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Structure, composition and economic potential of molluscs (gastropods and bivalves) in the Lembupurwo Lagoon Beach, Kebumen, Central Java, Indonesia

Cahya Maulidta Rohman[1], Asih Kinanti[1], Desma Asty Pramudita[1], Fariz Pradana Adil Fadzilah[1], Muhammad Fadhil Ramadhan[1], Aqra Danial Faturrahman[1], Devi Mayang Aurina[1], Mini Ambarwati Kusuma Dewi[1], Fadia Aulianissa Ainaya[1], Fayza Rachmalia[1], Layyinatssyifa A'yuni Fatikha[1], Gilang Dwi Nugroho[2,3], Chee Kong Yap[4], Ahmad Dwi Setyawan[1,5,*]

[1]*Department of Environmental Science, Faculty of Mathematics and Natural Science, Universitas Sebelas Maret. Jl. Ir. Sutami No. 36, Surakarta 57126, Central Java, Indonesia.*
[2]*Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A Surakarta 57126, Central Java, Indonesia*
[3]*Biodiversity Research Club, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia*
[4]*Department of Biology, Faculty of Science, Universiti Putra Malaysia. 43400 UPM Serdang, Selangor, Malaysia*
[5]*Biodiversity Research Group, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia*
**Correspondence: volatileoils@gmail.com*

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Abstract

The mangrove ecosystem is a productive ecosystem with economic and environmental functions. This research was conducted to determine the value of the ecological index and the economic potential of molluscs (Gastropods and Bivalves) found in Lembupurwo Lagoon Beach, Kebumen District, Central Java, Indonesia. Analysis of the data obtained descriptively with the support of tables and pictures. The study results showed that there were 17 species of molluscs consisting of 12 species belonging to the gastropod class and others belonging to the bivalves. The families with the most common species were Neritidae, Ellobiidae, and Littorinidae, whereas bivalves were only found one species per family. The total molluscs found had a density value of3.95 ind/m^2. The H', E, R, and D indexes were 1.48 (moderate), 0.52 (moderate), 1.71 (low), and 0.28 (no species dominated), respectively. For the economic potential found dominated by the food sector. included: *Faunus ater* L. 1758, *Isognomon ephippium* L. 1758, *Pilsbryoconcha exilis* I. Lea 1838, *Polymesoda expansa* Mousson 1849, and *Anadara antiquata* L. 1758.

Keywords: Biodiversity, Lembupurwo, mangrove, molluscs, snail

Introduction

Indonesia has a coastline of 81,000 km which is dominated by mangrove forests along the coast[1]. Mangroves are woody plants that are salt tolerant and generally found in or adjacent to the intertidal

zone in tropical and subtropical regions[2]. Mangroves grow and are commonly found in muddy coastal landscapes, deltas, and sheltered bays. The distribution of mangrove forests in Indonesia is high, so the mangrove forests in Indonesia are the largest in the world. Indonesia's total area of mangrove forests is 3,364,076 Ha. The total area of the mangrove forest is divided into three categories: dense mangroves, which are around 93% of the total area; 5% in the medium mangrove category; and the rest, sparse mangroves, around 2%. The distribution of mangrove forests in the Kebumen District is spread over several areas, such as river estuaries and coasts. According to the Forestry and Plantation Services, the total size of the mangrove forest in Kebumen District is around 40 hectares which have been appropriately cultivated out of the total area of 80 hectares of mangrove forest[3].

Mangrove ecosystems have abundant natural resource components in the form of landscapes consisting of flora, fauna, and local communities, where these components interact with one another within an ecosystem unit. The mangrove ecosystem is productive with economic and environmental functions[4]. In the coastal area, mangrove forests have a very important role from the local community's ecological, economic, and socio-cultural perspectives. From an ecological perspective, mangrove forests have several important roles, including natural carbon sinks, remediation of pollutants, preventing abrasion, and preventing intrusion and storms in coastal and coastal areas[5]. Besides having high diversity, mangrove forests have the potential to become natural tourist objects; in their implementation, they can apply the concept of education and conservation. Indirectly, mangrove forests are used as recreational facilities and provide visitors with knowledge and understanding of the importance of maintaining the authenticity of existing mangrove ecosystems and the enormous role mangroves play in the world, especially in coastal areas, in maintaining flora and fauna.

For fauna, mangrove forests serve as shelters, food providers, and spawning grounds. One of the abundance of fauna found in the mangrove ecosystem is molluscs. The existence of molluscs in the mangrove ecosystem is strongly influenced by environmental changes that occur in the mangrove ecosystem itself. Molluscs tend to settle in an area without moving to make molluscs able to accept all changes in the environment in that area. In other words, the adaptations possessed by these molluscs tend to be high[6]. As a result, Molluscs have an important role as environmental bioindicators. At the same time, mollusks are organisms that are quite sensitive to changes in water quality in the ecosystem they live in, for example, pollutants[7]. In addition, mollusks have economic potential for local communities where certain types of mollusks can be used as a source of food, accessories, decoration, or medicine. Therefore, the Mollusca survival must be maintained due to this fauna's role in terms of high ecological and economic values.

Lembupurwo Beach is located in Mirit Subdistrict, Kebumen District, Central Java, Indonesia. The beach has a good and sustainable mangrove ecosystem. The existence of mangrove forests can provide various benefits, including stabilizing coasal conditions, preventing abrasion and seawater intrusion, as a source of diversity of aquatic and non-aquatic biota, as a source of materials that the community and so on can consume. In addition, mangrove vegetation can create habitats and provide suitable food for various living fauna[8]. However, the existence of mollusks in terms of diversity, ecological aspects, and economic potential in the mangrove ecosystem of Lembupurwo Beach has not been carried out by researchers. Therefore, the aim of this study was to find out the diversity and ecological index of Mollusca, environmental conditions, and the economic potential of these molluscs in

the Lembupurwo Lagoon Beach (Wawar River Estuary), Mirit Subdistrict, Kebumen District, Central Java, Indonesia.

Materials and methods

Study area

Sampling was conducted in November 2021 and is located in the mangrove ecosystem of Lembupurwo Lagoon (part of Wawar River Estuary), Kebumen District, Central Java, Indonesia. Kebumen District is located between 7°27' - 7°50' South Latitude and 109°22'-109°50' East Longitude. The total area of the Kebumen District is 1,281.12 km^2. Kebumen District is located between latitudes 7°271 and 7°501 south and longitude 109°331-109°501 east. It is bordered by Purworejo District and Wonosobo District in the east, Banjarnegara District in the north, Cilacap District, and Banyumas District in the west Samudera Indonesia (Indian Ocean) in the south. Sampling consisted of four locations around and on the coast of the Lembupurwo Lagoon in Lembupurwo Village, Mirit Subdistrict, Kebumen District, Central Java, Indonesia (**Figure 1**).

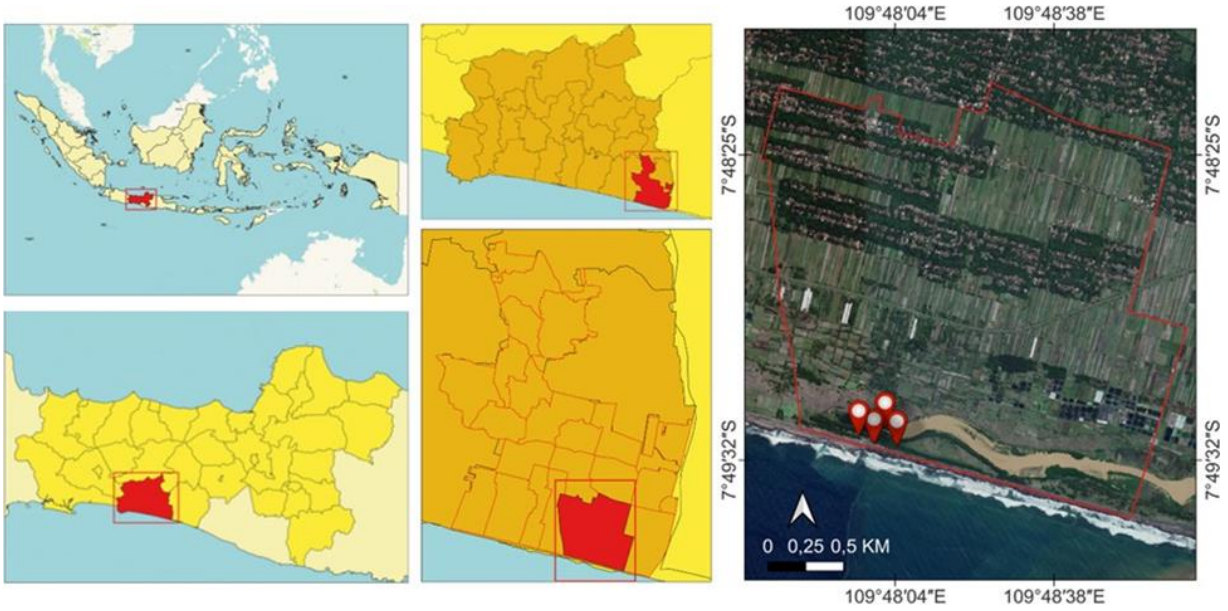

Figure 1. Mollusc sampling area at Lembupurwo Lagoon Beach, Kebumen District, Central Java Province, Indonesia

The Lembupurwo Lagoon is part of the Wawar River estuary, a semi-enclosed estuary in free contact with the sea so that the highly saline sea can mix with fresh water. What makes estuaries unique was the mixture of seawater and freshwater, which created brackish water that fluctuates in salinity. As the seasons changed, environmental conditions would also change. Mangrove and cypress trees grew in this lush, green estuary sea area. There were four research location points, each at the coordinates of station 1 was 7°49'24.3" E and 109°48'01.5" S. Mangrove dominated this location. At Station 1, the characteristics of muddy soil were because it was an area around the coast that empties directly into Lembupurwo Lagoon Beach (**Figure 2A**). This location was at the beginning of the entrance to the area but this location is not too close. Then, Station 2 is west of station 1 but further inward, nearing the lip of Lembupurwo Lagoon Beach at the coordinate point 7°49'24.8" E and 109°47'54.6" S. At this location,

there were mangroves around the water flow that directly empties into the sea. This location was a sandy and muddy area dominated by mangrove vegetation (**Figure 2B**). The third location was the coast of the beach, with coordinate points 7°49'28.7" E and 109°47'57.8" S, where the substrate was dominated by sand (**Figure 2C**). Station 4 was in the vicinity of a mangrove forest with coordinate points 7°49'26.7" E and 109°48'02.0" S. Station 4 was adjacent to Station 1 but was separated by a stream of water, which incidentally had the same substrate conditions as Station 1. The mangrove dominated along streams/puddles on the beach lagoon (**Figure 2D**).

Sampling

Mollusca sampling was carried out by hand, collecting all mollusc types found on the plots measured 10 × 10 m^2 at each study location. In the next stage, the molluscs contained in each plot were counted, and the number was recorded. Mollusca sampling in this study used the same method as research conducted by Ratih et al. (2021)[9]. The molluscs found were then put into plastic samples labeled with letters. Next, samples were taken from each type of mollusc to identify its species before being analyzed thoroughly. Finally, they measured abiotic and environmental factors in the form of temperature and pH (water and soil), and water salinity[8].

Table 1. Coordinates and substrates

Station	Coordinates	Habitat type
1	E: 7°49'24.3"	Mud substrate
	S: 109°48'01.5"	
2	E: 7°49'24.8"	Mud substrate
	S: 109°47'54.6"	
3	E: 7°49'28.7"	Sand substrate
	S: 109°47'57.8"	
4	E: 7°49'26.7"	Mud substrate
	S: 109°48'02.0"	

Identification

Furthermore, to simplify the identification stage, mollusc samples taken from the research location were preserved using 70% alcohol. In this study, the mollusc identification process was carried out at the Animal Taxonomy Laboratory, Faculty of Mathematics and Natural Sciences, Sebelas Maret University, Surakarta, Indonesia, based on a literature study from Choirunnisa and Ambarwati (2020)[10], Merly et al. (2022)[11], Wiraatmaja et al. (2022)[8]. Identification was carried out including morphological characteristics such as shell shape, color, and pattern. Then, documentation was carried out using a smartphone on each mollusc species that had been identified. After that, the mollusc samples were stored in a storage area.

The economic potential

The economic potential of molluscs was determined through secondary data of journal references from (Samsi et al., 2019)[12], (Surbakti, 2020)[13], (Widianingsih et al., 2020)[14], and internet books. This data could be used as a raw material for lime, food, home decoration, household equipment, and accessories.

Figure 2. Conditions of each sampling location at Lembupurwo Lagoon Beach, Kebumen District, Central Java, Indonesia: A. muddy soil; B. sand and muddy area; C. sand area; and D. mangrove trees dominate

Data analysis

This research journal article was presented in a quantitative form which is the result of data processing that has been obtained and collected, namely data on the number of species and the individuals on each species. Data were analyzed using the Density Formula (D), Shanon-Weiner Diversity Index (H'), Evenness Index (E), Simpson Dominance Index (D), and Margalef Species Richness Index (R). The analysis results using those formulas are then presented in paragraphs using descriptive sentences. The formula used will be described as follows:

Mollusca density is calculated using Brower and Zar analysis (1977)[15] with the formula:

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

Where:

D = mollusc density (ind/m^2)

Ni = the total number of individuals of the mollusc species A = Total area (m2)

Analysis of the diversity of mollusca species using the Shannon-Wiener Diversity Index formula (Odum, 1993)[16]:

$$H' = - \sum(Pi \ln Pi)$$

Where:

H' = mollusc species diversity index

ni = the number of individuals of the *i*-th species

Pi = the relative abundance of the *i*-th species

The evenness index is obtained using the formula (Daget, 1978)[17]:

$$E = \frac{H'}{lnS}$$

Where:

E = Evenness Index

H' = species diversity index
S = the number of species obtained
Calculation of the Dominance Index (D) using the formula that has been disclosed by Simpson (1949)[18] and Odum (1993)[16]:

$$D = (\frac{ni}{N})^2$$

Where:
D = Dominance Index
ni = the number of individuals of the *i*-th species
N = number of individuals of all species
The species richness index was calculated using the Margalef (1958)[19] Species Richness Index formula:

$$R = \frac{S-1}{\ln(N)}$$

Where:
R = Species Richness Index
S = total species obtained
N = total individuals obtained

Results

Mollusc diversity

Therefore, a total of 17 molluscs belonging to the gastropod and bivalves classes were found. The 12 species belong to the gastropod class with eight families: Neritidae, Ellobiidae, Littorinidae, Potamididae, Pachychilidae, Nassariidae, Thiaridae, and Ampullariidae. At the same time, five other species were identified as bivalves with five families: Isognomonidae, Unionidae, Cyrenidae, Archidae, and Veneridae. In the gastropod class, the families with the most common species are Neritidae = 3, Ellobiidae = 2, and Littorinidae = 2 (**Figure 4**). Apart from these three families, only one species was found in other families in the gastropod class (**Table 2**). In Bivalvia class, no single family dominated the study site or all the families encountered came from only one species (**Table 2**). Of the 12 gastropod species found among them *Vittina turrita* (Gmelin, 1791); *Neritodryas dubia* (Gmelin, 1791); *Clithon oualaniensis* (Lesson, 1831); *Cassidula aurisfelis* (Bruguière, 1789); *C. nucleus* (Gmelin, 1791); *Littoraria scabra* (Linnaeus, 1758); *L. angulifera* (Lamarck, 1822); *Pirenella cingulata* (Gmelin, 1791); *Faunus ater* (Linnaeus, 1758); *Nassarius margaritiferus* (Linnaeus, 1758); *Tarebia granifera* (Lamarck, 1816); and *Pomacea canaliculata* (Lamarck, 1822). On the other hand, there were 5 bivalve species namely *Isognomon ephippium* (Linnaeus, 1758); *Pilsbryoconcha exilis* (I. Lea, 1838); *Polymesoda expansa* (Mousson, 1849); *Anadara antiquata* (Linnaeus, 1758); and *Paphia textile* (Gmelin, 1791) (**Table 2**, **Figure 5**).

Ecological indexes

According to Saputra et al. (2020)[20], calculating mollusc density can be calculated using the Brower and Zar formula (1990)[15]. After calculating the number of individuals and species, the total density of the molluscs is 3.95 ind/m^2. The gastropod species with the highest density were *P. cingulata*, with a density value of 2.77 ind/m^2, F. ater with 2.51 ind/m^2, and *V. turrita* with 1.61 ind/m^2. Meanwhile, the species with the lowest density value were *L. angulifera*, *C. oualaniensis*, and *C. nucleus* with a density value of 0.01 ind/m^2. Beside density, several indices can be used in analyzing species diversity, including the Simpson Index, the Shanon-Wiener Index, the Brill Index, and the Brillouin Index. According to the

Nahlunnisa et al. (2016)[21]. H' is the most widely used index to determine species diversity. After calculating using this index (Odum, 1993)[16], the Lembupurwo Lagoon coast was known to have a moderate level of diversity with additional information that the number of individuals was almost uniform and there were several dominant species. This was supported by the 1.48 index result (**Figure 3**) and adjusted for the H' criteria mentioned by (Athifah et al., 2019)[22] that classified low (H' ≤1, the number of individuals is uniform), moderate (1≤H'≤3, the number of individuals is almost uniform), and high diversity (H'≥3, a uniform number of individuals and no dominant species).

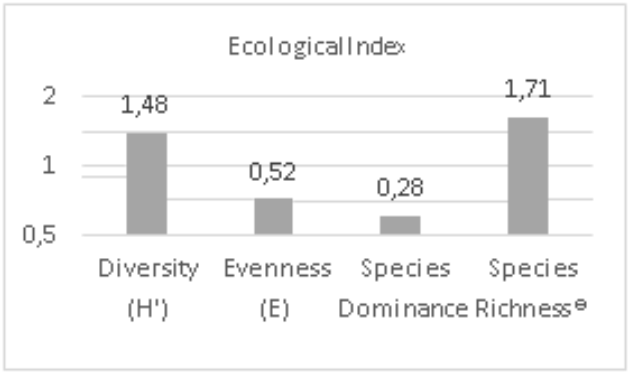

Figure 3. Ecological index value of mollusc at Lembupurwo Lagoon Beach, Kebumen District, Central Java, Indonesia

Figure 4. A. *Tarebia granifera* (27 mm); B. *Pirenella cingulata* (23 mm); C. *Faunus ater* (40 mm); D. *Pilsbryoconcha exilis* (25 mm); E. *Pomacea canaliculata* (31 mm); F. *Isognomon ephippium* (38 mm); G. *Polymesoda expansa* (45 mm); H. *Anadara antiquata* (30 mm); I. *Littoraria scabra* (11 mm); J. *Paphia textile* (7 mm); K. *Littoraria angulifera* (16 mm); L. *Vittina turrita* (25 mm); M. *Nassarius margaritiferus* (17 mm); N. *Cassidula aurisfelis* (21 mm); O. *Neritodryas dubia* (20 mm); P. *Clithon oualaniensis* (20 mm); Q. *Cassidula nucleus* (19 mm)

In addition, the ecological index to determine the evenness level of each species in the study site can be calculated using E. Calculating the species evenness index determined the community stability that depended on the evenness of the species[23]. According to Wahyuningsih et al. (2019)[24], if the calculated formula obtains a value of E<0.31 (low or the community is depressed); 0.31>E>1 (medium evenness, labile community); and E>1 (high, stable community). From this statement, it can be concluded that the evenness of molluscs in Lembupurwo Lagoon beach was due to the 0.52 score (**Figure 3**). Aside, the dominance index is a parameter used to express species dominancy level in a community. Mastery of this species can be concentrated on one, several, or many species, which can be estimated from the high or low index. A high dominance index indicates one species dominates and vice versa[25]. For example, for the D, the molluscs at Lembupurwo Lagoon Beach got a value of 0.28 in the category of no dominating species. This category was adjusted to the criteria of Tarida et al. (2018)[26], which states that 0<D<0.5 (no dominancy).

Besides, species richness is the number of species found in a community. According to Baderan et al. (2021)[27], the greater number of species found in a community the greater the wealth index. However, the R index indicated that the increase in the number of species is inversely proportional to the number of individuals. Instance, in a community with many species had 0.5<D>1 scale and in a community with many species, the number of individuals for each species will be small, and vice versa. On the research site, R was 1.71 or low species richness. Wahyuningsih et al. (2019)[24] stated the level consisted R<2.5 (low); 2.5>R>4 (moderate); and R>4 (high). These molluscs in Lembupurwo had a small number of species whereas the individuals obtained were high.

Environmental factors

Environmental conditions suitable for mollusc life will help them play important roles in the mangrove ecosystem. In this study, temperature parameters, pH, and salinity were measured (**Table 3**). The measurements of all temperatures ranged from 27-38°C whereas the pH at that location ranged from 7-7.8. This average was still fairly normal because the pH is still at 7+ classified as alkaline. Meanwhile, the salinity at this location was around 1-5 ppt, relatively normal for fresh water with soil moisture at 9-9.5.

Discussion

Molluscs are a group of macrozoobenthos with soft bodies and mostly secrete calcium carbonate, forming a hard shell of chitin that functions in self-protection[28]. In addition, this group acts as a decomposer of litter and mineralization of organic matter. In contrast, environmental pressures and changes tend to result in changes in mangrove ecosystems, affecting mangrove forests' physical, chemical, and biological conditions due to their habitat there mostly in coastal waters[29]. The calculation of dominancy, diversity, and richness could help the environmental monitoring besides the animal indexing. To analyze mollusc diversity, there were several indices can be used in analyzing species diversity such as the Simpson, the Shanon-Wiener, the Brill, and the Brillouin indexes. According to Nahlunnisa et al. (2016)[21], H' describes the state of a population of organisms mathematically to make it easier to analyze information on the number of individuals of each type in a community. For this reason, calculations were carried out using H'[30]. The E determines the distribution of each species in the

observation area. Meanwhile, the D is parameter of concentration for species dominance in a community. The abundance index is the number of individual species per station in cubic units[31].

Based on calculations using the H', the Lembupurwo Lagoon coast was known to have a moderate level of diversity with the additional information that the number of individuals was almost uniform. These results have also been adjusted by Athifa et al. (2019)[22]. The results of this study have moderate diversity that was 1.48 compared to several studies in other areas in Indonesia. This study had the same diversity category as in the Pacitan mangrove ecosystem8. However, it was still higher than the molluscs in the mangrove forest in the Sidangoli Island Cluster with 2.11 score[32]. In this study, 17 species of molluscs were found with 12 species belonging to the gastropod and the others were being bivalves. In the Pacitan Mangrove Ecosystem, there were 25 species found with 17 gastropods and 8 bivalves. Meanwhile, only 14 species were found in the Sidangoli mangroves, with gastropods and bivalves class. Another hand, the mollusc D in this study obtained a value of 0.28, Pacitan 0.34, and Sidongali 0.19 with all locations in the same category: no species domination the study area. However, based on the E, Sidongali had higher score that was 0.9 (high), Pacitan 0.66 (medium), and this study was 0.52 (medium) scores.

Table 2. List and density of mollusc species found at Lembupurwo Lagoon Beach, Kebumen District, Central Java, Indonesia

Class	Family	Species	Density (ind/m^2)
Gastropod	Neritidae	*Vittina turrita*	1.61
		Neritodryas dubia	0.57
		Clithon oualaniensis	0.01
	Ellobidae	*Cassidula aurisfelis*	0.26
		Cassidula nucleus	0.01
	Littorinidae	*Littoraria scabra*	0.06
		Littoraria angulifera	0.01
	Potamididae	*Pirenella cingulata*	2.77
	Pachychilidae	*Faunus ater*	2.51
	Nassariidae	*Nassarius margaritiferus*	0.19
	Thiaridae	*Tarebia granifera*	0.19
	Ampullariidae	*Pomacea canaliculata*	0.09
Bivalve	Isognomonidae	*Isognomon ephippium*	0.27
	Unionidae	*Pilsbryoconcha exilis*	0.06
	Cyrenidae	*Polymesoda expansa*	0.19
	Arcidae	*Anadara antiquata*	0.005
	Veneridae	*Paphia textile*	0.031
Total density			3.95

Abiotic parameters are a factor for the life and development of living things, and are a limiting factor. Limiting factors are all physical and chemical factors determining whether a living thing can live and develop; it also affects molluscs. Molluscs can be found in the sea, brackish, freshwater, and land.

Most of them live in the sea with various lifestyles including bottom feeders. At sea, it is generally found in the littoral zone to the deep seabed; some even live pelagic at sea level[20]. As previously mentioned, the existence and distribution of molluscs are influenced by biotic and abiotic factors. Molluscs can live and reproduce at 0 to 48.6℃, whereas to be active normally require a temperature range of 5℃-38℃. In addition, some aquatic biota are sensitive to changes in pH and prefer range of around 7-8.5. At the same time, the pH in the Lembupurwo Lagoon is around 7.6-7.8. So, it can be concluded that the abiotic conditions in the area supported life of molluscs in the range where molluscs can reproduce well[33].

Table 3. Environmental factors at Lembupurwo Lagoon Beach, Kebumen District, Central Java, Indonesia

Research site	Temperature (℃)			pH		Water salinity
	Air	Soil	Water	Soil	Water	
Lembupurwo Lagoon Beach	28.6-38.0	27.0–33.6	29.0-31.0	7.0	7.6–7.8	1.0—5.0

Lembupurwo Lagoon is a lagoon located near the beach face, where in the lagoon, the water stagnates, making the surrounding area wet and having a certain humidity. Such abiotic conditions can attract living things to inhabit that location. However, to proof the effect of abiotic conditions on the distribution of molluscs, it is necessary to compare the biotic conditions of the location with the suitable for their life and development conditions. After calculating the environmental parameters, it was found that the air temperature ranged from 28.6℃ to 38℃, the soil was 27-33.6℃, and the water was between 29 and 31℃. In addition, the mangrove area in the Lembupurwo Lagoon had a soil pH of 7 and water ranged from 7.6 to 7.8 while the water salinity was 1-5 and soil moisture was 9-9.5. As a comparison, one of the gastropod habitats was in Siklotok Waterfall, Purworejo District, Central Java. Although, as a habitat for gastropods, this waterfall has a soil pH between 5.8 and 6.8, the pH tends to being slightly acidic due to the full fallen leaves. The results of humidity measurements at the Siklotok was 92% in all repetitions and the temperature obtained from altitude and weather factors in March and April was 26℃ to 30℃[34].

In Lembupurwo Lagoon, there were more gastropod than bivalve molluscs. Eight families of gastropods were found, while only five were bivalves. This follows a study from Wiraatmaja et al. (2022)[8] stating that the higher diversity of gastropods compared to bivalves in mangrove ecosystems is due to the ability of gastropods to tolerate better environmental changes and the harsh conditions[35]. In addition, the distribution of the abundance of bivalves is generally limited to narrow tidal boundary zone due to food and larval life needs. Bivalves and other aquatic organisms will die from a lack of oxygen. A relatively high water temperature in a body of water is indicated by the emergence of fish and other marine organisms to the surface in search of oxygen. As previously mentioned, there are eight families of gastropods included Neritidae, Ellobiidae, Littorinidae, Potamididae, Pachychilidae, Nassariidae, Thiaridae, and Ampularidae with the most species were Neritidae.

Besides being dominant in the number of species, the Neritidae was also dominant in the number of individuals. The dominance of the Neritidae family occurs due to the wide spreading in temperate to tropical climates. Additionally, its distribution ranges from freshwater, brackish water, and saltwater, and the characteristics of this area were suitable for the Neritidae. Indonesia alone has 17 fresh water

and 20 salt water sepcies[36]. Therefore, observing this phenomenon, the domination of the Neritidae in the Lembupurwo could be understood because Indonesia is a comfortable habitat and is included in its distribution patterns. Nurfadilah et al. (2021)[37] examined the diversity of molluscs and their characters at Sujono Beach, Batu Bara, North Sumatr found the mussels *Perna viridis* was the most dominant species. Tyas and Widiyanto (2015)[38] mentioned the habitat and several other factors that can affect the molluscs growth consisted temperature, pH, and substrate conditions that impacting growth and diversity. The temperature changes beyond the optimum limit will decrease organisms' growth rate and production. Of a total of 17 molluscs found on Lembupurwo, five species were utilized by the local community like *N. dubia*, *Isognomon ephippium*, *P. exilis*, *P. expansa*, and *A. antiquate* as consumption needs. The most common species found in the culinary in Indonesia was *A. antiquata*[39].

Conclusions

This study can be concluded that the presence of molluscs provides economic benefits to society. The food sector is one of the benefits. Those species with potential in the food sector include: *F. ater*, *I. ephippium*, *P. exilis*, *P. expansa*, and *A. antiquata*. Additionally, the study results showed that the total molluscs found had a density value of3.95 ind/m^2. The H' was 1.48 (moderate), the E was 0.52 (moderate), the R index was 1.71 (low), and the D was 0.28 (no species dominated). Therefore, it is necessary to make an effort to understand the community structure of gastropods and bivalves for conservation, sustainable use, and management including other aquatic resources in the area. This research can provide recommendations for future research on mollusc diversity. Furthermore, the several index values that tends to be in the medium and low categories raises another question about the ecological conditions.

Acknowledgments

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Conflicts of Interest

There are not potential conflicts of interest.

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