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Gastropod Community Structure as Environmental Change Signals for Tropical Status in Sedati Waters, Indonesia

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ABSTRACT

Sedati is one of the Sidoarjo Regency's Coastal Areas, which has potential resources in capture fisheries. Many industries in Sedati have caused a decrease in the aquatic productivity and aquatic organism conditions, including gastropods. Gastropods are easy to find in various habitats, but their distribution is highly dependent on the habitat conditions such as physical, chemical and biological factors. Gastropods are sensitive to environmental changes and can withstand the environmental changes that are not too wide to be used as indicators of environmental pollution. This study aims to determine the structure of the gastropod community in the Sedati Waters. The research was performed using an observation method. The gastropod samples were taken using a dredge net, while the substrate samples were collected using Ekman grab. The gastropods found in Sedati Waters from October to December are nine species from 2 orders and six families. The species most commonly found in *R. venosa*, while the least is *C. ventricosa*. The abundance index of gastropods every month shows a marked difference between stations but not the other main parameters. The diversity index value was between 1.4846–2.0897. The evenness index value reached between 0.8284 and 0.9548. The dominance index ranged from 0.16 to 0.2299. The community structure of gastropods in the Sedati Waters, Sidoarjo, East Java shows a significant difference ($p<0.05$) between stations and belongs to the medium category.

Keywords: community-based conservation, marine, water quality, development aid, ecological footprint.

INTRODUCTION

In Sidoarjo, fishery is the dominant activity and included in the largest agricultural sector activities because they can produce regional domestic products reaching 1.79% (Badan Pusat Statistika, 2013; Sari et al., 2019a). Sedati is one of the coastal areas of Sidoarjo that is potentially experiencing environmental changes due to the disposal of industrial waste, agriculture and households originating from the river flow in Sidoarjo Regency (Sari et al., 2019b; Sari et al., 2018a). The number of industries in the Sedati region resulted in a decrease in water productivity and influenced the water biota, one of them gastropods.

Gastropod is a class of mollusk phylum and corresponds to almost three-quarters of the total number of mollusks. In Indonesia, mollusks are ranked second largest phylum and varies after fish (Badan Pusat Statistika, 2016). Gastropods can be found in a wide range of habitats, but their spread is strongly influenced by the habitat conditions, such

as physical, chemical and biological factors (Pyron and Brown, 2015). The diversity of gastropods is influenced by the salinity and substrate of water (Amini-Yekta et al., 2019) and influenced by temperature, dissolved oxygen and substrate (Islami, 2015). gastropods are sensitive to environmental changes and can withstand a range of not too wide environmental changes (Marwoto and Isnaningsih, 2014) to be used as an indicator of environmental pollution. The composition of the gastropods will be higher with the growing and fertile waters, and conversely, the composition of the gastropods will be lower in the case of decreased fertility in the water (Pribadi et al., 2009).

The information about the water condition of Sedati has not been found yet, including the community structure of gastropods, so that the research to evaluate the structure of gastropod communities that include composition, abundance, diversity, uniformity, and dominance needs to be carried out.

MATERIAL AND METHODS

The research was conducted from October to December and taken at Sedati Water, Sidoarjo Regency, East Java. The equipment used includes boats, GPS, dredge net, Ekman grab, plastic samples (2.5 kg), water bottles (1.5 L), Cool Box, DO meters, refractometers, thermometer, pH meters and cameras. The materials used are fresh water and ice cubes. The research was carried out based on the change of season from drought to rain. Sampling was conducted every month. The sampling location consists of three stations, and each station is three dots (Figure 1). The station coordinate points are marked on the GPS used during the research.

Sampling

The research took two samples, the gastropods and the substrates sample. The samples of gastropods were taken using a dredge net. The shape of the dredge net is triangular on the mouth and equipped with the rear pockets, on the lower part of the mouth, is equipped with an iron-made tooth (Martasuganda, 2004). The dredge net is operated is by dropping it into the water and then pulling by a vessel; in turn, substrate sampling was performed using Ekman grab. The Ekman grab measured 20×20 cm and was made of brass or stainless-steel material (Romdon, 2003).

Data retrieval of environmental conditions

The quality of water measured at the research site include DO, temperature, salinity and pH. DO was measured using DO meters, temperature using a thermometer, salinity using a refractometer and pH using a pH meter (Sari et al., 2018b; Azmi et al., 2020; Rinawati et al., 2020). The current and precipitation data is obtained from BMKG Sidoarjo and Tanjung Perak. Other data, such as organic substrate material, were tested in

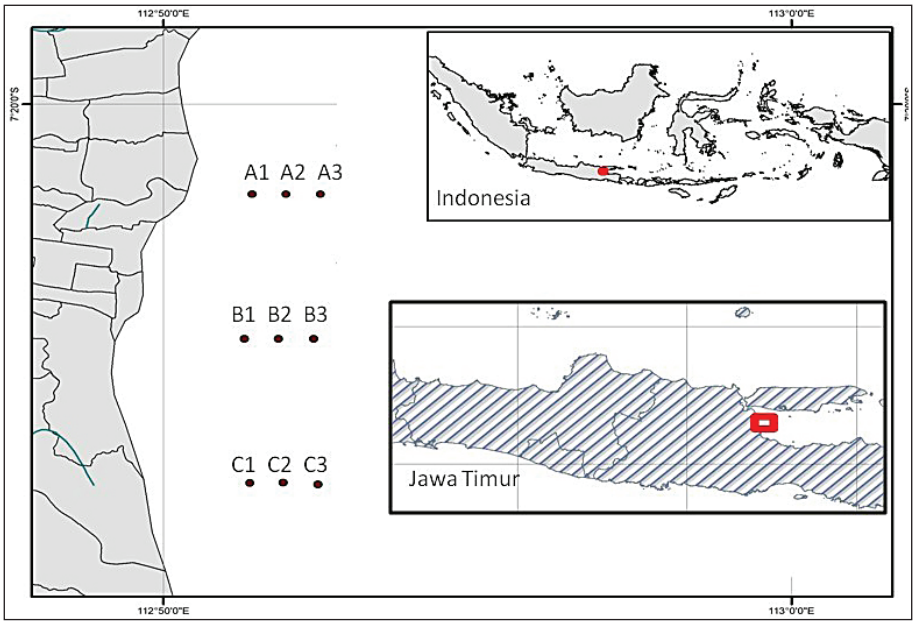

Figure 1. The sampling location

the nutrition laboratory during substrate fraction data in the soil mechanics laboratory.

Data analysis

The research parameters were analyzed using the test Analysis of Variance (ANOVA), followed by a test Duncan Multiple Range Test with a software tool SPSS 16. 0. Composition is a description of a community structure based on the types of organisms found in a particular region. Identification of gastropods was performed using identification keys according to Abbott and Dance (2000), Jeeva et al. (2018), and Kantharajan et al. (2017).

Abundance

Abundance represents the number or number of individuals in a specific area of a community (Nento et al., 2013). The abundance of gastropods is derived from the total number of gastropods each month and at each station. The abundance of gastropods is presented in Table 2.

Diversity index

Calculation of diversity indices was performed using the Shannon-Wiener diversity index. Its Shannon-Wiener diversity index is classified into three levels, if 0<H '<1 is low diversity, 1<H '<3 is medium diversity, and when H ' > 3 is high diversity (Setyono et al., 2019).

Evenness index

The evenness index calculations were conducted using the evenness index formula of Pielou, if the evenness index (E) > 0.6 then the evenness index of the high species, medium evenness if the evenness index 0.6 > E > 0.4 and when E<0.4 is low evenness (Munthe et al., 2012).

RESULT AND DISCUSSION

Composition

Table 1 shows that the results of a gastropod catch in Sedati Waters in October to December identified as nine species of the two orders and six families of gastropods. The most widely discovered type of gastropods comes from the neogatropod order consisting of Muricidae, the Nassariidae, Clavatulidae, Marginellidae and Babyloniidae. The other type is derived from the order of the family Littorinimorpha and Naticidae. The species of gastropods are most commonly found in Sedati Waters are *R. venosa* with 137 individuals (25.23%) of the total of all caught gastropods, and the fewest gastropods are *C. ventricosa* with a total of 9 individuals or at a percentage of 1.47%.

The species of gastropods found can be seen in Figure 2. Identification of the gastropods is performed by observing their morphological features such as the shape, colour and characteristic

Table 1. Types of gastropods found in Sedati Waters

Ordo, Family, Genus	Species	October			November			December			N	%
		A	B	C	A	B	C	A	B	C		
Littorinimorpha												
Naticidae												
Notochocilis	*N. trigina*	+	+	+	-	+	+	+	+	+	81	14.92
Natica	*N. vitellus*	-	-	-	-	-	+	+	+	+	15	2.76
Neogatropoda												
Muricidae												
Rapana	*R. venosa*	+	+	+	+	+	+	+	+	+	137	25.23
Murex	*M. trapa*	+	+	+	-	+	+	+	+	+	45	8.29
Nassariidae												
Nassarius	*N. olivaceus*	+	+	-	+	+	+	+	-	+	41	7.55
	N. stolatus	+	+	+	+	+	+	+	+	+	55	10.13
Clavatulidae	*T. javana*	+	+	-	+	+	+	+	+	+	42	7.73
Marginellidae	*C. ventricosa*	+	-	-	-	-	-	+	-	-	8	1.47
Babyloniidae	*B. spirata*	+	+	+	+	+	+	+	+	+	119	20.23
	N	106	13	30	19	110	36	32	58	139	529	

Note: (+) there are species; (–) there are no species; (N) the total number of species.

Figure 2. Gastropods species in Sedati Waters

of the case (Baharuddin and Zakaria, 2018). The basic forms of gastropod shells have three, namely conical, spiral, and Planospiral (Pyron and Brown, 2015). The gastropod shells are several parts that can be used as identification keys, and those parts are the apex, body whorl, spire, columella, umbilicus and aperture (Sturm et al., 2006). The gastropods with spiral shell forms, such as *Babylonia spirata*, *Nassarius olivaceus*, *Turricula javana*, *Nassarius stolatus*, *Rapana venosa* and *Cryptospira ventricosa*, are dominant.

Abundance

The abundance of gastropods each month shows a significant difference ($p<0.05$) between stations. Table 2 shows that the C station in December is a station with the highest average abundance reaching 46. 33 ± 22.19 individual. In October, station B became a station with the lowest average abundance of only 4.33 ± 2.52 individuals.

The highest abundance of gastropods occurred in December at the C station, with an average abundance reaching 46. 33 ± 22.19 individuals, while the lowest abundance of gastropods occurred in October at B station, reaching only 4.33 ± 2.52 individuals. This abundance is included in the low abundance group, compared to other coastal areas (Maturbongs et al., 2017; Manullang et al., 2018; Amini-Yekta et al., 2019). The low abundance of individuals in the Sedati Waters is influenced by the quality of the physics and water chemistry and the basic substrate conditions of the waters.

Table 2. Abundance of gastropods based on sampling time at each station

Sampling time	Station	Gastropods abundance
October	A	35.33^{a}± 13.32
	B	4.33^{b} ± 2.52
	C	10^{b} ± 3, 61
November	A	5^{b} ± 3.61
	B	$36. 67^{a}$ ± 14.57
	C	12^{b} ± 5, 29
December	A	10.67^{b} ± 6. 11
	B	19.33^{ab} ± 6. 66
	C	$46. 33^{a}$ ± 22.19

Note: Different superscript in the same column that show significant differences.

Diversity, evenness and dominance

The diversity of gastropods at stations A, B and C from October to December belongs to medium diversity and shows no significant difference results ($p > 0.05$). Table 3 shows that the diversity of gastropods ranges from 1.4844 – 2.0897 and is included in moderate group. The uniformity index ranged between 0.8284 – 0.9548 and included in high uniformity. The dominance index ranges from 0.16 – 0.2299, and there are no dominant species.

The diversity of gastropods at stations A, B and C from October to December belongs to the medium category, as the results of the calculations of diversity index range from 1.4846-2.0897 (Setyono et al., 2019). This diversity index value is lower compared to other water diversity values (Marshall et al., 2018; Baharuddin and Zakaria, 2018; Rumahlatu and Leiwakabessy, 2017; Amini-Yekta et al., 2019). The evenness index indicates the result of high species evenness, ranging from 0.8284–0.9548 (Munthe et al., 2012). The value of the gastropod evenness in the Sedati Waters showed similar results to the uniformity of gastropods in the mangrove ecosystem (Chusna et al., 2017; Merly and Elvina, 2017) but indicated higher results compared to other coastal areas (Amini-Yekta et al., 2019; Baharuddin and Zakaria, 2018). The dominance index of gastropods ranges between 0.1384–0.2299 and belongs to the category of no dominating species (Magurran, 1987). The value of a gastropod dominancy in the Sedati Waters shows similar results to the value of dominancy gastropods in the mangrove ecosystem (Merly and Elvina, 2017; Chusna et al., 2017) but higher yield compared to other coastal areas (Amini-Yekta et al., 2019; Nugroho et al., 2012).

The value of the diversity index is proportional to the evenness index and inversely proportional to the dominance index value. The increasingly high diversity shows that the greater number of species present in the waters and the higher the evenness of the number of individuals between the species, the lower the value of domination means that there are no dominating species. In November, the diversity of station A decreased from 1.858 in October to 1.5137 and resulted in a decline in evenness value and increased the dominance value. The value of diversity of the B station from October to December continues to increase. The increase in diversity value is followed by increasing value of evenness and decline in the dominance value. The value of diversity C station in November decreased from 1.916 to 1.8249, which resulted in a decreased evenness value, and the value of dominance increased (Table 3).

Condition of the Sedati Waters

The condition of the Sedati Waters in the period from October to December continues to change. It results from the rainfall, water quality, as well as the content of the organic substrate.

The salinity levels in the Sedati Waters from October to December range from 29.45–36 ppt. The dissolved oxygen (DO) levels are in the range of 4.12–5.56. Temperatures range between 28.85–31.33, and degrees of acidity (pH) range between 7.86–8.53. The COD and BOD levels in the substrate are in the range 58-91 and 31–63, respectively. Current velocity continues to decrease and is in the range of 3.03–13.35 cm/s, while rainfall has increased and is 0–220.7 mm. The substrate of the Sedati Waters is dominated by clay fraction. Station A has the highest fine-grain fraction of the other stations (90.17%), followed by the B station (88.48%) and C station (81.59%).

Table 3. Results of diversity, evenness and dominancy calculations

Month	Station	H'	E	C
October	A	1.8580	0.9548	0.1832
	B	1.4844	0.8284	0.2899
	C	1.9160	0.9214	0.1622
November	A	1.5137	0.9405	0.2299
	B	1.7144	0.8810	0.2136
	C	1.8249	0.8776	0.1944
December	A	2.0897	0.9511	0.1348
	B	1.7525	0.9006	0.1914
	C	1.9362	0.9311	0.1600

The C Station contains the most gravel fraction compared to other stations (9.27%).

The result of water quality measurement indicates that salinity, DO, temperature and pH of the Sedati water are included in the range of the appropriate quality for the life of gastropods. The parameters that have undergone significant changes are salinity and temperature. The current velocity in Sedati Waters is included in the current slow category. The highest current velocity occurs in October, especially at the station B, while the lowest current speed occurs in December in the B station. The BOD and COD measurements show that the levels of these parameters in the Sedati Waters are high. Rainfall is in the rapid increase. The month of October is the dry season. The rainfall in November experiences a slight increase, and this month is the transitional season. In December, there was a significant increase in rainfall, and this month entered the rainy season.

The gastropod community structure in the period of October to December shows varied results each month. The abundance of gastropods has increased from October to December (Table 2). The increase in the abundance of gastropods is caused by the current velocity of the Sedati Waters, which decreased from October to December. The current is also one of the causes of the increasing diversity of gastropods on the B Station (Table 3). Station A achieves highest gastropod diversity from October to December because station A has a fine grain in the sediment with the highest amount compared to other stations. The abundance of the C station gastropods increased from October to December because the salinity at the C station increased. The value of diversity C station decreases and increases as the temperature changes.

Currents become one of the limiting factors in macrobenthos deployments. The aquatic organisms that live on the substrate need a current that can carry food, oxygen and others (Nybakken, 1992). Ira and Irawati (2015), current velocity affect the gastropods existence and composition as well as affects the groundwater substrate. The flow can move the gastropods at the water base so that the gastropod can quickly move around (Fadli et al., 2012). The areas with a more robust current flow have lower diversity than the weaker areas (Ruswahyuni, 2010).

Salinity has a positive relationship with the gastropod community structure (Rumahlatu and Leiwakabessy, 2017; Pratama et al., 2020). Salinity is a limiting factor in the distribution of aquatic organisms and its effect on body physiology and the osmolarity of hemoglobin with water content in the tissues that can cause death in organisms (Xiao et al., 2014; Nindarwi et al., 2020). The salinity of water too low resulted in decreased respiration rate and caused the gastropods to withdraw and hide into the case (Islamic, 2015; Liyana et al., 2019). In December, a decrease in the water's salinity value occurs because the rainfall in December increases sharply from November. Ismail and Ankiq (2012) reveal that freshwater intrusion can spread to the bottom of the water in shallow waters, making the salinity lower.

Temperature is the same as salinity, having a positive relationship with an abundance of gastropods (Cabuk et al., 2004; Dwiardan et al., 2020; Damayanti et al., 2020). Garg et al. (2009) revealed that high water temperature caused increased decomposition so that the amount of organic matter and macrophytes increased. Too low temperatures can cause excessive osmotic pressure on cells and intracellular damage as well as affect the digestive system, breathing, and gastropods' excretion (Zhang et al., 2016; Holy and Sari, 2020). Station B suffered a decrease in the abundance of gastropods in December due to the temperature drop in the station, which resulted from high rainfall in December. Hamuna et al. (2018) revealed that rainfall can lower the temperature of the seawater level.

The substrate is a place to attach, creep, immerse themselves, and food sources for gastropods (Riniatsih and Kushartono, 2009; Loekmanet al., 2018). Gastropods are found more often in muddy substrates because they can bind higher organic materials (Ulmaula et al., 2016; Zamkowski et al., 2013). A sandy substrate cannot be a place to strengthen the gastropod because the current can move the substrate particles so that the substrate can be shifted and moving in the other direction (Puspasari et al., 2012) and the sand substrate is more easily fragmented than the mud substrate (Sahidin et al., 2014). The organic material that settles on the substrate is the foodstuffs source for macrobentos (Shalihah et al., 2017).

The organic material content on substrates can be seen at the COD and BOD substrates. High BOD and COD show that aerobic organisms use more dissolved oxygen to degrade the organic matter of a substrate. The higher the organic material, the higher the BOD and COD (Pratami et al., 2018). The abundance of benthos organisms

often supports the substrates containing more organic materials because of the need for organic materials to be fulfilled (Shalihah et al., 2017).

The Sedati water is water with medium hardness (Hidayani, 2015). Contamination with the medium category is caused by the pollutants that are found in great amounts in the Sedati Waters because the research was conducted in a capture fisheries area which is a path of ship entrance, but also because it is the estuary of waste polluters from the Sidoarjo Regency.

CONCLUSIONS

The types of gastropods found in the Sedati Waters period of October to December are nine species of 2 orders and six families. The most widely found species is *R. venosa*, while the fewest ones are *C. ventricosa*. The abundance of gastropods in every month showed a significant difference ($p<0.05$) between stations but not among other significant parameters. The diversity index ranged between 1.4846 – 2.0897. The highest evenness index ranged between 0.8284 and 0.9548, and the dominancy index ranged from 0.16 to 0.2299.

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