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Ecological index and economic potential of mollusks (Gastropods and Bivalves) in Ayah Mangrove Forest, Kebumen District, Indonesia

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Abstract. *Dewi MAK, Aurina DM, Faturrahman AD, Fatikha LA, Rachmalia F, Ainaya FA, Kinanthi A, Rohman CM, Fadzilah FPA, Pramudita DA, Ramadhan MF, Mahajoeno E, Nugroho GD, Sujarta P, Dadiono MS, Yap CK, Rahim KABA, Setyawan AD. 2023. Ecological index and economic potential of mollusks (Gastropods and Bivalves) in Ayah Mangrove Forest, Kebumen District, Indonesia. Biodiversitas 24: 1231-1241.* Mollusks are a group of triploblastic coelomates with soft bodies that live in various ecosystems, one of which is mangroves. This research was conducted with the aim of knowing the ecological index and economic potential in the mangrove forest of Ayah Village, Kebumen District, Central Java, Indonesia. First, the sampling method for each location using a transect plot measuring 10 x 10 m² was made. Mollusk species in each plot that had been obtained were then counted, collected, and recorded. Furthermore, abiotic variables such as water salinity, soil and water pH, and air, water and soil temperature, were measured. Then, the individuals and mollusk species that have been collected are calculated using ecological indices, such as the Shannon-Wiener biodiversity index, species density, Margalef species richness index, Evenness index, and Simpson dominance index. Meanwhile, the economic potential of the mollusk was searched using references from scientific journals and books. Finally, all data obtained were analyzed descriptively with supporting figures and tables. The results obtained 23 identified species of mollusk, i.e.: Gastropods (18 species) and Bivalves (5 species). The total density of mollusk obtained was 3.49 ind/m^2, the species diversity index was 2.22 (moderate), the species evenness index was 0.71 (relatively even), the species dominant index was 0.16 (low), the species richness index was 2.71 (low). The environmental factors are as follow: temperature of air (30-30.3°C), water (28-29°C), soil/sediment (24-30°C), water pH 7.5-7.7, soil pH 7 and salinity 1-5 ppt. Of the total of 23 mollusks, 18 species could be consumed, i.e.: *A. granosa, B. spirata, C. angulifera, C. aurisfelis, C. oualaniensis, E. aurisjudae, F. ater, L. scabra, N. lineata, N, violacea, N. dubia, P. viridis, P. cingulata, P. expansa, P. canaliculata, P. maculata, S. cucullata,* and *T. telescopium*. The seven species of mollusks can be used as accessories, i.e.: *B. spirata, N. lineata, P. cingulata, P. exilis, P. expansa, P. canaliculata,* and *P. maculata.* Meanwhile, the mollusks used as decorations are as many as eleven, i.e.: *A. granosa, B. spirata, C. corona, C. oualaniensis, N. margaritiferus, N. dubia, P. expansa, P. canaliculata, P. maculata, S. cucullata* and *V. turrita.*

Keywords: Bivalves, ecological index, Gastropods, mangrove ecosystem, mollusk potential

INTRODUCTION

According to Nugroho (2020), Indonesia is one of three countries with the world's largest natural resources besides Brazil and the Democratic Republic of Congo. Biodiversity can also be used as a foundation or basis for human health and food security because this biodiversity provides various human goods and services, such as a source of food, climate control, disease control, etc. (Samedi 2015). The habitat of biodiversity is an ecosystem. Indonesia potential is quite superior regarding the diversity of ecosystems, one example of which is the mangrove ecosystem. That is because Indonesia has a very wide ocean, so its coastal areas stretch wide, with many mangrove ecosystems. Indonesia has the world's largest mangrove area, approximately 3.2 million ha (Eddy et al. 2015). Where previously, Indonesia had a mangrove area of 6.7 million ha, but 50% of Indonesia's mangrove land has been lost (Fitry and Anwar 2014). The biggest cause that causes the loss of mangroves is anthropogenic activity (Eddy et al. 2015).

Mangrove ecosystems are forests located in tidal areas, so the mangrove plants will be flooded during high tide and when low tide will be free of water (Majid et al. 2016). Mangrove is a plant that usually grows in tropical and sub-tropical areas (Imran and Efendi 2016). Mangrove ecosystems have the function and role of storing species richness and providing various services and ecosystem services (Siburian and Haba 2016). In addition, mangrove ecosystems also provide goods and services for living things needs, especially humans, such as providing wood products, providing land for fishery resources, providing plants used as medicine, and preventing degradation (Riungu et al. 2022). In addition, the mangrove ecosystem has an important role as a habitat for the diversity of fauna, one of which is a mollusk.

Mollusks are triploblastic coelomate group animals with soft bodies especially living in mangrove ecosystems (Chen et al. 2019). Mollusks live by attaching to the substrate surface, in the substrate, or to mangrove trees. There are eight classes of mollusk including Caudofoveata, Aplacophora, Monoplacophora, Polyplacophora, Scaphopoda, Cephalopods, Gastropods, and Bivalvia. However, the mangrove ecosystem is dominated by the Gastropods and Bivalvia classes (Manner et al. 2021). Gastropods and Bivalves have an important role as a factor supporting the ecological function of the mangrove ecosystem directly or indirectly. Gastropods and Bivalves act as bioindicators in mangrove waters because they are sensitive to environmental changes (Srivastava and Singh 2020). In the food chain, Gastropods and Bivalves act as consumers and main decomposers (Katukdoan et al. 2018). The role of Gastropods and Bivalves in mangrove ecosystems is also found in the carbon cycle because their shells contain calcium carbonate, which has an extensive fossil record so that they can store information on environmental changes (Ginantra et al. 2020). In addition, from an economic perspective, Gastropods and Bivalves can be used as accessories and sometimes even as raw materials for medicines and food products (Kristiningrum et al. 2019).

One of the mangrove ecosystems that is a habitat for mollusks (Gastropods and Bivalvia) is Ayah Mangrove Forest, Logending Beach, Ayah District, Kebumen District, Central Java. This mangrove ecosystem is a dense mangrove forest area with diverse mangrove tree vegetation on mud and sand substrates as the habitat of various fauna. The density of mangrove vegetation also supports the diversity of mangrove fauna, such as Gastropods and Bivalves (Tantu et al. 2012). However, no research on mollusks (Gastropods and Bivalves) related to ecological aspects and their economic potential for humans in this region has been conducted. Therefore, with the limited information available, researchers are encouraged to research the ecological index and economic potential of mollusks in Ayah Mangrove Forest. Knowing the existence of mollusks (Gastropods and Bivalves) in the Ayah Mangrove Forest ecosystem is hoped to be useful for preserving the mangrove ecosystem and its environment. Also, could provide information about the economic benefits of mollusks to the local community needs.

MATERIALS AND METHODS

Study area

Sampling was conducted on November 2022 from 07.00 pm to 17.00 pm in Ayah Mangrove Forest, Logending Beach, Ayah Sub-district, Kebumen District, Central Java, Indonesia (Figure 1). Kebumen District is located between latitudes 7º271-7°501 S and 109°331-109°501 E (Tawari et al. 2021). To the east, it is bordered by Purworejo and Wonosobo Districts, north by Banjarnegara District, and west by Cilacap and Banyumas Districts, while to the south is the Indonesian Ocean.

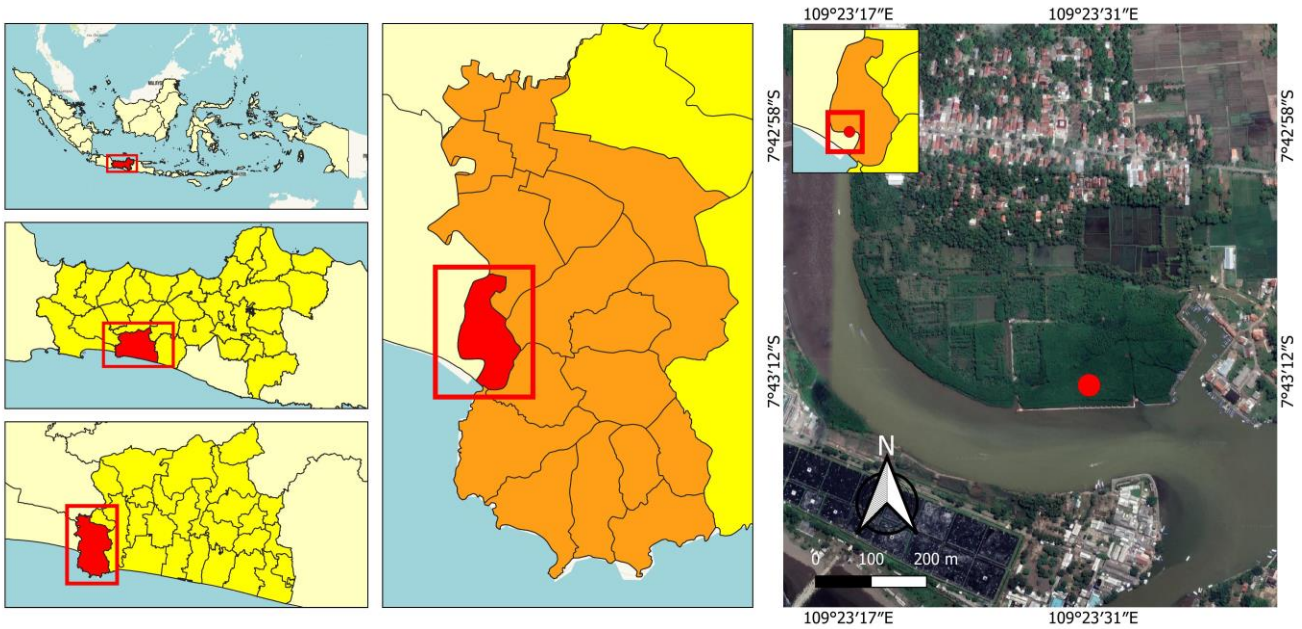

Figure 1. The sampling area in the mangrove ecosystem of Ayah Mangrove Forest, Kebumen District, Central Java, Indonesia

The research location is located between -7°718677 and 109°394317. *Rhizophora mucronata* (Pure mangroves or oil mangroves) are the most commonly planted and used to accelerate ecosystem growth to protect resources and reduce the risk of natural disasters (Badan Pengelola Geopark Nasional Kebumen 2019). The soil type is sandy and muddy, a riverbank area directly leading to Logending Beach. In addition, there are also *Avicennia marina* (Api-api mangroves) and *Nypa fruticans* (Nipah mangroves), beside *R. mucronata* which are dominantly growing at the selected stations.

Procedure

Sampling was carried out at three stations with 30 plots in one location. The sample location was selected based on the abundance of mollusks. Six people conducted the survey, and the data collection was conducted from 07.00 am to 17.00 pm. Sampling was carried out on November 2022, and all areas sampled showed a different number of species. Stations and plots were observed based on the characteristics of the substrate, such as sandy, muddy and existing vegetation. Gastropod and Bivalve specimens in the plots were collected by hand picking on the surface of the substrate and from mangrove trees such as stems, roots, and leaves following Kantharajan et al. (2017). The species collected in each plot were then counted and recorded. Furthermore, abiotic variables such as water salinity, water and soil pH, and air, water, and soil temperature, were also measured. Abiotic factor measurements were carried out at 07.00 am, 12.00 pm, and 04.00 pm with three times rolling. The equipment used to measure abiotic factors, namely a soil tester, thermometer, and refractometer. Dominant mangrove tree vegetation was also recorded (Wiraatmaja et al. 2022). The following picture shows the coordinates of the sampling locations for Gastropods and Bivalves, the type of habitat, and the vegetation of the dominant mangrove trees (Table 1 and Figure 2).

Figure 2. Condition of each mangrove ecosystem in Ayah Mangrove Forest, Kebumen District, Central Java, Indonesia. A. Station 1, B. Station 2

Table 1. Sampling site in mangrove ecosystem of Ayah Mangrove Forest, Kebumen District, Central Java, Indonesia

Location	Coordinate	Habitat type	Dominance vegetation
Station 1	7°43’16’’S 109°23’43’’E	Sand substrate	*Avicennia marina* dan *Nypa fruticans*
Station 2	7°43’13’’S 109°23’34’’E	Mud substrate	*Rhizophora mucronata*

Identification mollusks

From the sampling plot, one of each species was taken for identification. First, the sample is taken using a digital camera or cellphone then the process of identifying this mollusk is carried out by observing morphological characteristics such as shell color, pattern, and shape. Next, the samples were preserved in 70% alcohol and taken to the Biology Laboratory, Sebelas Maret University, Surakarta, Indonesia. Samples were identified with references from Dolorosa and Galon (2014), Choirunnisa and Ambarwati (2018), Islamy and Hasan (2020), Merly et al. (2022), and Wiraatmaja et al. (2022). After being photographed and identified, the sample is stored in the collection bottle.

Ecological index calculation

Data on the number of species obtained were then analyzed using the Mueller-Dombois and Ellenberg density formula, Shannon-Wiener diversity index (H'), Evenness index (E), Simpson dominance index (D), and Margalef species richness index (R).

To calculate the density, using the Mueller-Dombois and Ellenberg (1974) as follows:

$$\text{Density (K)} = \frac{Number\ of\ individuals}{Plot\ area}$$

The diversity index of Shannon-Wiener (Zar 2010) is as follows:

$$H' = -\Sigma\ (Pi\ In\ Pi)$$

$$Pi = \frac{ni}{N}$$

Where:
H' : Diversity index of Shannon-Wiener
Pi : number of individuals of the i species divided by the total number of individuals
ni : The number of individuals of each species
N : Total number of individuals
S : Total number of species
Ln : Natural Logarithm

The Evenness index (Prechzsch 2009) is as follows:

$$E = \frac{H'}{ln\ (S)}$$

Where:
E : Evenness index
H' : Diversity index of Shannon-Wiener
S : Total number of species
Ln : Natural Logarithm

The dominance index of Simpson (Odum 1993) is as follows:

$$C = \Sigma \left(\frac{ni}{N}\right)^2$$

Where:
C : Dominance index of Simpson
Ni : The number of individuals of each species
N : Total number of individuals

The richness index of Margalef (Ismaini et al. 2015) is as follows:

$$R = \frac{s-1}{In\ (N)}$$

Where:
R : Richness index of Margalef
S : Total number of species
N : Total number of individuals

Economic potential

The economic potential of mollusk was identified using secondary data, namely in the form of references to journals and books on the internet by Appukuttan and Ramadoss (2000), Wei-dong et al. (2003), Suharto et al. (2006), Kusnadi et al. (2008), Tan (2008), Szabó and Amesbury (2011), Hamli et al. (2013), Saenab et al. (2014), Soon and Ransangan (2016), Antoni and Febri (2017), Parorrongan at al. (2018), Barbittaa et al. (2020), Hristov (2020), Idris et al. (2020), Kumari et al. (2020), Musapana and Amalia (2020), Soegianto et al. (2020), Abubakar et al. (2021), Islamiyah et al. (2021), Merly et al. (2019, 2022), and Oktavia et al. (2023). The economic potential of this mollusk can be used as food, home decoration, and accessories.

Data analysis

In this study, quantitative data analysis was carried out through direct observation and secondary data, which was presented and supported by figures, and tables of observations which were then described descriptively.

RESULTS AND DISCUSSION

Diversity

A total of 23 mollusk species were identified from the study site in Ayah Mangrove Forest. Gastropods are represented by 18 species from nine families: Pachycillidae, Potamididae, Thiaridae, Ampullaridae, Neritidae, Littorinidae, Ampullariidae, Babyloniidae, and Ellobiidae. In addition, there are five species of Bivalvia from five different families: Ostreidae, Mytilidae, Cyrenidae, Arcidae, and Unionidae. Families with the most species of Gastropods include Neritidae (6 species), Ellobiidae (3 species), and Potamididae (2 species). The other families have only one species. Meanwhile, the families in the Bivalvia species only have one species in each family (Table 2, Figures 3 and 4).

The mollusks found consisted of 18 species of Gastropods: *Faunus ater* (Linnaeus, 1758); *Pirenella cingulata* (Gmelin, 1791); *Stenomelania plicaria* (Born, 1778); *Pomacea canaliculata* (Lammark, 1822); *Clithon oualaniensis* (Lesson, 1831); *Clithon corona* (Linnaeus, 1758), *Vittina turrita* (Gmelin, 1791); *Nerittina violacea* (Gmelin, 1791); *Neritodryas dubia* (Gmelin, 1791); *Pomacea maculata* (Perty, 1810); *Babylonia spirata* (Linnaeus, 1758); *Nerita lineata* (Gmelin, 1791); *Telescopium telescopium* (Linnaeus, 1758); *Nassarius*

margaritiferus (Dunker, 1847); *Cassidula aurisfelis* (Bruguire, 1789); *Cassidula angulifera* (Petit de la ssausayye, 1841); *Ellobium aurisjudae* (Linnaeus, 1758), and *Littoraria scabra* (Linnaeus, 1758). On the other hand, five species of Bivalves were found, including *Saccostrea cucullata* (Born, 1778); *Perna viridis* (Linnaeus, 1758); *Polymesoda expansa* (Gmelin, 1791); *Pilsbryoconcha exilis* (I. Lea, 1838); *Anadara granosa* (Linnaeus, 1758) (Figure 3).

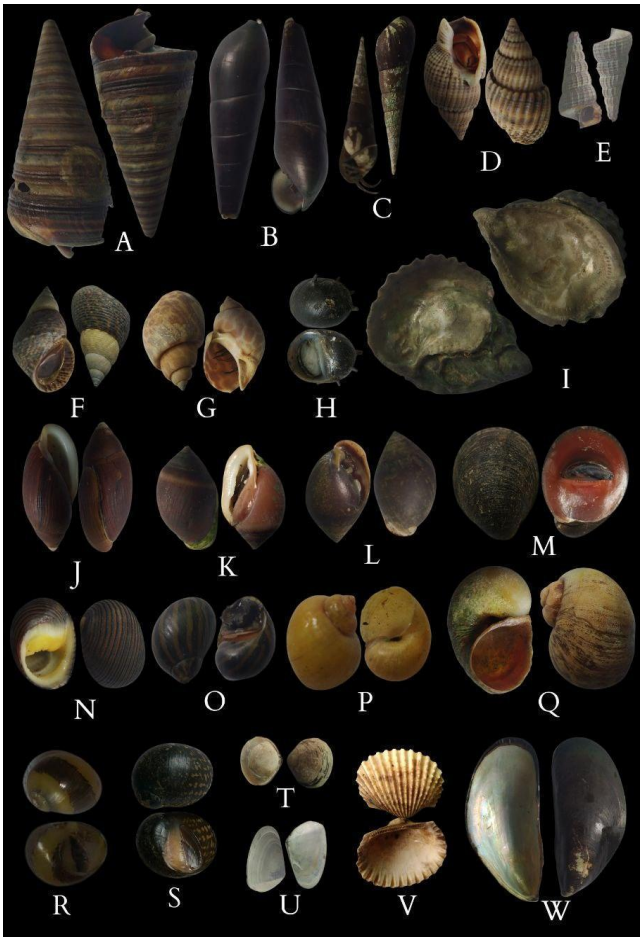

Figure 3. List of mollusks in the Ayah Mangrove Forest, Kebumen, Central Java, Indonesia: A. *Telescopium telescopium* (90 mm) B. *Faunus ater* (70 mm), C. *Stenomelania plicaria* (30 mm), D. *Nassarius margaritiferus* (35 mm), E. *Pirenella cingulata* (27.1 mm), F. *Littoraria scabra* (30 mm), G. *Babylonia spirata* (75 mm), H. *Clithon corona* (13.2 mm), I. *Saccostrea cucullata* (60 mm), J. *Ellobium aurisjudae* (37 mm), K. *Cassidula aurisfelis* (35 mm), L. *Cassidula angulifera* (35 mm), M. *Neritina violacea* (20 mm), N. *Nerita lineata* (26 mm), O. *Vittina turrita* (10 mm), P. *Pomacea canaliculata* (35.2 mm), Q. *Pomacea maculata* (150 mm), R. *Clithon oulaniense* (20 mm), S. *Neritodryas dubia* (40 mm), T. *Polymesoda expansa* (10.7 mm), U. *Pilsbryoconcha exilis* (5 mm), V. *Anadara granosa* (60 mm), W. *Perna viridis* (85 mm)

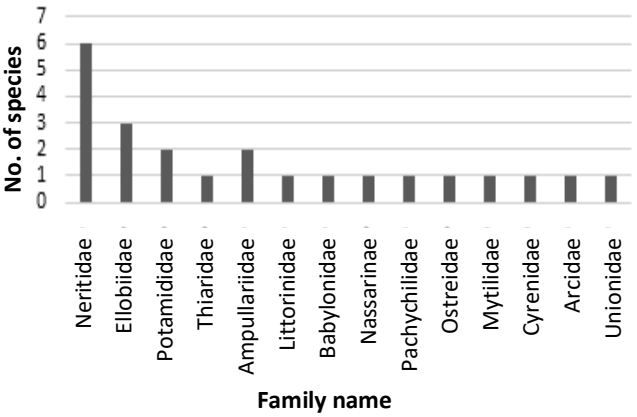

Figure 4. Number of species by family in this study

Ecological index

In this study, the density value of mollusks in Ayah Mangrove Forest was 3.49 Ind/m^2. The highest species density value was obtained by *S. cucullata*, 0.75 Ind/m^{2,} with a total of 749 individuals. Meanwhile, the lowest density value was found for *B. spirata*, *P. exilis*, and *T. telescopium*, with 0.01 ind/m^2 or 2 individuals each. Species density shows the number of individuals of a species in a certain area. The mollusk density values in Ayah Mangrove Forest are detailed in Table 2.

Shannon-Wiener diversity index (H'). The species diversity index in Ayah Mangrove Forest is 2.22. According to Odum (1993), the criteria for the species diversity index are (i) H'<1: low level of species diversity, (ii) <H'≤3: moderate level of species diversity, and (iii) H'>3: level of diversity high kind. Thus, the species diversity index in Ayah's Mangrove Forest is in the medium category. The calculation of the Shannon-Wiener index is carried out to make it easier to analyze the number of individuals of a species in the community. Therefore, the value indicates species diversity at a particular community level. Species diversity (H') is related to species richness in an area and is influenced by species abundance distribution. The higher the value of diversity (H'), the higher the diversity of species, ecosystem productivity, pressure on the ecosystem, and ecosystem stability.

Evenness index (E). The evenness index of species in this study was obtained at 0.71. According to Pielou (1997), the criteria for the Evenness of species are (i) evenness index 0.00<E<0.25, so Evenness is not uniform. (ii) evenness index of 0.26<E<0.50 means less even. (iii) evenness index in the value range 0.51<E<0.75 means relatively even. (iv) the evenness index in the range of 0.76<E<0.95 means almost evenly distributed, and (v) the evenness index in the range of 0.96<E<1.00, then is evenly distributed. Meanwhile, the Evenness index in Ayah's Mangrove Forest belongs to the relatively even category. The Evenness index value shows the evenness relationship between the individual abundance of a species and the maximum species diversity found. Species with the same number of individuals mean that the community has the maximum evenness value. Conversely, if the evenness value is low, the community has the dominant species and the minimum evenness value (Ismaini et al. 2015).

Simpson dominance index (D). The species dominance index in this study was obtained at 0.16. According to Odum (1971), there are three dominance index criteria, including (i) a dominance index value of 0<D<0.5 means low species dominance, (ii) a dominance index value of 0.5<D<0.75 means relatively moderate species dominance, and (iii) when the dominance index value is 0.75<D<1.00 then the dominance of the species is quite high. So, the dominance of species in Ayah Mangrove Forest is in a low category; no species dominate in that location.

Margalef species richness index (R). The species richness index in this study was 2.71. According to Magurran (1998), there are three criteria for species richness, namely (i) richness index H<3.5 means low species richness, (ii) richness index 3.5<H<5 means medium richness index, and (iii) richness index R>5 hence the high wealth index. So, the species richness in Ayah's Mangrove Forest is in a low category. The species richness index shows the number of species in a community. The more species found, the greater the richness index value. Ismaini et al. (2015) explained that the number of species in the Margalef index is divided by the natural logarithmic function. That way, the number of species will be inversely proportional to the increase in individuals so that a community/ecosystem with a variety of species will have a low number of individuals in each species. A comparison of ecological index values can be seen in Figure 5.

Environmental (abiotic) factors in the research location

At the research location, Ayah's Mangrove Forest has several abiotic environmental parameters related to mollusk diversity. The results of this study obtained measurements of temperature (air, water, and soil), pH (water and soil), and salinity at the study site. The results of measuring temperature data at all points of the Ayah Mangrove Forest research location obtained the air temperatures ranging from 30-30.3°C, then soil temperatures ranging from 24-30°C, and water temperatures ranging from 28-29°C. Then, measuring soil pH parameters at all sampling locations is 7. While overall water pH is 7.5-7.7. The results of measuring the parameters of water salinity at the Ayah Mangrove Forest location are equal to 0-5 because the research location is closer to the river than the sea. Hence, the salinity level is not too high. Table 3 shows the results of abiotic parameter measurements in this study.

Table 2. List and density of mollusk species recorded in the mangrove ecosystem of Ayah Mangrove Forest, Kebumen, Central Java, Indonesia

Class	Family	Species	Density (ind/m²)
Bivalvia	Ostreidae	*Saccostrea cucullata* (Born, 1778)	0.75
	Mytilidae	*Perna viridis* (Linnaeus, 1758)	0.04
	Cyrenidae	*Polymesoda expansa* (Gmelin, 1791)	0.17
	Arcidae	*Anadara granosa* (Linnaeus, 1758)	0.03
	Unionidae	*Pilsbryoconcha exilis* (I. Lea, 1838)	0.01
Gastropod	Potamididae	*Pirenella cingulata* (Gmelin, 1791)	0.45
		Telescopium telescopium (Linnaeus, 1758)	0.01
	Thiaridae	*Stenomelania plicaria* (Born, 1778)	0.18
	Ampullariidae	*Pomacea canaliculata* (Lammark, 1822)	0.11
		Pomacea maculata (Perry, 1810)	0.13
	Neritidae	*Clithon oualaniensis* (Lesson, 1831)	0.04
		Clithon corona (Linnaeus, 1758)	0.02
		Neritina violacea (Gmelin, 1791)	0.13
		Neritodryas dubia (Gmelin, 1791)	0.49
		Nerita lineata (Gmelin, 1791)	0.1
		Vittina turrita (Gmelin, 1791)	0.17
	Littorinidae	*Littoraria scabra* (Linnaeus, 1758)	0.23
	Babylonidae	*Babylonia spirata* (Linnaeus, 1758)	0.01
	Pachychilidae	*Faunus ater* (Linnaeus, 1758)	0.18
	Nassarinae	*Nassarius margaritiferus* (Dunker, 1847)	0.13
	Ellobiidae	*Cassidula aurisfelis* (Petit de la ssausaye, 1841)	0.08
		Cassidula angulifera (Bruguire, 1789)	0.03
		Ellobium aurisjudae (Linnaeus, 1758)	0.02

Table 3. Environmental (abiotic) factors in the mangrove ecosystem of Ayah Mangrove Forest, Kebumen, Central Java, Indonesia

Repetition	Temperature °C			pH		Salinity (ppt)
	Air	Water	Soil/sediment	Water	Soil/sediment	
1	30.3	29	28	7.7	7	1
2	30.1	28	30	7.5	7	3
3	30	29	24	7.6	7	5

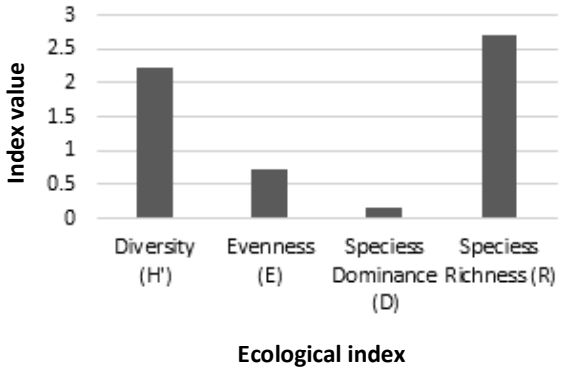

Figure 5. Comparison of ecological index values in this study

Figure 6. One of the species in the Neritidae family found in this study, *Vittina turrita*

Discussion

Diversity

This study revealed that the families of Neritidae, Ellobidae, Potamididae, and Pachycillidae are species found in mangrove habitats close to mangrove trees. The importance of an area as a habitat for mollusk and the species of flora that exist in an area, such as mangrove trees, both affect the distribution of this species (Rangan 2010; Khade and Mane 2012; Kabir et al. 2014; Kementerian Kelautan dan Perikanan Indonesia 2014; Samson and Kasale 2020). This Family is commonly found because it prefers tidal areas and muddy places. Due to the limitation for foraging and larval life, the abundance distribution of Bivalves is often restricted to a fairly narrow zone at the low tide boundary (Yadav et al. 2019).

Another mollusk (Gastropods and Bivalves) study also found that the species diversity of these Gastropods is higher than the species diversity of Bivalves in the mangrove ecosystem. For example, a study conducted in India, Asia, found seven Gastropods and four Bivalves (Sharma et al. 2013). Then, in the Asia continent, namely China, 60 species of Gastropods and 38 species of Bivalves were found (Sor et al. 2020). Furthermore, on the South American continent, The Strait of Magellan Chile, Aldea et al. (2020) summarized 134 studies and found 173 species of Gastropods and 107 species of Bivalves. Then on the Australian continent, South Australia, to be precise, as many as 47 species of Gastropods and 14 species of Bivalve were found (James et al. 2013). Then on the European continent, in Portugal to be precise, Delongueville et al. (2019) stated that naturalist Drouët (1858), for the King of Portugal, found 51 species of Gastropods and 15 species of Bivalve. Then on the African continent of Morocco, 26 species of Gastropods and ten species of Bivalves were found (Irikov and Gerdzhikov 2013).

Meanwhile, in other parts of Indonesia, precisely in Kolaka, Southeast Sulawesi, Hasidul et al. (2020) found that there were 182 species in 10 Gastropod families and six species in four Bivalve families. In addition, a study conducted by Rohmayani et al. (2021) on the North Coast of the Java Sea found ten Gastropods and seven species of Bivalves. Gastropod diversity is higher than Bivalves because Gastropods are epifauna that associate more easily with mangroves than Bivalves (Masni et al. 2016). Gastropods are also detritus eaters in mangrove areas. Gastropods associated with mangroves at this recent study site are the Neritidae, Ellobidae, Potamididae, Thiaridae, Ampullariidae, Littorinidae, Babylonidae, and Nassarinae families. Then the most dominant Gastropod family at this study site is the Neritidae family, comparing six species. This Neritidae is a Gastropod family that usually lives in colonies, and its habitat is along the coast, in the middle, to the intertidal zone (Juniar et al. 2021). In Figure 6, one of the species in the Neritidae family found in this study, *V. turrita.*

Environmental abiotic factors

Abiotic parameters (temperature, pH, humidity, and salinity) are very important factors that influence mollusks' existence. According to Ratih et al. (2020), the measurement of abiotic parameters aims to determine the physicochemical conditions of aquatic ecosystems related to environmental conditions that support aquatic biota. Like the air temperature conditions in this study, which ranged from 30-30.3°C. That aligns with Pertiwi and Lathifah's (2018) statement that the optimal temperature for mollusk organism growth is between 20-30°C. On the water pH parameters, Shalihah et al. (2017) explained that the optimal pH for maintaining the existence of mollusk ranged from 6.5-7.5. The results of the water pH in this study were slightly different from the optimal pH value, which ranged from 7.5-7.7. Whereas in the salinity parameter, the optimal salinity value to support and maintain the existence of mollusk is in the range of 28-34 ppt (Saputra et al. 2020), while in this study, the salinity value was 1-5. Due to the research location in the river estuary, even though it is close t the sea, there is no salt content, so it is categorized as brackish water.

Ecological index

Mollusk community stability can be analyzed using index values such as population density, Evenness (E), diversity (H'), species richness (R), and dominance (D). The density index of mollusks in Ayah Mangrove Forest is 3.49 ind/m^2; this value is higher than the Mangrove

Ecosystem in Pacitan District, East Java, which is a density of 0.3,49 ind/m² (Wiraatmaja et al. 2022). The diversity index of mollusks in Ayah Mangrove Forest is 2.22, which is in the medium category. That is higher than the Mangrove Ecosystem in Pacitan District, with a diversity index of 2.14 from a literature study (Wiraatmaja et al. 2022). That means the diversity of species in Ayah Mangrove Forest is greater than that of the Mangrove ecosystem in Pacitan District. Diversity includes two main dimensions, the variation in the number of species and the number of individuals of each type in an area. At each location, the abundance of each species varies quantitatively because some species are much more important than others, resulting in high and low diversity of ecosystems (Hasan et al. 2020). Then, the evenness index of the species in Ayah's Mangrove Forest was obtained at 0.71; this evenness index belongs to the relatively even category. Meanwhile, the evenness index in the Ecosystem in Pacitan District is 0.66 (Wiraatmaja et al. 2022), which means that each species in the area has an almost equal or uniform number of individuals. That shows the species are spread evenly in an ecosystem, and no species is dominant. The species richness index is the simplest measure of biodiversity because it only considers differences in the number of species in a certain area. The species richness of an area depends on the healthy of its habitat or ecosystem. The species richness index in Ayah Mangrove Forest was 2.71; this value was lower than the richness index in the Ecosystem in Pacitan District, which was 4.1 (Wiraatmaja et al. 2022). Finally, the dominance index in Ayah's Mangrove Forest, with a value of 0.16, was the relatively low category. This value is not much different from the research by Wiraatmaja et al. (2022), where the mollusk dominance index value of the ecosystem in Pacitan District was obtained at 0.34. That means the dominance is low so that no species dominates the area.

The economic potential of mollusks (Gastropods and Bivalves)

Mollusks such as Gastropods and Bivalves are mangrove resources that can be utilized by the community for their daily needs, primarily to support the economy (Table 4). In supporting the economy of the local community, mollusks can be edible, accessories (such as bracelets and necklaces), and parts of decorations to beautify a place (Appukuttan and Ramadoss 2000; Weidong et al. 2003; Suharto et al. 2006; Kusnadi et al. 2008; Tan 2008; Szabó and Amesbury 2011; Hamli et al. 2013; Saenab et al. 2014; Soon and Ransangan 2016; Antoni and Febri 2017; Parorrongan at al. 2018; Barbittaa et al. 2020; Hristov 2020; Idris et al. 2020; Kumari et al. 2020; Musapana and Amalia 2020; Soegianto et al. 2020; Abubakar et al. 2021; Islamiyah et al. 2021; Merly et al. 2019, 2022; Oktavia et al. 2023). In Figure 7, we also find several local residents who took *F. ater* and *P. expansa* to be collected as food.

Out of a total of 23 mollusks identified in Ayah Mangrove Forest, ten species are edible, namely *F. ater* (Saenab et al. 2014), *C. oualaniensis* (Tan 2008), *T. telescopium, N. lineata, C. angulifera,* and *L. scabra* (Merly et al. 2019), *P. cingulata* and *N. violacea* (Weidong et al. 2003), *N. dubia* (Szabó and Amesbury 2011), *E. aurisjudae* (Hamli et al. 2013), *A. granosa* (Soegianto et al. 2020), *P. expansa* (Idris et al. 2020), *B. spirata* and *S. cucullata* (Kumari et al. 2020), *P. viridis* (Soon and Ransangan 2016), *C. aurisfelis* (Oktavia et al. 2023), *P. canaliculata* and *P. maculata* (Suharto et al. 2006; Barbittaa et al. 2020). In addition by Antoni and Febri (2017), mollusks contain many essential amino acids and fatty acids, vitamins B6, B12, choline, and niacin, as well as the minerals calcium, phosphorus, iron, zinc, selenium, and magnesium. These nutrients are useful for preventing anemia, optimizing blood circulation, growth of bone and nerve tissue, formation of various enzymes and hormones, immunity, and strong body capital (Antoni and Febri 2017).

Table 4. The economic potential of mollusk

Species	Utilization		
	Foods	**Accessories**	**Decoration**
Anadara granosa	+	-	+
Babylonia spirata	+	+	+
Cassidula angulifera	+	-	-
Cassidula aurisfelis	+	-	-
Clithon corona	-	-	+
Clithon oualaniensis	+	-	+
Ellobium aurisjudae	+	-	-
Faunus ater	+	-	-
Littoraria scabra	+	-	-
Nassarius margaritiferus	-	-	+
Nerita lineata	+	+	-
Neritina violacea	+	-	-
Neritodryas dubia	+	-	+
Perna viridis	+	-	-
Pilsbryoconcha exilis	-	+	-
Pirenella cingulata	+	+	-
Polymesoda expansa	+	+	+
Pomacea canaliculata	+	+	+
Pomacea maculata	+	+	+
Saccostrea cucullata	+	-	+
Stenomelania plicaria	-	-	-
Telescopium telescopium	+	-	-
Vittina turrita	-	-	+

Note: +: present, -: absent

Figure 7. Several local residents who took *F. ater* and *P. expansa* to be collected as food in this study

Besides being edible, mollusk shells can also be made into handicrafts with economic value. So far, solid waste in the form of shells has been used more as a craft material, such as body accessories such as bracelets, necklaces, brooches that humans can wear, then wall ornaments or interior design materials (Kusnadi et al. 2008). According to Musapana and Amalia (2020), it is possible to make brooches with aesthetic value and an economical selling price as a substitute. Utilization of craft shell waste is one of the benchmarks at every level of production and customer orders. For example, one of the brooches in the gallery gets special attention from foreign tourists. Shell waste has great potential and opportunity to improve the economy of coastal communities. Therefore, making brooches to deal with marine debris and using social capital can be a way to empower communities and create jobs (Abubakar et al. 2021). Some shells that can be potentially used for accessories in this study are *P. cingulata*, *P. expansa*, *P. exilis*, and *N. lineata*, also *B. spirata* by Appukuttan and Ramadoss (2000) and Kumari et al. 2020), then *P. canaliculata* and *P. maculata* (Suharto et al. 2006; Barbittaa et al. 2020) because they are considered to have a unique shell shape. Then, according to Kumari et al. (2020), colorful and large mollusk shells have the potential to be decorative items. So, some shells that can be potentially used for decorations in this study are *P. canaliculata* and *P. maculata* (Suharto et al. 2006; Barbittaa et al. 2020), *C. corona* (Parorrongan et al. 2018), *V. turrita* (Hristov 2020), *B. spirata* (Kumari et al. 2020), then *S. cucullata*, *P. expansa*, *N. margaritiferus*, *N. dubia*, *C. oualaniensis* and *A. granosa* can also enter into potential as decorative items.

There were 23 species of mollusks identified in the Ayah Mangrove Forest. There are 18 Gastropods from 9 families: Pachycillidae, Potamididae, Thiaridae, Ampullaridae, Neritidae, Littorinidae, Ampullariidae, Babyloniidae, and Ellobiidae. On the other hand, there are five species of Bivalvia from five different families: Ostreidae, Mytilidae, Cyrenidae, Arcidae, and Unionidae. With the obtained mollusk density value of 3.49 Ind/m^2. The highest species density value was obtained by the species *S. cucullata*, which was 0.75 Ind/$m^{2,}$ with a total of 749 individuals found. While the lowest species density value was obtained by the species *B. spirata*, *P. exilis*, and *T. telescopium*, namely 0.01 Ind/m^2 with each number of findings of 2 individuals. Then for the species diversity index in Mangrove Forest Ayah in the medium category with a score of 2.22 and the species density index obtained was 0.71 and classified in the relatively even category, for the species dominance index obtained was 0.16 and classified in the low category. Then, the species richness index was obtained at 2.71 and belonged to the low category. The economic potential obtained from the mollusk species in Ayah village, among others, can be used as a food source. Besides being consumed for meat, clam shells can also be used for handicrafts, such as accessories and decorations, becoming high-value products. Eighteen species could be consumed from a total of 23 mollusks: *A. granosa, B. spirata, C. angulifera, C. aurisfelis, C. oualaniensis, E. aurisjudae, F. ater, L. scabra, N. lineata, N, violacea, N. dubia, P. viridis, P. cingulata, P. expansa, P. canaliculata, P. maculata, S. cucullata,* and *T. telescopium.* The seven species of mollusks that can be used as accessories include *B. spirata, N. lineata, P. cingulata*, *P. exilis*, *P. expansa, P. canaliculata,* and *P. maculata*. Meanwhile, the mollusks used as decorations are as many as eleven: *A. granosa, B. spirata, C. corona, C. oualaniensis, N. margaritiferus, N. dubia, P. expansa, P. canaliculata, P. maculata, S. cucullata* and *V. turrita.*

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