

Species Diversity of Gastropods In The Mangrove Forest of Pangpang Bay Ijen Geopark, Banyuwangi Indonesia

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Abstract

Gastropods are invertebrate animals from the phylum Mollusca which have soft bodies and most of them have shells. The Pangpang Bay mangrove forest has a muddy substrate type and contains a lot of organic matter as a food source. This research was conducted in October - December 2022 at the Pangpang Ijen Geopark Bay. The area of the research area is about 900 meters² with a total plot size of 1x1 m totaling 99 plots. The gastropod data collection method uses the systematic plot transect method. The recorded data contains the local name/type/type code, the number of species, and the number of individuals of each type. Data on abiotic environmental factors which include temperature, pH, and salinity are determined by the range of values and the type of substrate. Further data analysis was carried out by determining the species composition of gastropods by calculating the Shannon-Wiener (H') species diversity index. The results showed that there were 20 types of gastropods with members from 11 genus and 7 families. The results showed that the gastropod diversity index at the study site is in the medium category with a value of 1.95. The conclusion of this study is the diversity of species found in the mangrove forest of Pangpang Ijen Geopark Bay as many as 20 species. The value of diversity of gastropod species in the Pangpang Ijen Geopark Bay mangrove forest is in the moderate category because there are quite a lot of species found and only one species dominates.

Keywords: Gastropods, Diversity, Mangrove Forest, Pangpang Bay

Introduction

Gastropods are invertebrate animals from the phylum Mollusca which have soft bodies and most of them have shells (Marwoto *et al.*, 2020). Gastropods are the largest class in the Mollusca phylum with 60,000 to 80,000 species living in various habitats (Rhaesa *et al.*, 2016). Widjaja *et al.* (2014) stated that there are 4,000 species of gastropods spread across Indonesia, with 1,500 species found in marine areas. The ecological roles of gastropods include herbivores (grazers), carnivores, scavengers, suspension feeders, and detritivores (Santhanam, 2018). Prasetia *et al.* (2019) stated that the more organic material available, the more abundant gastropods in an area will be. The Pangpang Bay mangrove forest has a muddy substrate type and contains a lot of organic material (Munirul *et al.*, 2018). These ecosystem conditions correspond to the habitat needed by biota such as gastropods.

Species composition of gastropod is generally divided into two based on their shells, namely snails and slugs. The main characteristic of a snail is that it has a shell. Slugs usually do not have shells, even though the shell only covers part of their soft body (Marwoto *et al.*, 2020). This composition makes up the species diversity of gastropods that exist in nature. Gastropods are influenced by abiotic and biotic factors, for example abiotic conditions (temperature, salinity, pH, light, humidity, etc.), food availability, predation by predators, and competition (Rahmasari *et al.*, 2015). Apart from that, the composition and diversity of gastropod species play an important role in describing the condition of the ecosystem they live in (Romdhani *et al.*, 2016). Gastropods have high adaptability in various habitats including mangrove forests, if the species composition and diversity is low, it indicates disruption of the ecosystem (Rosario *et al.*, 2019). This is based on the slow movement of gastropods, living sedentary for long periods, and differences in tolerance ranges between species (Husamah & Rahardjanto, 2019).

The Teluk Pangpang mangrove forest is one of the mangrove forests in East Java. The area is administratively located in two sub-districts, namely Muncar District and Tegaldlimo District, Banyuwangi Regency (Neka, 2019). Pangpang Bay has been designated as an essential ecosystem area (KEE) and Biosite Ijen Geopark with high biodiversity potential which is closely related to geological processes (Ijen Geopark, 2022). According to Nurrudin *et al.* (2015) and Laraswati *et al.* (2020), gastropods use mangrove forests as a place to live (nursery ground), spawning ground, and place to find food (feeding ground). In general, mangrove gastropods play a role in decomposing fallen litter, neutralizing organic material, and helping to accelerate the decomposition process by microorganisms (Laraswati *et al.*, 2020; Susanti *et al.*, 2021).

Information regarding gastropods in the Pangpang Bay area, especially in the Alas Purwo National Park area, has been reported. Susanti *et al.* (2021) and Setiawan *et al.* (2021) stated that around 13 genera of gastropods had been found in the Jatipapak Block of Alas Purwo National Park and the species diversity was in the medium category. The composition and diversity of gastropod species is important for the stability of the environmental ecosystem. Gastropoda play an important role as the dominant group of mollusks that make up communities in mangrove ecosystems (Kasim *et al.*, 2022). However, related research at Teluk Pangpang Ijen Geopark has never been carried out. Apart from that, reforestation in the Pangpang Bay mangrove forest area continues to increase in area, especially in unproductive shrimp pond land (Neka, 2019). The mangrove forest in this area has also become a conservation area and has been opened as a tourist destination. It is feared that the habitat of gastropods, which tend to live sedentary lives, will decline due to activities around the area. Therefore, efforts to preserve gastropods are needed by conducting research and collecting data regarding the diversity of gastropod types in the mangrove forests of Teluk Pangpang Ijen Geopark. The aim of this research is to determine the species diversity of gastropods in the mangrove forests of the Teluk Pangpang Ijen Geopark

Material And Methods

This research was conducted in October - December 2022. Data collection was carried out at the Teluk Pangpang Ijen Geopark, Banyuwangi. The geographical location is between 8°27'05.2" - 8°32'09.8" South Latitude and 114°20'98.8" - 114°21'74.7" East Longitude (Figure 1).

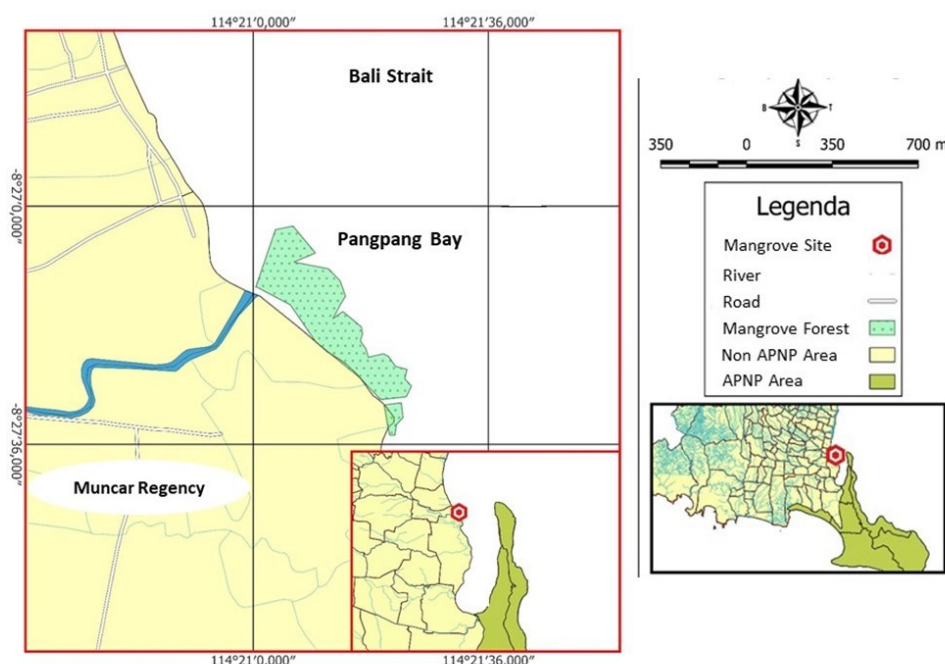


Figure 1. The Map of Sampling Location at Mangrove Forest, Pangpang Bay Ijen Geopark

The method for collecting gastropod data uses a systematic transect plot method measuring 1x1 m which is placed on a transect line in the Mangrove Forest Pangpang Bay Ijen Geopark (Figure 2). Three plots measuring 1x1 m were placed with a distance between transects of 20 meters and the distance between each plot was 5 meters (Figure 3). The number of plots obtained was 99 plots. The research area is approximately 900 meters² with coordinate points marked in the research area using GPS Garmin 64S.

Sampling was carried out using purposive sampling which focused on the presence of gastropods on the surface of the substrate (epifauna) and mangrove tree roots, stems and leaves (treefauna) which was carried out when the water was at low tide (Lestariningsih *et al.*, 2020). The receding water conditions aim to make it easier to collect and observe gastropod species at the research location. Epifauna collection is carried out by hand collecting (using hands) by taking gastropods on the surface of the substrate. Treefauna collection is done by hand collecting by taking gastropods attached to the roots, stems and leaves of mangroves. Taking infauna gastropods digs the substrate in a 1x1 m plot three times using a shovel to a depth of ± 20 to 30 cm with an area of 30x30 cm (Setiawan *et al.*, 2021).

The gastropods found in each plot were recorded with the local name/type/species code, number of types, and number of individuals for each type. Unknown gastropod types were recorded for their morphological characteristics and a type code added for identification. Representatives of each type of gastropod found were put in a plastic ziplock, then cleaned using a brush and stored in a jar with 70% alcohol for preservation. Gastropod specimens were placed on millimeter block paper and then documented using the cameras. Gastropod specimens whose type has not been identified are taken to the laboratory for further identification.

The process of description, identification and data analysis was carried out at the Ecology Laboratory of the Biology Department, Faculty Mathematics and Science, Universitas Jember. Gastropod specimens that had been taken as representatives of each type were identified using guides and pictures from the books Recent & Fossil Indonesia Shells (Dharma (2005) and The Living Marine Resources of The Western Central Pacific. Volume 1. Seaweeds, Corals, Bivalves, and Gastropods (Carpenter & Niem (1998) by matching morphological characteristics (based on color, shape, surface, and shell type; number of sutures; shape and presence of operculum.

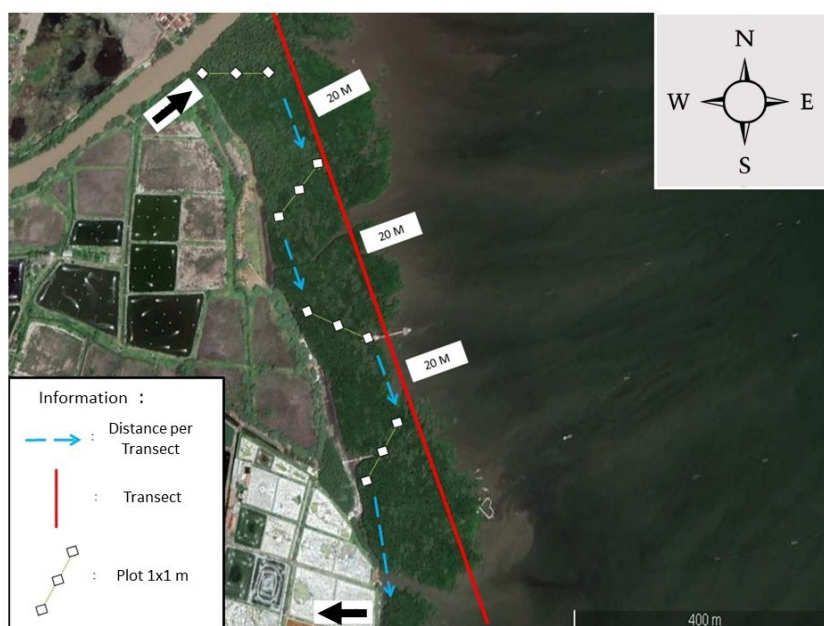


Figure 2. Techniques of Gastropods Collection Based on Mangrove Forest Pangpang Bay

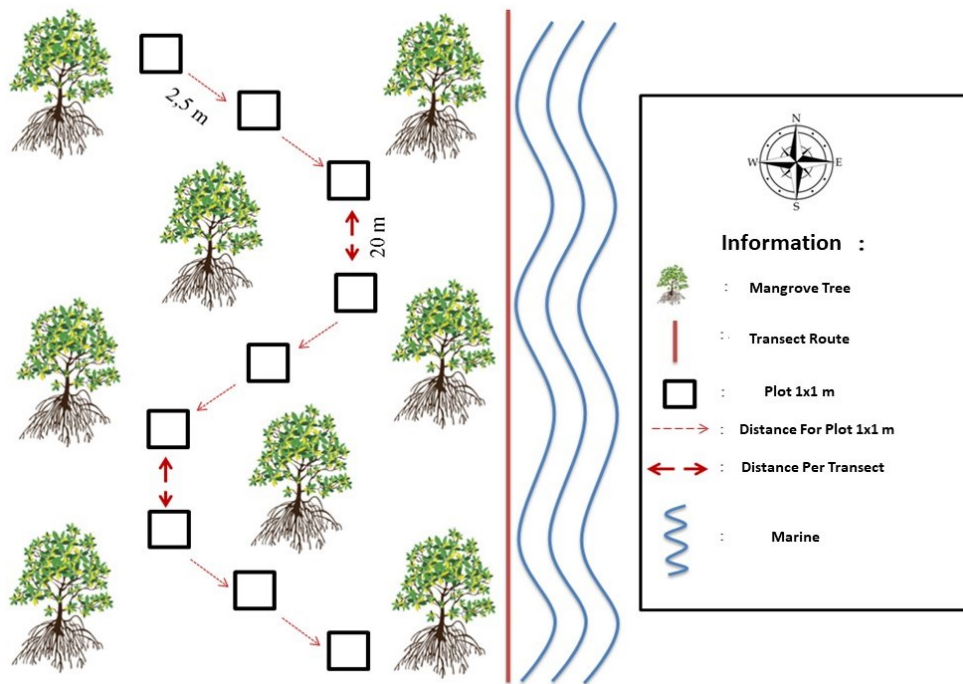


Figure 3. Technique of Schematic data collection in the Mangrove Forest Pangpang Bay

Data Analyzes

Data on gastropod types that have been identified and verified are then tabulated based on their taxon including family, genus, type, number of individuals, way of life, and number of individual types. Abiotic parameter data is used to analyze the physical condition of the environment in the Mangrove Forest of the Pangpang Bay Ijen Geopark. The data that has been obtained is then entered into a table and the smallest to largest range value is determined. Analysis of species diversity (H') uses the Shannon-Wiener Diversity Index with the following formula:

$$H' = - \sum p_i \ln p_i \text{ with } p_i = n_i/N \text{ (Magurran, 1988)}$$

H' value is the Shannon Wiener diversity index with the value of p_i being the abundance of species and n_i being the number of individuals per species. while the N value is the total number of all types. This formula is used to calculate all types of gastropods found in the Pangpang Bay area.

Result and Discussion

The results of research in the mangrove forest Pangpang Bay Ijen Geopark found 1442 individuals of gastropods belonging to 7 families, 11 genus and 20 species (Table 1). The composition of gastropod types based on their way of life showed that 16 species were epifaunal and 4 other species were treefaunal, while no gastropods were found that were infaunal. There are 4 species of epifauna and treefauna gastropods out of a total of 20 species of gastropods found in the mangrove forests of Pangpang Bay Ijen Geopark. Infauna gastropods that submerge themselves in the substrate are only carried out by certain types, for example *Telescopium telescopium*. According to Arbi (2014), extreme changes in habitat conditions around the mangrove ecosystem area affect the existence of gastropod infauna. The substrate conditions at this research location are thought to be less suitable to support the life of infauna gastropods. Apart from that, it is suspected that the substrate excavation carried out was not deep enough or was not representative of the plot, causing infauna gastropods not to be found.

Table 1. Species Composition of gastropods in the Mangrove Forest of Pangpang Bay Ijen Geopark

Family	Genus	Species	Number of Individual	Way of Life	
Cerithiidae	<i>Cerithium</i>	<i>Cerithium kobelti</i>	17	Epifauna	
Ellobiidae	<i>Cassidula</i>	<i>Cassidula aurisfelis</i>	31	Epifauna	
		<i>Cassidula nucleus</i>	36	Epifauna	
		<i>Cassidula sulculosa</i>	16	Epifauna	
		<i>Cassidula vespertilionis</i>	64	Epifauna	
Littorinidae	<i>Littoraria</i>	<i>Littoraria articulata</i>	42	Treefauna	
		<i>Littoraria carinifera</i>	28	Treefauna	
		<i>Littoraria melanostoma</i>	176	Treefauna	
		<i>Littoraria scabra</i>	191	Treefauna	
Muricidae	<i>Chicoreus</i>	<i>Chicoreus capucinus</i>	5	Epifauna	
	<i>Drupella</i>	<i>Drupella margariticola</i>	26	Epifauna	
Nassariidae	<i>Nassarius</i>	<i>Nassarius olivaceus</i>	17	Epifauna	
		<i>Nassarius reevanus</i>	9	Epifauna	
Neritidae	<i>Nerita</i>	<i>Dostia</i>	<i>Dostia violacea</i>	1	Epifauna
		<i>Nerita balteata</i>	20	Epifauna, Treefauna	
		<i>Nerita undata</i>	31	Epifauna, Treefauna	
		<i>Cerithidea cingulata</i>	674	Epifauna, Treefauna	
Potamididae	<i>Cerithidea</i>	<i>Cerithidea quadrata</i>	45	Epifauna, Treefauna	
		<i>Terebralia</i>	<i>Terebralia sulcata</i>	1	Epifauna
		<i>Telescopium</i>	<i>Telescopium telescopium</i>	12	Epifauna

Epifauna gastropods are more common than treefauna gastropods. This can be caused because each type of gastropod has a certain habitat and adaptations to maintain its life. Based on its morphological characteristics, this type of gastropod, which has a large, heavy shell and is not equipped with an operculum, is unable to move up into the mangrove vegetation. Several types of gastropods have smaller shell sizes and are lighter with their operculum, allowing these types to live on the surface of substrates and mangrove vegetation as treefauna. In addition, the different ecological roles of each type of gastropod will influence the type of food they eat. Detritivorous gastropods generally break down organic litter and help the decomposition process so they live on the substrate. The herbivorous or grazer nature of gastropods will occupy mangrove vegetation because they eat mangrove leaves or fungi attached to mangrove stems.

The Ellobiidae family and the Littorinidae family have the most species compared to other families in the Teluk Pangpang Ijen Geopark mangrove forest. The four species of the Ellobiidae family found were *Cassidula aurisfelis*, *C. nucleus*, *C. sulculosa*, and *C. Vespertilionis* (Figure 4). In the Littorinidae family, four species are also found, including *Littoraria articulata*, *L. carinifera*, *L. melanostoma*, and *L. Scabra* (Figure 5). The number of species from the Ellobiidae family and the Littorinidae family that were found more frequently than other families is thought to be due to living in groups and the presence of few types of mangrove gastropod predators. The species found to be predatory comes from the Muricidae family, namely *Chicoreus capucinus*. According to Mujiono (2020), the Ellobiidae family breathes in the open air (air-breathing) and lives on the surface of the mangrove ecosystem substrate. The Ellobiidae family does not have an operculum, so this species defends itself against predators by developing serrations on its aperture (Gabbi, 2020).

The Littorinidae family occupies mangrove vegetation (treefauna) and attaches itself with the help of mucus on its body. According to Marwoto *et al.* (2020), Littorinidae eat micro-macro algae, lichens and mangrove leaves. Littorinidae excrete mucus or slime as adhesive and a form of self-protection from predators. Besides that, this species have an operculum to prevent drying out and fold the body into the mantle so they can breathe without having to be flooded with water (Lalita and Rangan, 2018). This ability allows the Littorinidae family to survive in the extreme mangrove ecosystem and is not easily preyed upon by other predators.

Cerithidea cingulata is the most common type of gastropod found in most of the research plots (Figure 6). This type was found living in groups with the number of individuals found in one plot reaching 122. Its ability to reproduce quickly means this type is found more often. One characteristic that appears different from other types of gastropods is the aperture. Karyanto *et al.* (2014) stated that the *C. cingulata* has an aperture that is equipped with a siphon channel and forms a corner shape. This shaped siphon helps this species to facilitate the process of taking in water and laying eggs on the substrate. This also helps *C. cingulata* in activities such as reproducing and eating mangrove litter.

Terebralia sulcata was only found in one individual from all research plots (Figure 6). The substrate at the research location where this type was found tends to be dry even though it is of the mud type. This is because when the data was collected it was at low tide and the mangrove vegetation cover was more open. The number of *T. sulcata* individuals is small because this type requires a substrate with sufficient water availability and is wet. Substrate conditions that do not contain standing water cause the movement and adaptation of *T. sulcata* to the environment to be limited. This type has a mechanism to survive drought by immersing itself in the substrate (Budiman, 2018). According to Slim *et al.* (2017), *T. sulcata* tends to live solitary lives and hides in muddy soil to avoid stress due to drought and direct sunlight. Another type of gastropod that is only found in one individual is *Dostia violacea*. The small number of individuals is thought to be due to their shell morphology. The morphological structure of the *Dostia violacea* shell, which tends to be thin and

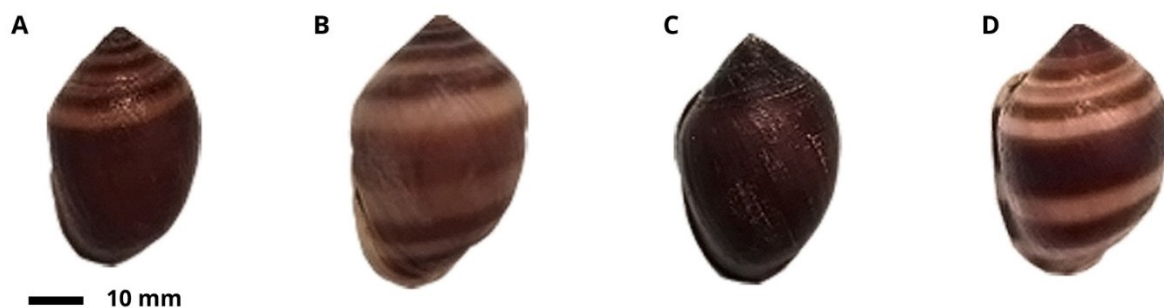


Figure 4. Family Ellobiidae in the Mangrove Forest Pangpang Bay Ijen Geopark. A) *Cassidula aurisfelis*. B) *Cassidula nucleus*. C) *Cassidula sulculosa*. D) *Cassidula vespertilionis*

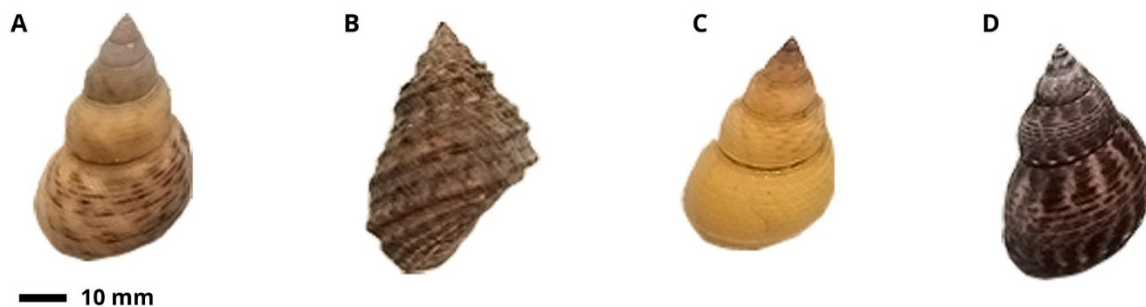


Figure 5. Family Littorinidae in the Mangrove Forest Pangpang Bay Ijen Geopark. A) *Littoraria articulata*. B) *Littoraria carinifera*. C) *Littoraria melanostoma*. D) *Littoraria scabra*

small in size, is vulnerable to predator threats. These animals also live solitary lives rather than in groups. Therefore, this species avoids predation by hiding in the substrate or attached to mangrove roots. This statement is also supported by Algifari *et al.* (2019) that *D. violacea* attaches itself more to trees as a form of protection from predator attacks.

Gastropod species that have been found in mangrove forests in Indonesia have been widely reported in several other locations. In the western part of Java, specifically in the Ujung Kulon National Park, Banten, 59 species of gastropods have been found (Mujiono, 2010) and in the East Java region by Adi *et al.* (2013) recorded 37 species of gastropods in the Segoro Anak Blok Bedul mangrove forest, Alas Purwo National Park. This number is higher than the number of gastropod species found in the mangrove forests of Teluk Pangpang Ijen Geopark. Mujiono & Isnainingsih (2022) in the Segara Anakan lagoon mangrove area, Cilacap Regency also found 18 species of gastropods while Siwi *et al.* (2017) in the mangrove forest of Runtuh Beach, Baluran National Park found around 19 species of gastropods. This information can provide an idea that there are similarities in gastropod species in nearby locations. The existence of this species shows the choice of habitat as a place for gastropods to live and their way of life. Apart from that, many gastropod species were found in other locations compared to this research because the research area was wide, data collection was carried out over a longer period of time, and was supported by the condition of the natural mangrove ecosystem.

The calculation results show that the gastropod species diversity index at the research location is included in the medium category with a value of 1.95. This category shows that the gastropod community is composed of abundant types, but there is one type that dominates. *Cerithidea cingulata* is a type of gastropod that has a higher number of individuals than other types so its presence is dominant. The dominant species generally have high productivity and can influence community stability (Latuconsina, 2019). The diversity index becomes moderate if the number of individuals of each type of gastropod is uneven. The uneven number of individuals of each type is related to gastropod adaptations, for example abiotic environmental conditions, substrate type and food sources.

The condition of the ecosystem in the mangrove forest Pangpang Bay Ijen Geopark area is still good, which can be seen from the mangrove vegetation which grows thickly and has quite dense roots. The way of life of gastropods, which tends to be sedentary, causes the frequency of their presence to be influenced by changes in the environment and mangrove vegetation. According to Raiba *et al.* (2022), environmental factors that influence the diversity of gastropod types such as food availability, habitat, predation and competition. The conditions in mangrove forest Pangpang Bay Ijen Geopark enable the availability of food sources in the form of high organic material and suitable habitat for the survival of gastropods. This can reduce the high level of competition between gastropods, thereby providing an opportunity for other types of gastropods to survive. A community will have high species diversity if it is composed of a large number of species. Communities that only consist of a few species result in low species diversity values (Latuconsina, 2019).

The lowest water temperature value at the research location was 25.5^o C while the highest value was 35.8^o C (Table 2). This range is still considered normal to support the life of gastropods. The lowest temperature obtained was because the data collection was carried out at low tide, causing sunlight to penetrate directly to the bottom of the water. This is because the waters are shallow, which will result in an increase in temperature. Furthermore, Hambran *et al.* (2014) also stated that the temperature of mangrove areas with open areas tends to be high, while the temperature in areas that are flooded for longer is lower. Susintowati *et al.* (2019) stated that normal temperatures in mangrove forests are generally around 27-29^o C. Water temperatures that are too low or high will have a negative impact on the life of gastropods. The research results of Sibua *et al.* (2021) found that gastropods can still tolerate water temperatures in the range of 29-36^o C.

Table 2. The Value of Environmental Abiotic in the Mangrove Forest Pangpang Bay Ijen Geopark

Abiotic Environmental	Value Range
Temperature (°C)	25,5 – 35,8
pH	7,61 – 7,84
Salinity (‰)	31,8 – 37,8
Type of Substrate	Clay

The salinity obtained during measurement shows a value that can still be tolerated by gastropods. Salinity measurements at the research location are in the range of 31.8 - 37.8 ‰. Mathius *et al.* (2018) stated that mangrove forests generally have a salinity range of between 0.5 – 35 ‰. The salinity values obtained are classified as normal and are in accordance with the life of gastropods. This salinity is thought to be more influenced by fresh water originating from river estuaries. This is because the mass of sea water has not yet reached the mangrove area because the measurements were carried out at low tide. Sinaga *et al.* (2019) that the distribution of salinity in mangrove areas is influenced by depth, surface flow, tides and rainfall. Pamungkas (2022) states that salinity affects the osmotic pressure in waters. Gastropods that are unable to control osmotic pressure will experience stress or death.

The pH of the water at the research location shows normal limits and a good range of values for gastropods. Based on the results of water pH measurements, the range of values obtained is 7.61 - 7.84 and is slightly alkaline. This range is still in a stable condition and can be tolerated by gastropods. The research results of Rahmawati *et al.* (2013) stated that a pH value of 7 - 8 is the optimal level for gastropod life. This range of values is thought to be because sea water in the mangrove area is more dominant than fresh water. According to Rahayu *et al.* (2018), waters with higher levels of sea water result in a relatively alkaline pH because the pH of sea water is also slightly alkaline. Persulesy & Arini (2018) explained that a pH that is too acidic or alkaline will disrupt the survival of gastropods.

Muddy substrate types tend to be preferred by gastropods because they contain high levels of food sources. Muddy substrates also allow the movement of gastropods to be easier so that their distribution is more widespread. Based on this, the substrate conditions at the research location are muddy. The mud layer is quite thick and this condition allows the availability of food sources in the form of organic material needed by gastropods. Additionally, gastropods can hide in mud to protect themselves from predation. According to Romdhani *et al.* (2016), organic materials tend to settle more easily on fine particles, so that muddy substrates tend to have higher nutrient levels than coarse-textured substrates.

CONCLUSION

The conclusion of this research is that the species composition of gastropods in the Mangrove Forest Pangpang Bay Ijen Geopark is 20 species and belongs to 11 genus and 7 families. The value species diversity of gastropods is classified as medium (1.95).

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