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ENVIRONMENTAL FACTORS THAT AFFECT THE BIODIVERSITY AND COLOR OF STARFISH IN MENJANGAN BESAR ISLAND, KARIMUNJAWA

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ABSTRACT

Starfish as one of the macrozoobenthos in coastal and marine waters has various important roles. However, with the effects of global warming that alters the habitat function and exploitation of starfish cause its existence in the threatened one of them in the area of MenjanganBesar Island. Until now, no studies have reported what kind of starfish is found in the waters of Menjangan Besar Island and what are the environmental factors that influence the starfish color. This study aims to determine the types of sea stars that are found around the waters of Menjangan Besar Island and what factors influence it. The research was conducted in May 2017 in Menjangan Besar Island. The samples were obtained from 3 research stations. Based on research that has been done in the waters of MenjanganBesar Island found 4 types of sea stars that is *Linckia laevigata, Culcita sp., Protoreaster nodosus*, and *Achantaster plancii*. *Protoreaster nodosus* is the largest number of sea stars found in the study sites. Environmental factors that affect the body color of *Culcita sp*. Is the salinity of water, organic matter, and dissolved oxygen with positive correlation, whereas the water temperature is negatively correlated. Environmental factors that affect the color of Linckialaevigata and Achantasterplancii are water pH with positive correlation, while the color of Protoreasternodosus is negatively correlated with water pH.

Keywords : Starfish, Body Color, MenjanganBesar Island

INTRODUCTION

Karimunjawa islands, located in the north of Java Island, in the district of Jepara-Central Java, and in position 5 '40 "- 5' 57" LS and 110 '4 "- 110' 40" BT, North West Jepara regency. Located about 45 miles or about 74 km from the port of Kartini - Jepara, Central Java. It is a Marine National Park that became one of the objects of marine tourism in Indonesia. Defined as a Marine National Park since 1988, with a land area of 7.033 ha and 104,592 ha of marine waters, the total total area of Karimunjawa Islands Marine National Park reaches 111,625 ha [1].

MenjanganBesar Island is one of 27 islands that belong to the conservation area of Karimunjawa Islands National Park. This place keeps the charm of natural beauty so that serve as one of tourist destination. In addition to observing marine biota, this location is also suitable for activities such as diving, snorkeling and research. Divers can enjoy the beautiful panorama that is served by the nature of the ocean floor through the coral reef ecosystem with a variety of ornamental fish, anemones and other marine biota living there.

One of the marine biota is often found in the waters of MenjanganBesar Island is a starfish. According to[2] starfish is one of the group of animals in Echinodermata phylum which has the second highest diversity after the infectious star group. Starfish can be found in various water microhabitats. This animal has a skin that is covered by fine spines so that it belongs to the phylum Echinodermata (echinos = duri, derma = skin). Often the starfish is found to have five arms, sometimes also seen only four or six arms[3]. If one arm is severed then the new arm will be formed immediately because of the regeneration of this animal. In general, these animals have relatively thin bodies. If the dorsal, there is madreporit and anus then the ventral found the mouth and leg tube (ambulakral legs) on each arm[4], [5].Madreporit is a kind of hole that has a filter in connecting the sea water with vascular system and genitals. The rigid condition of the arm and likes the habitat with sandy substrates makes it easy to distinguish the star of sea snakes[6], [7]. These animals are often found living in small groups by immersing themselves in the sand. If the sea water receded, often these biota are trapped in shallow puddles [8], [9],[10].

Changes in animal body colors such as starfish are generally difficult to explain because they are always qualitative. Currently there is an analysis system that can change the qualitative color changes to be quantitative by using the help of multimedia software on the computer. In this analysis the starfish body color can be expressed in 'hue'. According to[11] the colors reflected or transmitted by an object can be seen from the hue value measured from the standard color wheel expressed with the angle value value from 0˚ to 360˚. The color of the starfish will be affected by the condition of the habitat. If there is a change in the color of the body of the starfish observed and measured through hue it can be said that there is also a change in the condition of the starfish.

Until now, no studies have reported what kind of starfish is found in the waters of MenjanganBesar Island and what are the environmental factors that influence the starfish color. Therefore it is necessary to do research that aims to determine what types of sea stars found around the waters of MenjanganBesar Island and what factors influence it. The results of this study are expected to contribute to the management of marine areas in Indonesia, especially in the Karimunjawa Islands.

METHODS

The material of this research is samples of starfish obtained from 3 stations in May 2017 and several environmental factors observed in the location of the starfishes found in the waters of MenjanganBesar Island.

Starfish samples were observed and measured in color taken from 3 stations. In addition to each station measured physical and chemical parameters including water temperature, water salinity, dissolved oxygen, water pH, and sediment organic matter.

The starfish samples obtained are then placed into an artificial mini studio photo for taking pictures on the surface of the starfish body using a high resolution camera. The distance of the leaf shooting is 30 cm. Color values are taken on each surface by determining the point of color values taken on each part of the body of a starfish randomly. The method used in this leaf color value is the Haphazard sampling method. According to[12] The Haphazard method is the method by which the observer attempts to create a random sample of the selected material in order to try and create the correct randomness. In order to create a correct random selection, it is necessary to use one of the random selection methods that has been tested, such as simple random selection.

The results of the actual shot starfish samples applied to computer software Adobe Photoshop CS3. The value of starfish samples it can be seen through the value of hue that was found in the software. Identification technique is used also on [6] arrangement that using cameras and the lighting standardized test was to observe the influence of variety of food to its color on coral fishes nemo (*Amphiprionocellaris*) who assisted use Adobe Photoshop software 7.0.

Fig 1. Example Results of Starfish Taking
(Source :Personal Documentation)

RESULT AND DISCUSSION

Based on research that has been done in the waters of MenjanganBesar Island found 5 types of starfish that is *Linckialaevigata*, *Culcita* sp., *Protoreasternodosus*, *Nardoaturbeculata*, and *Achantasterplancii*. *P.nodosus* is the largest number of sea stars found in the study sites. In addition, many starfish samples are found on rare reef areas. This is reinforced by[7] coral reefs are stable and highly productive ecosystems in terms of providing a variety of habitat options for different animal groups, both for different types of living and different living needs. Echinoderms occupy both hard and fine substrate and a variety of suitable habitats provided by coral reef ecosystems[8].

Linckia laevigata

L.laevigata is one of the Asteroideas belonging to the Ophidiasteridae family. This starfish has five cylindrical and blunt-shaped arms at its end. In the aboral section, *L.laevigata* has a madreporit while ambulaclar and mouth openings are in the oral section. The starfish has small granules covering the disc (Fig. 2). [9]adds that *L. laevigata* is one of the largest types of starfish but has slow growth and low recruitment rates.

Generally L.laevigata has a blue color on the aboral. Classification of this marine biota, namely Kingdom Animalia, Phylum Echinodermata, Class Asteroidea, OrdoValvatida, Family Ophidiasteridae, Genus Linckia, Species *L.laevigata*. The distribution of *L.laevigata* is located in Micronesia (Chuuk, Kosrae, Yap), Korea (Jeju Island), Taiwan, South China, Hongkong, Guam, Australia, Indo-West Pacific, Eastern Africa (Madagascar, Mauritius), And Red Sea [10].

Fig 2. *Linckia laevigata*
(Source :Personal Documentation)

***Culcita* sp.**

Culcita sp. Is a starfish that has no arms. His body pentagonal with the arrangement of the legs of the tube on the ventral. Pedicellaria slit brown with clear brown legs on both sides. This gap is composed of five that look like a star (pentagonal). The thickness of the body ranges from 6 s.d 9 cm with a diameter of 16 s.d 23 cm this animal looks like a cushion so that the local people named it with a sea pillow (Figure 3.). The dorsal part (aboral) found pedicellaria that serves to rid his body of sand grains and other organic particles. Culcita sp. Has pigment red, yellowish and blackish. This section also contained a pentagon-like ornament. The middle part of aboral is a pale yellow madrepotite[11].

Fig 3. *Culcita* sp.
(Source : Personal Documentation)

Protoreaster nodosus

According to [12] the starfish *P.nodosus* is one of the large sea stars that can be found in large numbers in the shallow waters of the Indo-Pacific.[13]adds that the species are known to eat meiofauna, microorganisms and macrofauna sand, and choose sandy habitats such as sand or seagrass beds. In addition to its role as a small organic eater, *P.nodosus* is capable of being an opportunistic predator and has been noted to eat gastropod, soft corals, and heart sea urchins.

Starfish *P.nodosus* has a large and hard body, the dorsal part of its body has a tapered, black, and gray colored color (Figure 4).

Fig 4. *Protoreaster nodosus*
(Source : Personal Documentation)

Nardoa turbeculata

The color in nature is blue or yellow with large grains of different colors on the body's aboral surface. The entire surface is coated with a fine grain covering the base plate. On the flat part of the aboral frame measuring 48 mm. But at the convexity they become very rough, especially toward the end of the plate. Tubercul plates are relatively low and rare, often limited to the distal side of the arm and rarely exceeding 2.8 mm. The supero-marginal plates (0.5mm long) are all similar and barely convex. Blunt arm at the end. The main series of actuator plates runs along the length of the arm. Adambulacral plates for most of the four bear sleeves, rarely five, prismatic spikes, fans slightly tilted so that the consecutive ones tend to overlap [14] (Fig 5.)

N. tuberculata has convex and nodular discs on the upper part of its body. This species is yellowish with a brownish brown ring in its hands. Actinal row is present throughout arm length [15].

Fig 5. *Nardoa turbeculata*
(Source : Personal Documentation)

Achantaster plancii

Starfish *A.plancii* is one of the major problems faced in the management of coral reefs. Among the existing coral predators, A. planci is the most dangerous reef predator when there is an outbreak, so that almost all living corals are preyed by A. planci. The explosion of *A.plancii* populations in Bootless Bay, Papua New Guinea, is reported to have a population density of about one individual per m2[16]. The size of body diameter of *A. plancii* population varies between 3-46 cm, with population dominated by the size of 15-20 cm and 20-25 cm in diameter. In Kapoposang Island, the population density reached 120 individuals per 100 m2, or equivalent to 1.2 individuals per m2[17].

The structure of *A.plancii* body is similar to the general structure of Asteroidea. The body is symmetrically radial, with the body resembling an oral and abortive axial disc that has arms. The oral portion faces downward while the aboral portion is facing upwards. In the aboral section there are madreporit and anus. Madreporit hole amounted to 6-13, while the anus hole amounted to 1-6 pieces. Star of *A.plancii* has an arm between 8-21 pieces. The toxic spikes measuring 2-4 cm adom the aboral surface of the disc body and the arms. In Indonesia, the color of red and gray *A.plancii* body in the waters of Java Sea and Flores Sea. In Cocos Island and Christmas Island (Southwest Java), Australia, there are two colors of A. planci showing the type of Pacific Ocean and Indian Ocean [18] (Figure 6.)

Fig 6. *Achantaster plancii*
(Source : Personal Documentation)

Based on the results obtained from the field, the composition of Asteroidea (Sea Star) in MenjanganBesar Island can be seen in Table 1.

Table 1. Composition and Abundance of Asteroidea (Sea Star)

No	Spesies	Stasiun 1	Stasiun 2	Stasiun 3	Total
1	*Linckia laevigata*	1	2	0	3
2	*Culcita* sp.	2	0	0	2
3	*Nardoa tubeculata*	2	1	1	3
4	*Protoreaster nodosus*	3	4	3	10
5	*Achantaster plancii*	0	1	0	1

Abundance Asteroidea (sea star) is found in sandy substrate areas, coral fragments and live coral in MenjanganBesar Island. The beach at MenjanganBesar Island is famous for its wide expanse of white sand with flat topography, so that the sand substrate is more dominant compared to other substrates. Asteroidea (sea star) is often found that is *L.Laevigata* species. According to [19], ordinary Starfish lives to form small groups consisting of several individuals. These animals are sometimes not visible from the surface of the water for hiding by immersing themselves in a pile of sand. *L. laevigata* is mostly found in dead coral and live coral ecosystems, while the *C. novaeguieae* species during sampling are present in the sandy substrate ecosystem and seagrass beds. The species of *N. tubeculata* is found in the crevices of living coral reefs.

Environmental Factors

The result of environmental factor measurement can be seen in Table 2.

Table 2. Environmental Parameter Measurement Results

Environmental Parameter	Station		
	I	II	III
Water temperature (°C)	31	31	30
Water pH	6,91	6,85	6,96
Water salinity (ppt)	30	33	35
Dissolved Oxygen (mg/l)	5,46	6,43	6,42
Sediment organic matter (%)	3,88	4,25	4,81

Based on the measurement of environmental factors that have been done, it can be seen that station III has the highest environmental factor value compared to other research stations.

Organic material at station III is higher than other stations because the station III is dominated by seagrass ecosystem which resulted in the leaf litter supply is quite high and its location is adjacent to the mainland. According to[20] in general sediments in coastal areas have a fairly high organic material. This is due to the removal of carbon-organic material and its condition (materials derived from shells and corals) are more prevalent in areas close to the coast also usually derived from the litter of the land.

In addition, at station III has the highest dissolved oxygen content this is due to the station having a lower temperature. This is reinforced by[21] which states that the solubility of oxygen in water is mainly influenced by the temperature factor, where the maximum solubility is at 0°C, which is 14.16 mg/l, whereas the dissolved oxygen value in the water is not more of 8 mg/l. With the increase in temperature will cause the oxygen concentration will decrease and otherwise the lower temperature will increase dissolved oxygen.

Starfish Body Color and Biodiversity Relations with Environmental Factors

The results of Principal Component Analysis (PCA) analyzes of starfish body color with environmental factors in the waters of MenjanganBesar Island can be seen in the Rotated Component Matrix table presented in Table 2.

Based on the results of PCA analysis has been done, it can be seen that the body color Culcita sp. Influenced by water salinity, organic matter, dissolved oxygen, and water temperature. These factors have a positive correlation with body color Culcita sp. But the water temperature has a negative correlation with the color of the body which means if there is an increase in water temperature then the color Culcitasp tends to fade.

Table 2. *Rotated Component Matrix*

Variabel	Component	
	1	2
Water salinity	1.000	.004
*Culcita*sp	.989	-.149
Sediment organic matter	.972	.235
Dissolved Oxygen	.916	-.402
Water temperature	-.800	-.600
Achantaster plancii	-.317	.949
Water pH	.345	.939
Linckia laevigata	-.438	.899
Protoreaster nodosus	-.590	-.807
Nardoa turbeculata	.216	.976

As one of the macrozoobenthos in marine waters, Culcita sp. Influenced by several environmental factors during its lifetime such as water temperature, water salinity, organic matter, and dissolved oxygen.

Temperature has a significant effect on the diversity of macrozoobentos because macrozoobentos have tolerance range to live well in that place. Dissolved oxygen is one of the important factors in a waters for the survival of macrozoobenthos. According to[22], to survive, water organisms depend on dissolved oxygen. Salinity affects the life of macrozoobentos, among others, affect the rate of growth, the amount of food consumed, the value of food conversion and the survival of water biota. The organic content of the substrate exerts an influence because the habitat of macrozoobentos is present in the bottom substrate of the waters [23].

Other results obtained were that body color on Achantasterplancii, Nardoa turbeculata, and *Linckia laevigata* correlated positively with water pH, while Protoreasternodosus was negatively correlated with water pH.

In general, the pH of water is very influential on the growth of water biota one of them is the starfish as makrozoobenthos. This is reinforced by[24] which states the degree of acidity (pH) is very important to support the survival of aquatic organisms because pH can affect the type and composition of substances in aquatic environments and the availability of nutrients and toxicity of renewable elements. Conditions of very acidic or alkaline waters will endanger the survival of the organism as it will lead to disruption of metabolism and respiration, where low pH leads to the survival of aquatic organisms.

The effect of water pH is also evident from the diversity of Echinodermata present in the waters. This is evident in the results of [25] studies in which the decrease in pH values resulted in a decrease in the diversity of Echinoderms in a region.

From the above results it can be seen that Protoreasternodosus has a wider range of life against water pH than other types of sea stars. This is evidenced by the number of starfish is found more.

CONSLUSION

The conclusions can be obtained as follows:

1. The types of starfish found in the waters of MenjanganBesar Island are Culcita sp., Linckialaevigata, Achantasterplancii, and Protoreasternodosus are the most common.
2. Environmental factors that affect the body color of Culcita sp. Is the salinity of water, organic matter, and dissolved oxygen with positive correlation, whereas the water temperature is negatively correlated. The environmental factors affecting the color of Linckialaevigata, Nardoaturbeculata, and Achantasterplancii are water pH with positive correlation, whereas the color of Protoreasternodosus is negatively correlated with the pH of water.

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