SAND DOLLARS DISTRIBUTION PATTERN AND ABUNDANCE AT THE COAST OF CEMARA KECIL ISLAND, KARIMUNJAWA, JEPARA, INDONESIA

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SAND DOLLARS DISTRIBUTION PATTERN AND ABUNDANCE AT THE COAST OF CEMARA KECIL ISLAND, KARIMUNJAWA, JEPARA, INDONESIA

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Graphical abstract

Abstract

This research is aimed to know the distribution patterns and abundance of *sand dollars* [*Clypeaster subdepressus* (Gray, 1840)] at different spatial distances from the coast of Cemara Kecil Island Karimunjawa, Indonesia. The data were collected using purposive sampling and analyzed using cluster analysis PAST-3. The results indicate that the abundance of *sand dollar* amounts to 2 200 individuals, and the existing species are *Laganum centrale, L. laganum, L. fudsiyama, L. depressum, L. retinens, L. boschi, L. depressum tonganense, L dickersoni, L. decagonale rectum, L. joubini and L. decagonale*. The cluster analysis using *PAST-3* reveals that there are clumped distributions and uniform distributions of *L. centrale* and *Laganum laganum*. At a distance of 23 m to 38 m from the coastline the animals form clumped distributions.

Keywords: Abundance, sand dollars [*Clypeaster subdepressus*(Gray, 1840)], spatial distribution pattern

1.0 INTRODUCTION

Sand dollars [*Clypeaster subdepressus* (Gray, 1840)] belong to the class of echinoidea of the phylum echinoderms and have irregular anatomy, flattened and have no arms. In general, sand dollars live in the area of intertidal to sub-tidal zone, buried in mud or fine sand [1]. This animal is a deposit feeder, eating the residuals of living organisms found in a substrate and ingesting planktons and algae, or passively collects microorganisms and organic matters trapped by the spines in particular with aboral sucker [2]. The body of sand dollars is wrapped in structured shells (test), consisting of dials that form a box like a hard shell. Usually there are 10 double columns of plates and five pierced for the vessel-like feet which are slender out through shells. The mouth of sand dollars is located in the middle and the interior of the mouth or teeth moor and form a structure called Aristotle's *Lantern* [3].

Cemara Kecil Island is one of the islands of Karimunjawa islands, Jepara, Central Java, Indonesia. Cemara Kecil Island is uninhabited and is the area included in tourism zone as it has abundant potential natural resources such as seagrass beds, coral reefs, mangrove ecosystem and various kinds of echinoderms, one of which is sand dollars [4, 5].

Geographicaly, Cemara Kecil Island is located at 110° 22' 38" to 110° 22' 44" EL and 5° 49' 51" to 5° 50' 2" SL covering an area of 1.5 ha. Cemara Kecil Island Is a beach with white sand with some kinds of seagrass beds, dead coral fractions, mangrove and some coral reefs [6, 7].

Sand dollars have important roles in ecology as the basic ecosystems in terms of cleaning environment as they usually live in fine sand habitats. The abundance and the spatial distribution of this unique biota in Pulau Cemara Kecil coastal waters therefore need to be analyzed. The present work studies the abundance and the spatial distribution of sand dollars at different

distances from the coastline of Cemara Kecil Island in Karimunjawa, Jepara. The study was conducted from March 2015 to April 2015 and an analysis was made utilizing some statistical method.

2.0 EXPERIMENT

Materials used in this research are sand dollars found in Cemara Kecil Island Karimunjawa Jepara, while the data were collected using purposive sampling and the descriptive-qualitative method. Purposive sampling method is the determination of recipient with some certain consideration by researchers based on features or properties of the population which are already known [8, 9].

2.1 The Sampling Location

Sampling was conducted at the sand zone of the lowest low tide spanning 50 m along the coastline. The location was then divided into sections by drawing seven virtual lines each separated 5 m from the next line, and repeated twice as shown in Figure 1.

2.2 Data Analysis

The data obtained from the survey were then statistically analyzed using multivariate statistical analysis with cluster analysis with the help of PAST-3 / Paleontological Statistics_3. Program Multivariate analysis is a statistical analysis best used to analyze data that arise from more than one variable in the experimental design [10, 11].

2.3 Relative Abundance and the Distribution Pattern

The Relative Abundance of sand dollars is the number of percent composition of sand dollars relative to the total number of organism in the area.

$$RA = Pi \times 100\% \quad (1)$$

Where :
RA = Relative Abundance;
Pi = Probabilities of species i in the total organisms

The distribution pattern of sand dollars at certain distances from the coastline can be obtained from the mean values and the variance [12].

The mean value and the variance were obtained using the formula (2):

$$V = \sqrt{\frac{2}{n-1}} \quad \text{and} \quad m = \frac{n}{N} \quad (2)$$

Where:
V= variance; n = number of individuals, m = mean; N = sample size

The distribution of organisms in nature is grouped into three:
V = m indicates random distribution
V > m indicates clumped distribution
V < m indicates uniform distribution

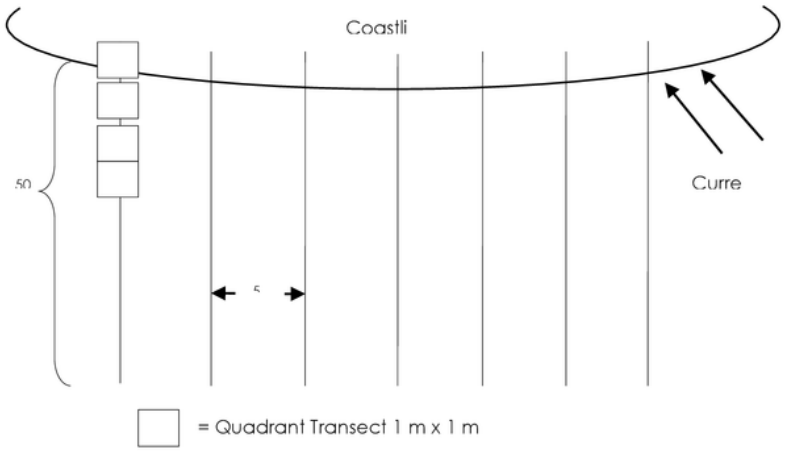

Figure 1 Sampling with Quadrant Transect

3.0 RESULTS AND DISCUSSION

3.1 Result

The cluster analysis using PAST-3 program reveals that sand dollars in Cemara Kecil Island (presented in Table 1 and Figure 3) are mostly clumped; some, such as *Laganum centrale* and *Laganum laganum* are uniformly distributed. At a distance of 23 m to 38 m along the coast sand dollars are found clumped in sandy mud substrate. The clumped and clustered distributional patterns of sand dollars are the most common in nature (Figure 2).

Table 1 Abundance and distribution patterns of sand dollars in Cemara Kecil Island

No	Species	Individu	RA (%)	(v)	(m)	DP
1	*L. centrale* (H.L. Clark, 1925)	384	17.5	0.07	0.17	*Uniform*
2	*L. laganum* (Leske, 1778)	661	30.0	0.06	0.30	*Uniform*
3	*L. fudsiyama* (Mortensen, 1948)	130	5.9	0.12	0.06	*Clumped*
4	*L. depressum* (L. Agassiz, 1841)	125	5.7	0.13	0.06	*Clumped*
5	*L. retinens* (Koehler, 1922)	145	6.6	0.12	0.07	*Clumped*
6	*L. boschi (Jeannet & Martin, 1937)*	124	5.6	0.13	0.06	*Clumped*
7	*L.depressum tonganense* (L. Agassiz, 1841)	141	6.4	0.12	0.06	*Clumped*
8	*L. dickersoni* (Israelsky, 1933)	149	6.8	0.12	0.07	*Clumped*
9	*L. decagonale rectum* (Gregory, 1892)	110	5.0	0.14	0.05	*Clumped*
10	*L. joubini* (Koehler, 1922)	121	5.5	0.13	0.06	*Clumped*
11	*L. decagonale* (Blainville, 1827)	110	5.0	0.14	0.05	*Clumped*
	Σ	2 200	100			
	H'	2.149				
	E	0.896				

Note : RA : Relative Abundance; DP: Distribution Pattern; V: Variance; m: Mean Value

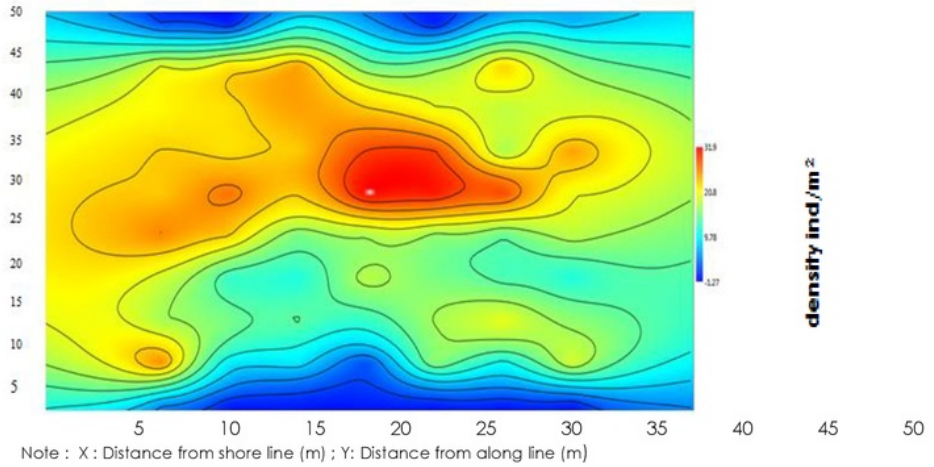

Figure 2 Geometry map showing sand dollars distribution and abundance in Cemara Kecil Island using PAST-3 (scale 1:5)

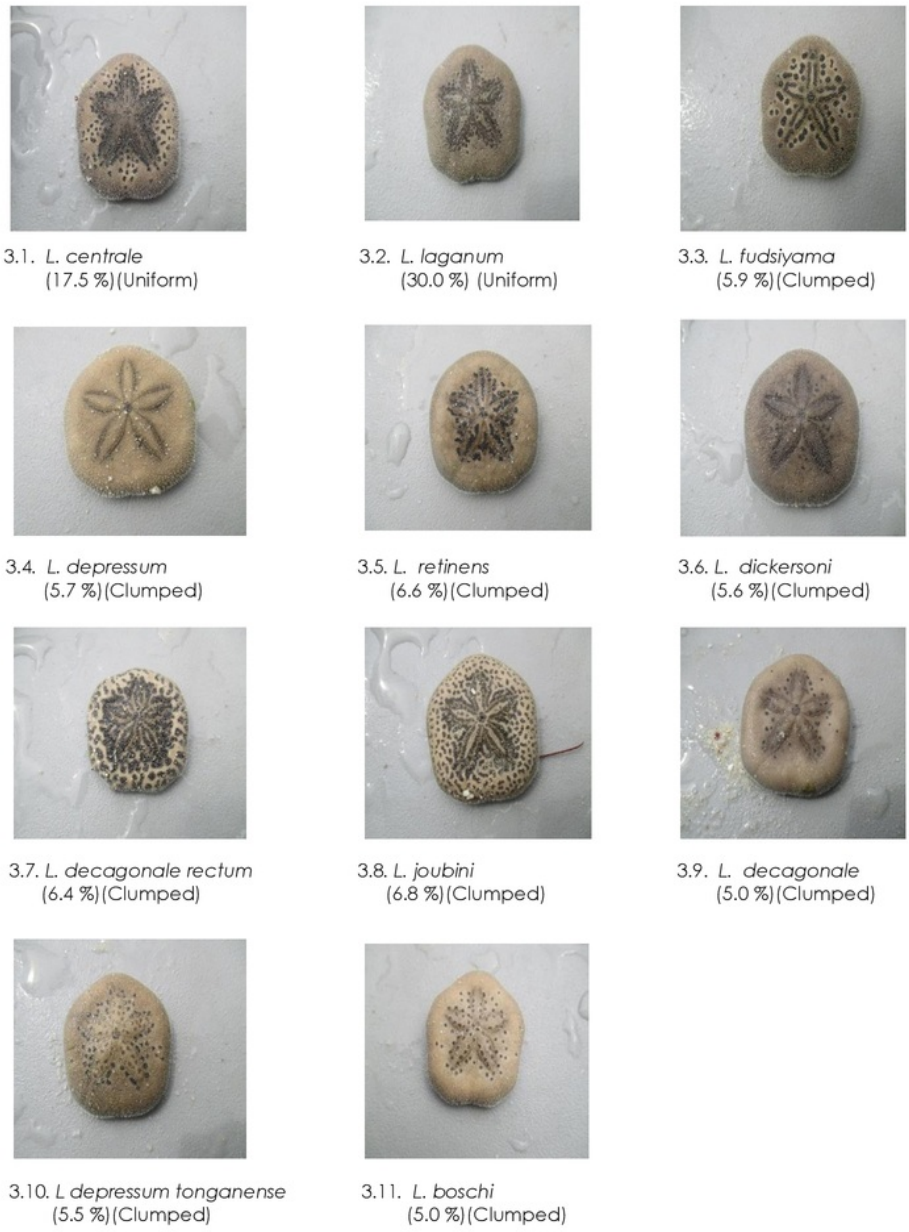

Figure 3 Sand dollars found on the Cemara Kecil Island, relative abundance and distribution pattern

3.2 Discussion

Sand dollars are abundantly found in the coastal area of Cemara Kecil Island which is known for its vast sloping white sand zone. This is naturally dominated by fine sand substrate in addition to some coral and seagrass beds. This type of substrate may become the underlying condition for the sand dollars abundance.

The abundance of sand dollars on Cemara Kecil Island Karimunjawa was obtained from the analysis using PAST-3, and is classified into three groups based on the distance to the coastline:

a. The distance of 0 m to 22 m
   The number of sand dollars within a distance of 0 m to 22 m from the coastline was found to be 632, which can be classified as medium abundance. This may be due to the coarse substrate from coral and shell fractions of some crustacean and bivalve. This finding is in line with a study discovering that the distribution of local sea fauna

is influenced by the habitats, a base substrate, the depth and zoning. Sand dollars of *Laganum laganum* kind was found in a depth of 1 m to 2 m [13].

b. The distance of 23 m to 38 m
The abundance of sand dollars at a distance of 23 m to 38 m from the coast belongs to the highest category as many as 1 103 individuals were found. This is because sand dollars bury themselves in a substrate of fine sand or sandy mud and obtain the food by swallowing sand which is in the surrounding area. This finding is in line with a study indicating that sand dollars obtain the food by swallowing sand around them [14]. Sand dollars are deposit feeder organisms. Other study shows that sand dollars are organisms that prefer basic sandy mud substrate [15].

c. The distance of 39 m to 50 m
The abundance of sand dollars at a distance of 39 m to 50 m from coastline belongs to the lowest category with 465 individuals. This is because the more distant from the coastline, the deeper the area whilst sand dollars have tendency to be buried in shallow water. Therefore sand dollars are found more in abundance in sandy areas and sometimes stranded on the coast [16].

The outer margin of these populations is well-defined in 4 m to 12 m of water, and here the largest individuals and greatest densities occur. Most of our observations are of these populations. The other type of distribution is similar, except that it extends into deeper water, and below about 10 m to 15 m; individuals become progressively smaller with depth [17].

3.2.1 Distributional Pattern

The distributional patterns of sand dollars on Cemara Kecil Island are dominated by clumped distributions, and some are random and uniform as in the case of *Laganum centrale* and *Laganum laganum*. The density of the sand dollars and organic matter from sediment is a major factor that regulates the density of sand dollars and muddy sand substrates as there is enough food and place to reproduce. When the density is high, sand dollars are less packed. On the other hand, when the density is low, the amount of organic matter, plankton and algae are eaten more. The proportions can be set by changing the organic content of the sediment [1, 13].

The types of clumped or clustered distributional pattern are the most commonly found in nature. This is because the sand dollars (*Laganum* sp.) tend to find a place suitable for them which then determines the distributional patterns [12].

The diversity index (H') of sand dollars is 2.149 which belongs to high category. According to Odum [12] the diversity index (H') 1.6 to 3.0 indicates high diversity. The high value of diversity can be acquired if all individuals collected are samples of different species, and on the other hand, diversity is low if there is only one kind of species in the samples [18, 19].

The calculated index of uniformity (e) is 0.896 indicating that the uniformity of sand dollars of the island is high. Index of uniformity of the population (e) having the value > 0.6 is classified as high [12].

3.2.2 Water Quality Parameter

Water temperature on the island of Cemara Kecil is around 29 °C to 30 °C. In terms of the temperature range of the water, it can be seen that this water temperature meets the requirements for the survival of sand dollars. This is further strengthened by Page [19] who claimed that sand dollars can still live in water temperature range between 26 °C to 30 °C [19].

The salinity on the sampling site ranges from 32 °/₀₀ to 33 °/₀₀. which is suitable for sand dollars and also other marine biota. This is in line with the findings of a study that states that the ideal sea water salinity range is from 0 °/₀₀ to 33 °/₀₀. Salinity level change can make a significant difference to the properties of marine water and marine biota [3].

Sand dollars have a radially symmetrical body which is divided into five sections. The movement is slow with the vessel-like feet to regulate water pressure. Usually the animals bury themselves in the sandy substrate. According to Hawkes [20], the speed of either direct or indirect current affects the substrate base where the sand dollars community can be found.

The research site is mainly sandy and sand dollars can be found in the sandy substrates when the water recedes. Hawkes states that the substrate directly influences the composition and distribution of benthos, and serves as the habitat and the source of nutrients for the animals [20].

4.0 CONCLUSION

The composition of sand dollars on the island of Cemara Kecil consists of 11 patterns. The highest relative abundance is *L laganum* (30 %) and the lowest is *L.decagonale rectum* (5 %) and *L. decagonale* (5 %).

The distributional patterns of sand dollars in Cemara Kecil Island are uniform distribution for *Laganum central* and *Laganum laganum*, while the rest of the animal belongs to clumped distribution.

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