = \Sigma\ Pi^2$$

Index values range from 0 to 1 by following categories:
$0.00 < C \leq 0.50$ = Low dominance
$0.50 < C \leq 0.75$ = Moderate dominance
$0.75 < C \leq 1.00$ = High dominance

RESULTS AND DISCUSSION

Results

There were two species of sea urchins found in the area of Sari Ringgung Beach, i.e. *Diadema* sp. and *Brissus* sp. Sea urchins with the species of *Diadema* sp. were found grouped together and living on coral reef substrates. Among the sea urchin species, *Diadema* sp. has a rounded body shape, black color, radial symmetry, five white spots on the aboral part of each body segment, primary spines and secondary spines/tube feet all over the body (Figure 2a); the anus is located in the center of the aboral side, and there are pore-pairs and hollow tubercles arranged in an arc over the body (Figure 2b); the mouth and five pointed teeth known as Aristotle's lantern are located in the middle of the oral side, the buccal plate lacks of spines (Figure 2c); and the secondary spines have hollow centers (Figure 2d) and serrated surface (Figure 2e).

The sea urchins *Brissus* sp. were found living solitary lives in sand with rough texture. This particular sea urchin belongs to the group of irregular sea urchin, with brownish hemispherical shell and bilateral symmetry (Figure 3a); the anus is located on the side of oral side, the mouth is located in the middle of the oral side and it is located inside the crescent-shaped peristome (Figure 3b); it has small, short spines in nearly identical structure (Figure 3c); there are five petals in the aboral side known as petalloids, and a madreporite with a perforated surface is in the center of aboral region (Figure 3d).

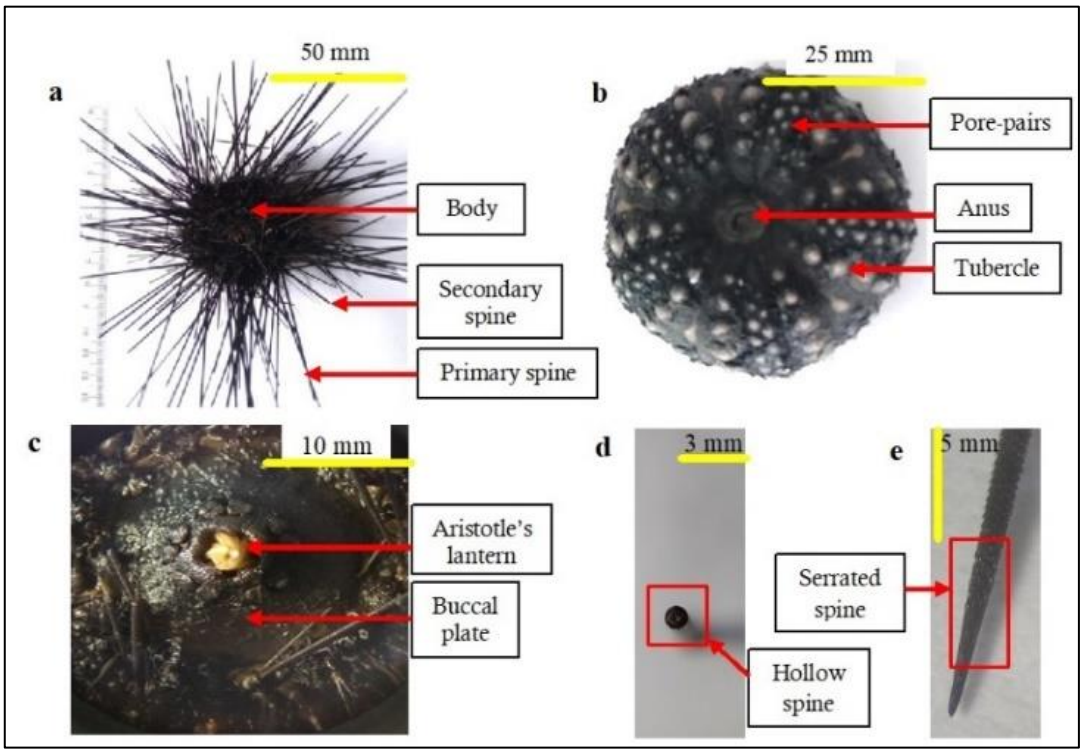

Figure 2. Morphology of *Diadema* sp. collected from Sari Ringgung Beach area (a) Sea urchin's body, primary spines, and secondary spines (aboral side); (b) Anus, pore-pairs, and tubercles (aboral side); (c) Aristotle's lantern and buccal plate (oral side); (d) Hollow spine (medial view); (e) Serrated surface of the spine (lateral view)

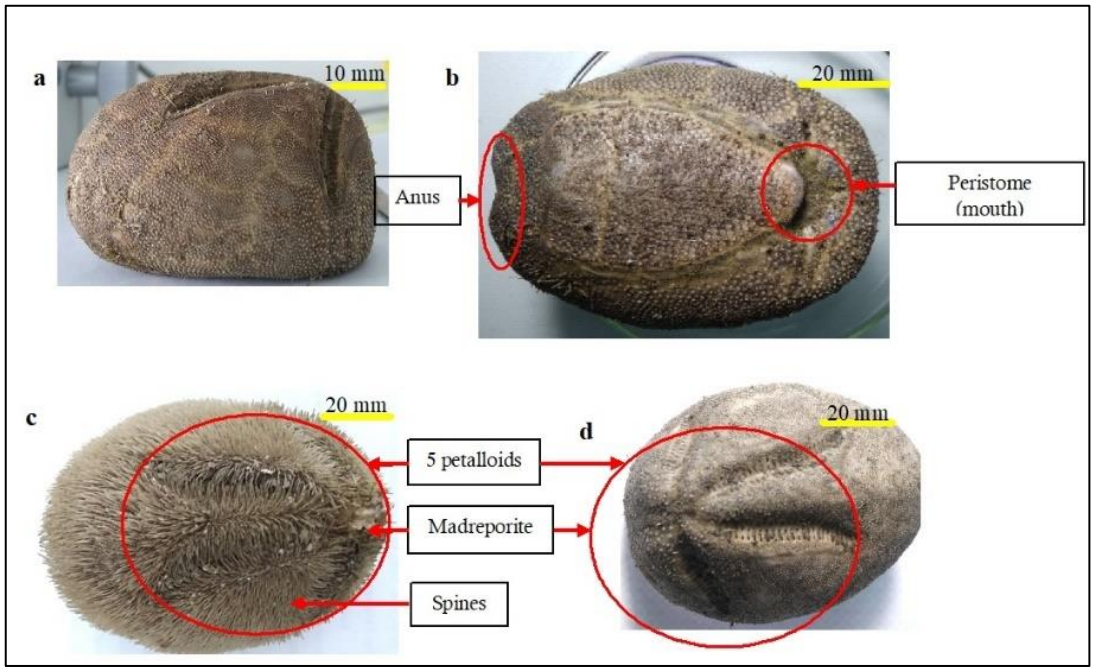

Figure 3. Morphology of *Brissus* sp. collected from Sari Ringgung Beach area (a) A hemispherical shell form (lateral view); (b) Position of the anus and peristome (mouth) (oral side); (c) The spines (aboral side); (d) Five petalloids & madreporit (aboral side)

The sea urchin species *Diadema* sp. was the one with the highest number of individuals, with up to 87 being found at station 2 (Figure 4). The individual value of sea urchins found in the area of Sari Ringgung Beach ranging from 0 to 0.027 individuals/m^2. The species *Diadema* sp. had the highest individual abundance value, which was 0.027 individuals/m^2 at station 2, while there were none to be discovered at station 1 (Table 1). The relative abundance of sea urchins has a value ranging from 0 to 96.67%. *Diadema* sp. at station 2 had the highest value of relative abundance which was 96.67%, while the lowest being 0% at station 1 (Table 2).

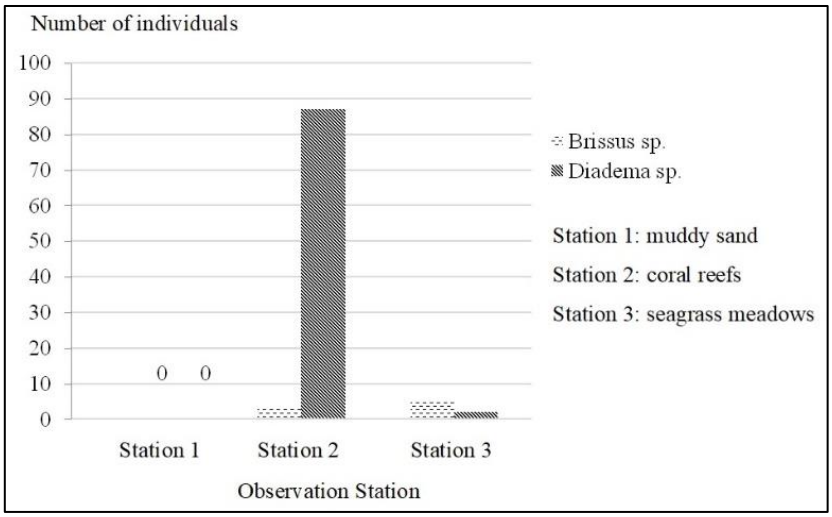

Figure 4. Number of sea urchin individuals at each observation station on Sari Ringgung Beach

Table 1. Individual abundance of sea urchins in the area of Sari Ringgung Beach

No.	Species	Station		
		1	2	3
1	*Diadema* sp.	0 ind/m²	0,027 ind/m²	0,001 ind/m²
2	*Brissus* sp.	0 ind/m²	0,00094 ind/m²	0,0025 ind/m²

Table 2. Relative abundance of sea urchins in the area of Sari Ringgung Beach

No.	Species	Station		
		1	2	3
1	*Diadema* sp.	0%	96,67%	28,57%
2	*Brissus* sp.	0%	3,33%	71,43%

The diversity index of sea urchins in the area of Sari Ringgung Beach in Pesawaran, Lampung had a value ranging from 0 to 0.5982. The highest diversity index was at station 3 with the value of 0.5982 and the lowest was at station 1 (Table 3). The dominance index had a value ranging from 0 to 0.9356. The highest dominance index was at station 2 with the value of 0.9356, while the lowest was at station 1 (Table 4).

Table 3. Diversity index of sea urchins in the area of Sari Ringgung Beach

Station	Shannon-Wiener Diversity Index
1	0
2	0,1462
3	0,5982

Table 4. Dominance index of sea urchins in the area of Sari Ringgung Beach

Station	Dominance Index
1	0
2	0,9356
3	0,5918

The average pH and temperature measurements from the three stations showed similar results. The three stations' salinity measurement all showed in at the same value, which was 30 ppm. The maximum value for the three stations' measurement of dissolved oxygen (DO) was 7.8 ppm and the lowest was 5.6 ppm (Table 5).

Table 5. Environmental conditions on average at observation sites

Environmental Factor	Station 1	Station 2	Station 3
Temperature (°C)	30,7 ± 0,06	30,5 ± 0,06	31,0 ± 0
Salinity (ppm)	30,0 ± 0	30,0 ± 0	30,0 ± 0
pH	7,2 ± 0,05	7,2 ± 0,06	7,3 ± 0,08
Dissolved oxygen (ppm)	6,2 ± 0,06	7,8 ± 0,04	5,6 ± 0,18

Discussion

Diadema sp. belongs to the group of regular sea urchins (Hartati et al., 2018). Morphologically, *Diadema* sp. has a hard shell, spherical body shape, radial symmetry, long and sharp primary spines used in defense mechanism, and hollow secondary spines

dispersed among the primary spines. Tube feet are utilized for locomotion and foraging. The anus is located in the center of the aboral side, whereas the mouth with five sharp pointed teeth, known as Aristotle's lantern, is located on the oral side. Pore-pairs and tubercles are arranged in an arc over the body of *Diadema* sp. Pore-pairs serve as the attachment points for secondary spines, while the tubercles is for primary spines.

Brissus sp. is categorized as irregular sea urchins. Based on the result of identification, *Brissus* sp. has hemispherical shell shape, anus on the oral side, mouth in the middle of a crescent-shaped peristome, and identical short small brownish spines. *Brissus* sp. has five petals in the middle part of the aboral side called petalloids. Petalloids serve as both structures for gas exchange and as aids to locomotion. Madreporite is located in the center of aboral side and its perforated surface works as water vascular system. *Brissus* sp. consumes the sand surrounding it in order to obtain nutrients from the organic matter present in the sand (Nigam & Raghunathan, 2017).

No sea urchins were found at station 1 so the individual abundance value obtained was 0 individuals/m2 and a relative abundance value was 0%. This might be because the substrate at station 1 was muddy sand, which was unsuitable for sea urchins. Sea urchins' tube feet struggle to find a spot to attach in muddy substrate, making it difficult to move (Yudasmara, 2013). In addition, station 1 was a tourist destination. According to Purnomo et al. (2019), various human activities like fishing boat docking and tourism activities can impair the growth and habitat of sea urchins.

Two species of sea urchins were found at station 2, i.e. *Diadema* sp. (87 individuals) and *Brissus* sp. (3 individuals). As a results, *Diadema* sp. had higher individual and relative abundance values compared to *Brissus* sp. Coral reef substrate at station 2 is able to support the survival of *Diadema* sp. According to Arhas et al. (2015), *Diadema* sp. live in groups to protect one another from predators, such as certain species of fish, crabs, lobsters, and human, as well as to facilitate reproductive stage. In station 2 with coral reef, sea urchins *Brissus* sp. were still found as many as three individuals. This is because Brissus sp. can submerge its body in the hard-textured sand substrate mixed with coral rubble that exists among the coral reefs. (David et al., 2009).

Sea urchin's species of *Brissus* sp. (5 individuals) and *Diadema* sp. (2 individuals) were found at station 3. As a result, *Brissus* sp. had higher individual and relative abundance values than *Diadema* sp. This seagrass substrate has firm sand texture to suit the habitat of *Brissus* sp. This species of sea urchin usually lives solitary in shallow sandy areas by burying its body in the sand as deep as 10-15 cm to protect itself from predators (David et al., 2009). *Diadema* sp. were found at station 3 as a result of their high level of substrate tolerance and capacity for adaptation (Ahad, 2016; Firmandana et al., 2014).

Generally, the diversity of sea urchin species in Sari Ringgung Beach was categorized into H'=<1, which denotes a low level of species diversity. Substrate types that do not support the survival of various species of sea urchins may be the reasons of the low diversity. For example, sea urchins that inhabit seagrass meadows mostly consume the seagrass species of *Thalassia*, *Syringodium*, *Thalassodendron*, and *Cymodocea* (Arifah et al., 2017). Only a few species of sea urchins were observed in the seagrass ecosystem at the study site because Sari Ringgung Beach has *Enhalus acoroides* seagrass. Human activities are still present in coral reef ecosystems, including fishing and tourism,

which is suggested to be a contributing factor in the research site's scant diversity of sea urchin species (Mustaqim et al., 2013). Overall, the composition of sea urchins was found to show dominance at station 2 with the species of *Diadema* sp. This is presumably because the coral reefs at station 2 provide a food source in the form of sponges and algae, which in turn sustain large populations of *Diadema* sp. (Haurissa et al., 2021).

Three sampling stations recorded temperatures of 30.7, 30.5, 31.0°C which are still suitable for sea urchin survival. This is in accordance with a study conducted by Lubis et al. (2017), a temperature range of 28-32°C is ideal for the survival of sea urchins. Salinity values at three sampling points, specifically at 30 ppm, continue to be favorable for the existence of sea urchins. Laheng et al. (2021) stated that sea urchins can still survive in waters with salinities between 30 and 35 ppm. The three stations' pH measurement readings of 7.2, 7.2, and 7.3 are still appropriate for sea urchin life. The pH range for aquatic creatures like Echinoidea is typically between 7 and 8.5. The three observation sites' DO conditions were 6.2, 7.8, and 5.6 ppm, respectively. Seawaters with oxygen concentrations of more than 5 ppm are ideal for sea urchin survival (Noviana et al., 2019). Environmental characteristics measured at Sari Ringgung Beach in Pesawaran, Lampung, support the survival of sea urchins overall.

CONCLUSION

Sea urchins of *Diadema* sp. and *Brissus* sp. were found in the waters around Sari Ringgung Beach. The most common species of sea urchin identified at each station was *Diadema* sp. because of its high individual and relative abundance values. Sea urchin diversity was low and was dominated by *Diadema* sp.

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