

## Distribution Pattern of Sand Dollar (*Arachnoides placenta*) in the Intertidal Ecosystem of Duta Coastal, Probolinggo Regency

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### Abstract

Species *Arachnoides placenta* can be found in tropical waters, one of which is in the intertidal ecosystem in Duta Coastal. Substrate types at Duta Coastal are dominated by sand and silt substrates and a small portion of muddy sand substrate. The various types of substrates at Duta Coastal are thought to be causing the population *A. placenta* choose a suitable habitat for their life, so that it can affect the pattern of distribution and density of *A. placenta*. This research aims to determine the distribution pattern and density of *A. placenta* in the intertidal ecosystem in Duta Coastal. This study used the method of systematic transect plots. Plots measuring 1x1 m were placed on the transects with a distance between plots of 10 meters. The number of plots laid was 332 plots. The results show the number of individuals *A. placenta* in the Duta Coastal intertidal ecosystem 828 individuals. The population of the *A. placenta* species in the Duta Coastal intertidal ecosystem is quite large because the type of substrate is suitable for the life of *A. placenta* Morisita Index value for the distribution pattern *A. placenta* is 9.3. Distribution pattern *A. placenta* in the Duta Beach intertidal ecosystem classified as aggregated and density values *A. placenta* in the intertidal ecosystem in Duta Coastal is 2.5 ind/m<sup>2</sup>.

**Keywords :** *Arachnoides placenta*, Duta Coastal, Distribution Pattern

### INTRODUCTION

Sand dollar is a member of the class Echinoidea and the phylum Echinodermata. Sand dollars have irregular bodies, tend to be bilaterally symmetrical, flat, oval-shaped, and have short, dense spines and have no arms (Swisher and Lin, 2019; Swisher, 2021). One species of sand dollar is *Arachnoides placenta*. The main characteristic of this species is that it has a small periproct at the edge of the skeleton and a canal leading to the periproct in the aboral part (Swisher & Lin, 2019).

Species *A. placenta* has an important role in the food chain in intertidal ecosystems, namely as an eater of detritus and organic particles (Brusca and Brusca, 2003). Species *A. placenta* also acts as a food source for the crab species *Matuta linaris* (Haycock, 2004). Another ecological role of the *A. placenta* species is that it plays a role in recycling nutrients by breaking down rotten organic material so that it can be utilized by other organisms (Newton and Dennis, 2021). According to O'Hara and Byrne (2017), *A. placenta* plays a role in sediment bioturbation in three ways, namely

stirring up particles of various sizes, releasing organic compounds into the water and circulating oxygenated water into the sediment. The distribution of the *A. placenta* species can be found in tropical waters, one of which is the intertidal ecosystem at Duta Coastal.

Duta coastal is located in Randutatah Village, Paiton District, Probolinggo Regency. Duta coastal is one of the tourist beaches and a mangrove conservation center. The survey results show that the substrate type at Duta coastal is dominated by sand and mud substrates, and a small portion of muddy sand substrates. the presence of *A. placenta* can also be found in locations where it is abundant The varying types of substrate at Duta coastal are thought to cause the *A. placenta* population to choose a suitable habitat for its life such as mud substrate used for shelter and foraging, thereby influencing the distribution pattern and density of *A. placenta*. Substrate type can influence the distribution pattern and abundance of benthic organisms because there is a source of nutrition in the form of organic material (Kusmana *et al.*, 2015;

Griffith *et al.*, 2017). According to Yunita *et al.*, (2020) differences in substrate type affect the organic material content in sediment.

Research related to the density of the *A. placenta* species was carried out by Tala *et al.* (2021) at Lakeba Beach, Bau-Bau City, Southeast Sulawesi. The results of research by Tala *et al.* (2021) shows that the density of the *A. placenta* species is only 0.00167 ind/m<sup>2</sup>. Meanwhile, research regarding the distribution pattern of the *A. placenta* species in Indonesian waters has never been carried out, so the information is still limited. The population of the *A. placenta* species in the Duta coastal intertidal ecosystem is thought to be quite large because the type of substrate is suitable for the life of *A. placenta*. Apart from that, tourists and local residents do not take the *A. placenta* species for any purpose. However, until now there has been no research regarding the distribution pattern and population density of the *A. placenta* species in the Duta coastal intertidal ecosystem. Therefore, it is important to carry out research regarding the distribution pattern and density of the *A. placenta* species in the Duta coastal. This research is useful for conservation and preservation efforts of the *A. placenta* species in its natural

habitat through a representative method approach that represents the population as a whole.

### MATERIAL AND METHODS

The research was conducted from October 2022 to January 2023. Data collection was carried out in the intertidal ecosystem of Duta Coastal, Probolinggo Regency, East Java (Figure 1) with coastline coordinates between 7°42'12.98"S and 113°28'31.86"E to 7°42'17.77"S and 113°28'19.67"E. Duta coast has a coastline length of ±400 meters and a width of ±150 meters at maximum low tide. Identification and data analysis activities were carried out at the Ecology Laboratory, Jember University.

Collecting biotic data and measuring abiotic factors used the systematic transect plot method, namely by systematically placing a plot 1x1 m along the transect line. The activity began by marking the starting point for data collection using the Global Positioning System (GPS) type Garmin Etrex 10. The length of the coastal determined as the research area was 400 meters and the width was 150 meters or with a total research area area of 58.038 m<sup>2</sup>. Transect placement starts from east to



**Figure 1.** Map of Research Location in the Intertidal Ecosystem Duta Coastal Probolinggo Regency

west and is carried out from the edge to the shoreline. The distance between transects is 20 meters. The number of transects placed at the research location was 25 transect. Plots measuring 1x1 m were placed on the transects with a distance between plots of 10 meters (Figure 2) (Setiawan, *et. al.* 2023). The number of plots laid was 332 plots.

Collecting *A. placenta* specimens was carried out directly. Specimens on the surface of the substrate were taken and counted. *Arachnoides placenta* that were in the substrate were taken by digging the substrate and counting the number. *Arachnoides placenta* found in the research plot were then documented using a camera. Twenty individual specimens of *A. placenta* were taken, then cleaned with water and stored in a plastic container containing 70% alcohol solution. Preservation with a 70% alcohol solution aims to prevent *A. placenta* specimens from rotting until the identification process (Triana *et al.*, 2015).

*Arachnoides placenta* found in the intertidal ecosystem were recorded for their morphological characteristics, including the aboral and oral parts of the body, as well as the color of the spines, and then documented. Identification is carried out after the specimen drying process. Type identification is based on the morphological characteristics of the skeleton which include the number of gonopores, the location of the periproct, and the channels leading to the periproct. Based on photos of specimens and morphological characteristics, the species refers to the identification key book Monograph of Shallow Water Indo-West Pacific Echinoderms (Clark and Rowe, 1971; Swisher and Lin, 2019).

Abiotic parameters measured and observed in this research include temperature (using thermohygrometer), pH (using pHmeter), salinity (using refraktometer) and substrate type (Hand Texture). Measurement and observation of abiotic data serves as supporting data for research. Abiotic data measurements were carried out directly at 9 different points, namely 3 points at the edge, 3 points in the middle and 3 points near the coastline. Each abiotic parameter was measured 3 times during high tide (Setiawan, *et. al.* 2023).

Data on the number of *A. placenta* individuals in the intertidal ecosystem Duta Coastal was used to analyze its distribution pattern. Analysis of distribution patterns of *A. placenta* using the Morisita Index. The Morisita Index equation is as follows (Soegianto, 1994);

$$Id = \frac{n \sum X^2 - N}{N(N-1)}$$

Note: Id = Morisita Index; n = Number of Plot; N = Total number of individuals in all plots;  $\sum X^2$  = Square of the number of individuals per plot

The distribution pattern of *A. placenta* was determined using the following criteria (Michael, 1995): Id < 1 = even distribution pattern; Id = 1 = random distribution pattern; Id > 1 = clustered distribution pattern

Data on the number of *A. placenta* individuals in the Duta Coastal was used to calculate population density. The density of *A. placenta* in the intertidal ecosystem Duta Coastal was calculated using the following equation:

$$D = \frac{ni}{A}$$

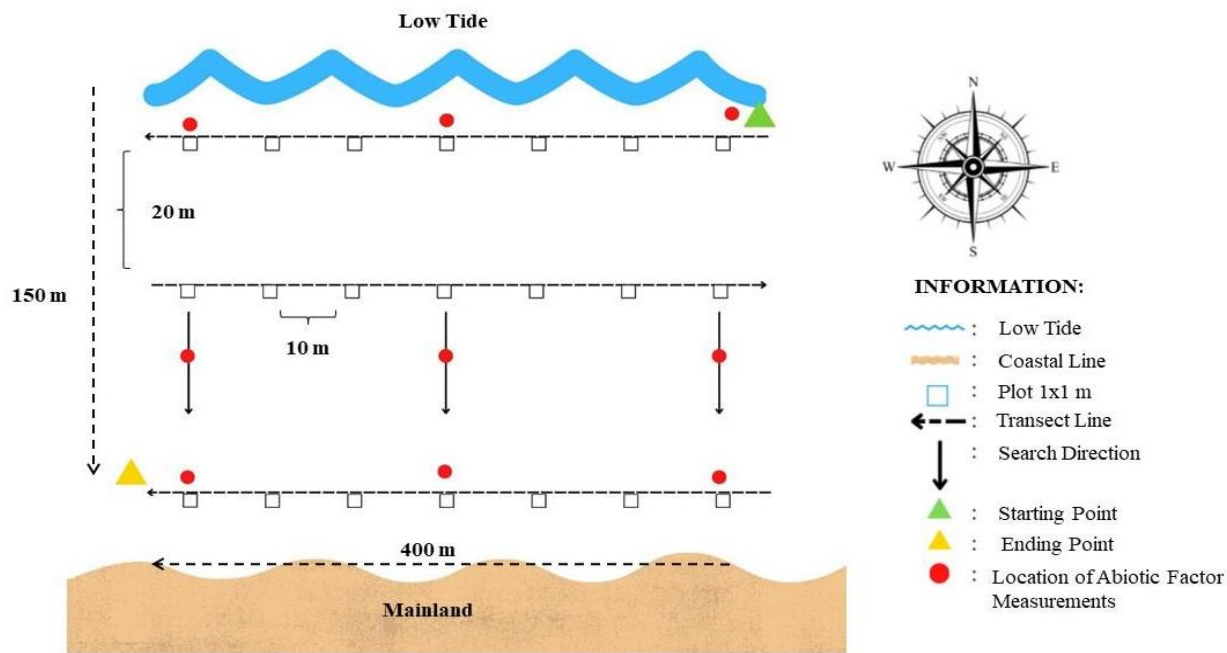
Note: D = Density; ni = Number of Individual; A = Total plot area (m<sup>2</sup>)

The results of abiotic parameter measurements obtained were then analyzed descriptively and qualitatively. The data shown is a range of values from direct measurements at the research site and is related to the habitat of *A. placenta*.

## RESULT AND DISCUSSION

The research results showed that the number of *A. placenta* individuals in the intertidal ecosystem of Duta Coastal was 828 individuals. The total number of research plots was 332 plots, and 121 of them were occupied by *A. placenta*. The Morisita Index value for the distribution pattern of *A. placenta* is 9.3. This value shows that the distribution pattern of *A. placenta* in the intertidal ecosystem of Duta Coastal is classified as clustered.

The clustered distribution pattern of *Arachnoides placenta* can be caused by two factors, namely substrate type and reproductive behavior. The substrate type in the intertidal ecosystem of Duta Coastal is dominated by sand and mud substrates. The *A. placenta* species were found clustered in plots with sand substrates. Substrate is important for the life of *A. placenta* because it is a place to live, shelter, and reproduce. The sand substrate also contains organic materials



**Figure 2.** Technique of Schematic data collection in the Intertidal Ecosystem Duta Coastal

such as litter and particles from scavengers, which are food for the *A. placenta* species. The organic matter content of sand substrates tends to be lower than mud substrates, but the *A. placenta* species can still live on these substrates. The *A. placenta* species is usually found in areas that have sand substrates with grains measuring 0.1 mm - 1 mm (O'Hara and Byrne, 2017).

Reproductive behavior is also thought to influence distribution patterns. During the research, many groups of *A. placenta* were found with the same size in one plot. The body diameter of the individual *A. placenta* found was more than 1.5 cm. This group is thought to be a group that was formed because it was spawning. According to Aung (2015), sexual maturity of the *A. placenta* species is when the body diameter reaches 15 - 20 mm. Avila (2005) stated that organisms within one species form groups during the reproductive period to facilitate the spawning process. Male and female *A. placenta* species come together so that spawning can take place perfectly and increase fertilization success (Haycock, 2004).

Abiotic environmental factors play an important role in supporting the life of *A. placenta*. The results of measuring abiotic factors show that the values obtained support the life of the *A. placenta* species in the intertidal ecosystem of Duta Coastal (Table 1). The results of salinity

measurements at the research location ranged from 29.7-30‰. This value is still within the appropriate range for the species *A. placenta*. Ali *et al.* (2017) stated that the salinity value suitable for the life of the Echinodermata group is around 29 - 30‰. The salinity value at Duta Coastal is still within the normal range even though Duta Coastal is classified as open water because there is a river that flows into the research location.

The results of water temperature measurements at Duta Coastal ranged from 30.7°C - 33.6°C. This value is relatively high, but can still support the life of *A. placenta*. Temperature measurements were carried out during the day, so the results obtained were quite high. This is in accordance with the statement of Angreni *et al.* (2017) which states that the temperature suitable for life in the Echinodermata group is in the temperature range of 28°C - 33°C. The pH measurement results at Duta Coastal ranged from 7.09 - 7.63. This value is included in the optimal range for the life of *A. placenta*. Sese *et al.* (2018) stated that echinoderms live well if they are in an environment with a pH value of around 6-8.

The research results show that the density value of *A. placenta* in the intertidal ecosystem Duta Coastal is 2.5 ind/m<sup>2</sup>. The density value of *A. placenta* in this study was higher when compared with research conducted by Tala *et al.* (2021) at

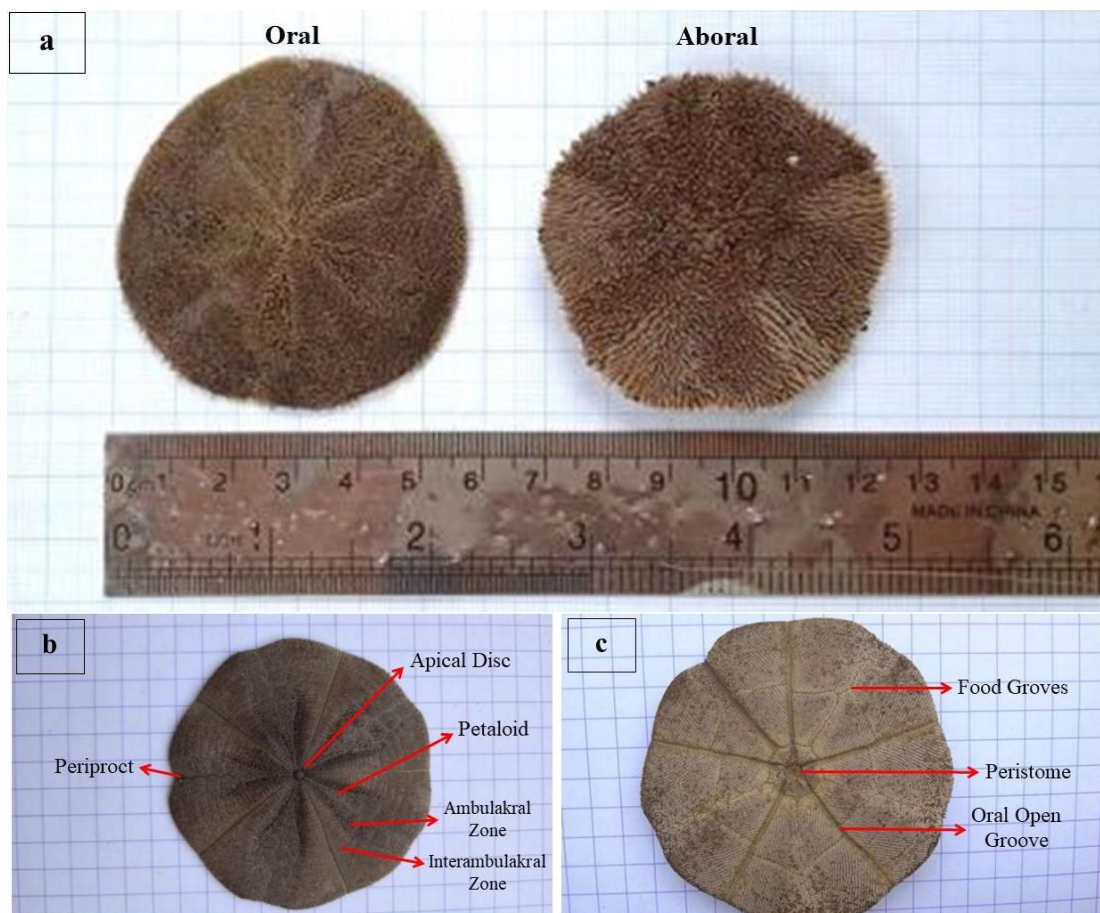


Lakeba Beach, Baubau City, Southeast Sulawesi, with a density value of *A. placenta* of 0.00167 ind/m<sup>2</sup>. The population density of *A. placenta* in the intertidal ecosystem Duta Coastal is thought to be influenced by the reproductive period and substrate type. Research by Tala *et al.* (2021) was conducted during the dry season, while this research was conducted during the rainy season. Seasonal differences in the research process are thought to influence the population density of the *A. placenta* species. The *A. placenta* species is thought to have spawned during the rainy season,

so the number of individuals and population density values obtained tend to be higher. Based on research by Haycock (2004), spawning in the species *A. placenta* is related to rainfall and a decrease in sea water temperature. The main spawning period for the *Arachnoides placenta* species occurs from March to July, and some individuals spawn from July to September, in which months rainfall tends to be high and sea surface temperatures reach a minimum. Meanwhile, according to Lee and Chen (2014), the *A. placenta* species spawns from September to October.

**Table 1.** The Value of Environmental Abiotic in the intertidal ecosystem Duta Coastal

Abiotic Environmental	Value Range
Temperature (°C)	30,7 – 33,6
pH	7,09 – 7,63
Salinity (‰)	29,7 – 30
Type of Substrate	Sand and Clay



**Figure 3.** (a) Morphology of *Arachnoides placenta*, (b) Part of the Oral Skeleton, and (C) Part of the Aboral Skeleton

In addition, the type of substrate is thought to influence the density of *A. placenta*. Based on research that has been carried out, the type of substrate that dominates at Duta Coastal is sand substrate. Sand substrates have larger particle sizes than mud substrates. The *A. placenta* species tends to prefer substrates that have a particle size of 0.1 mm - 1 mm, so it is found abundantly on sand substrates. This is related to the movement and feeding process of *A. placenta*. The *A. placenta* species is a biota that eats microalgae, detritus, deposits and sediment. This biota will bury itself to get its food. According to Haycock (2004) particle size can influence the feeding process and movement of *A. placenta*. In general, sand dollars cannot move on very small (<63 µm) or large (>1 mm) substrate particle sizes.

On the muddy substrate, only 1 individual of *A. placenta* was founded. The individual is thought to have been carried away by the current. Mud substrate is not suitable for the life of *A. placenta* because the substrate particle size is very small. According to Taqwa *et al.* (2014) mud sand substrates easily accumulate organic material, so the organic material content in them is higher than sand substrates. High organic material content in sediment can have a negative impact, namely it can block the respiratory organs of organisms (Rangkuti *et al.*, 2017). Therefore, the *A. placenta* species is unable to live in muddy substrates.

*Arachnoides placenta* found varied in size from 3 – 12 cm in body diameter with special characteristics that characterize this species (Figure 3). Species *A. placenta* is often found in the upper intertidal and middle intertidal, because this area still has a lot of standing sea water, so this area is favored by *A. placenta* to prevent dehydration of its body. Less *A. placenta* species are found in the lower intertidal, because this water area tends to be deeper and the substrate is smoother or muddy, so *A. placenta* does not like it.

## CONCLUSION

The conclusion of this research is that the distribution pattern of *A. placenta* in the intertidal ecosystem Duta Coastal is classified as clustered and the population density is 2.5 ind/m<sup>2</sup>.

## REFERENCES

Ali, A.I., Suryanti, & Sulardiono, B. 2017. Kelimpahan dan Pola Sebaran Echinodermata

di Pulau Karimunjawa Jepara. *Prosiding Seminar Nasional Hasil-Hasil Penelitian Perikanan Daamian Kelautan Ke-VI*. pp.159–172.

- Angreni, F., Litaay, M., Priosambodo, D. & Moka, W. 2017. Struktur komunitas echinodermata di padang lamun Pulau Tanakeke Kabupaten Takalar Sulawesi Selatan. *Bioma: Jurnal Biologi Makassar*, 2(1): 46-55.
- Aung, W. 2015. Observation on the Reproductive Biology of the Tropical Sand Dollar *Arachnoides placenta* (L.) (Echinodermata: Echinoidea). *Journal of Marine Science and Application*, 12(2): 79-86
- Avila, V.L. 2005. *Biology: Investigating Life on Earth*. New York: Bookmark Publisher.
- Brusca, R., & Brusca, G., 2003. *Invertebrates*. Princeton: Sinauer Associates, Inc.
- Clark, A.M., & Rowe F.E.W. 1971. *Monograph of Shallow Water Indo-West Pacific Echinoderms*. London : Trustees of the British Museum (Natural History).
- Griffith, J.R., Kadin, M., & Nascimento, F.J. 2017. The Mmportance of Benthic–Pelagic Coupling for Marine Ecosystem Functioning in a Changing World. *Global Change Biology*, 23: 2179-2196
- Haycock, L.J. 2004. The Reproduction and Recruitment of The Sand Dollar *Arachnoides placenta* (L.) (Echinoidea: Echinodermata) from Differing Habitats on the North Queensland Coast. *ICES: Journal of Marine Sciences*, 12(3): 111-118
- Kusmana, C., Setyobudiandi, I., Hariyadi, S. & Sembiring, A. 2015. *Sampling dan Analisis Bioekologi Sumber Daya Hayati Pesisir dan Laut*. Bogor: PT Penerbit IPB Press.
- Lee, K.S. & Chen, C.P. 2014. *Common Echinoderm of Taiwan*. Pingdong: National Museum of Marine Biology & Aquarium.
- Michael, P. 1995. *Metode Ekologi untuk Penyelidikan Ladang dan Laboratorium*. Jakarta: Penerbit Universitas Indonesia.
- Newton, A.L., & Dennis, M.M. 2021. *Echinodermata*. New York: John Wiley & Sons, Inc.
- O'Hara, T., & Byrne, M. 2017. *Ecology Behaviour*. Canberra: CSIRO Publishing.
- Rangkuti, A.M., Cordova, M.R., Rahmawati, A., Yulma, & Adimu, H.E. 2017. *Ekosistem Pesisir dan Laut Indonesia*. Jakarta: Bumi Aksara.

- Sese, M.R., Annawaty, & Yusron, E. 2018. Keanekaragaman echinodermata (Echinoidea dan Holothuroidea) di Pulau Bakalan, Banggai Kepulauan, Sulawesi Tengah, Indonesia. *Scripta Biologica*, 5(2): 73–77.
- Setiawan, R., Siddiq, A.M., Pratiwi, A., & Susanto, M.A.D. 2023. Pola Distribusi Dan Kepadatan Populasi Bulu Babi (*Tripneustes gratilla* Linnaeus, 1758) di Ekosistem Intertidal Pantai Bilik Taman Nasional Baluran. *Journal of Marine Research*, 12(4): 630-638.
- Soegianto, A. 1994. Ekologi Kuantitatif: Metode Analisis Populasi Komunitas. Surabaya: Penerbit Usaha Nasional.
- Swisher, R.E., & Lin, J.P. 2019. A geometric morphometric analysis of *Arachnoides placenta* (Echinoidea: Clypeasteroidea): An examination of ontogenetic development and morphological variation. *Zoozymposia*, 15(20): 159-171.
- Swisher, R.E. 2021. Convergent discoidal sand dollars from isolated regions: A geometric morphometric analyses of *Dendraster* and *Arachnoides*. *Journal of Marine Ecology*, 17(3): 201-207.
- Tala, W., Kusriani, K. & Jumiati, J. 2021. Struktur Komunitas Echinodermata pada Berbagai Tipe Habitat di Daerah Intertidal Pantai Lakeba, Kota Baubau Sulawesi Tenggara. *Jurnal Kelautan Tropis*, 24(3): 333–342
- Taqwa, R.N., Muskananfolo, M.R. & Ruswahyuni. 2014. Studi Hubungan Substrat Dasar dan Kandungan Bahan Organik Dalam Sedimen dengan Kelimpahan Hewan Makrobenthos di Muara Sungai Sayung Kabupaten Demak. *Diponegoro Journal of Maquares*, 3(1): 125 - 133
- Triana, R., Elfidasari, D. & Vimono, I.B. 2019. Identifikasi Echinodermata di Selatan Pulau Tikus, Gugusan Pulau Pari, Kepulauan Seribu, Jakarta. *Prosiding Seminar Nasional Masyarakat Biodiversitas Indonesia*, 1(3): 455-459.
- Yunita, R.R., Suryanti, S. & Latifah, N. 2020. Biodiversitas echinodermata pada ekosistem lamun di Perairan Karimunjawa, Jepara. *Jurnal Kelautan Tropis*, 23(1): 47-56.