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Short Communication: Distribution and diversity of Gastropods in the rice-fish farming system

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Abstract. *Fitriadi R, Palupi M, Azhari RF, Candra RA, Sukardi P. 2023. Short Communication: Distribution and diversity of Gastropods in the rice-fish farming system. Biodiversitas 24: 2006-2012.* The rice-fish farming system is a planting system that combines paddy fields and fish farming. Combining these activities aims to maximize the potential for land use and increase farmers' income. The process of decomposing metabolic waste produced by fish and rice plants requires the help of decomposer organisms such as bacteria or gastropods. Apart from their nature which sometimes becomes a rice pest, gastropods also have an important role in an aquatic environment as detritivores. This study aimed to determine the composition of the gastropods in Panembangan Village and determine the physical factors of the waters in seeking information on the condition of rice-fish farming system rice fields, which were in good or unfavorable condition. The results showed that five species of gastropods were found at the four sampling stations in Panembangan Village, namely *Pomacea canaliculate*, *Melanoides tuberculate*, *Radix rubiginosa*, *Pila ampullacea*, and *Melanoides turricula*. The Gastropod diversity index ranged from 0.75-1.11, uniformity values ranged from 0.68-0.80, and dominance index values ranged from 0.38-0.51. As for the physical and chemical parameters of the waters, the quality of the waters at the four sampling stations still supports the life of organisms.

Keywords: Gastropods, Panembangan Village, rice-fish farming system, water quality

INTRODUCTION

The gastropod is a type of mollusk that generally forms part of the benthic community in some waters (Liu et al. 2019). Gastropods have a fairly high distribution depending on environmental factors; it is proven that they can be found from downstream to upstream, from low-salinity waters to high-salinity waters (Abdou et al. 2015). Therefore, the characteristics that live at the bottom of the waters and their adaptability can be used to find out information about the condition of water in good or polluted status (Islamy and Hasan 2020; Lailiyah et al. 2021; Isroni et al. 2023). This makes gastropods often used as research objects, mainly knowing environmental conditions, one of which is the rice paddy ecosystem (bioindicator) (Abdel 2018).

The rice paddy ecosystem is one of the ecosystems closest to the people of Indonesia. As an agricultural country with a large enough need for rice (Tomiyasu et al. 2017). Many technological innovations and advances have resulted in the use of modern tools, the manufacture of the latest fertilizers, the manufacture of pesticides, and changes to different planting systems to produce more rice. The breakthroughs certainly impacted the rice field ecosystem (Hidayat et al. 2020). Talking about the breakthroughs that have occurred in the rice field ecosystem, it is interesting to see a system that, in recent years, has become a hot topic in several regions, namely the application of the rice-fish farming system (Nurhayati et al. 2016).

The rice-fish farming system is a planting system that combines rice fields and fish farming (Ahmed and Garnet 2011). The fish chosen are common fish that are used in Indonesia, such as tilapia and carp (Hasan and Tama 2019; Serdiati et al. 2021; Wijayanti et al. 2021; Pradana et al. 2022; Robisalmi et al. 2023). Combining these activities aims to maximize the potential for land use and increase farmers' income (Bosma et al. 2012). In Indonesia, the rice-fish farming system has been known for a long time, but in its application, it is still relatively rare; until the last few years, it has started to attract many people (Halwart and Gupta 2004). In addition to increasing farmers' income, the rice-fish farming system, which utilizes fish cultivation, is considered to reduce the cost of pest control and fertilizers used to increase the fertility of rice fields (Rahaman et al. 2018; Bashir et al. 2020).

Panembangan Village, Cilongok, is one of the villages in Banyumas District which implements the rice-fish farming system in their farming activities. The geographical superiority of the village, which is at the foot of Mount Slamet. The rice-fish farming system has been utilized since the early 2000s and has covered up to 25 hectares of village land. The results of this application are proven to improve people's welfare with high rice and fish cultivation yields.

The existence of fish farming in the rice-fish farming on the rice field system in Panembangan Village has proven to be quite effective in advancing the economy and the environment. Fish farming could reduce pesticide and fertilizer usage, which directly impacts increasing income by using fewer pesticides (Shunlong et al. 2018). According to current understanding, fish operate by eating moving biota as feed and excreting excrement, which improves water fertility through decomposition (Zhu et al. 2022).

The process of decomposing metabolic waste produced by fish and rice plants requires the help of decomposer organisms such as bacteria or gastropods (Pardamean et al. 2021; Eriksen et al. 2022). Apart from their nature which sometimes becomes a rice pest, gastropods are also important in an aquatic environment as detritivores. Therefore, this important gastropod is an interesting topic, especially with the rice-fish farming system in Panembangan Village as a bioindicator (Thanomsit et al. 2018). Furthermore, this study aimed to determine the composition of the gastropods in Panembangan Village and the physical water factors in determining the condition of the rice-fish farming system on rice fields, whether in good or unfavorable conditions.

MATERIALS AND METHODS

The research was conducted in June 2022, with four different rice-fish farming system locations (*mina padi*) in Panembangan Village, Cilongok Sub-district, Banyumas District, Central Java Province, Indonesia (Figure 1). This location determined refers to the four different rice-fish farming system groups. Stations 1 and 2 are close to settlements and schools, flow conditions are quite small with a depth of 20 cm, the number of fish is small, and rice ponds are not too wide. Unlike the case with Station 3, the location is also close to the school, has a large water source, and is close to irrigation canals; the depth of the pond reaches 40 cm, and the number of fish is large. On the other hand, at station 4, the field is far from settlements, has a fairly small flow source with a depth of about 40 cm, and the number of fish and ponds is quite large. Data collection included gastropod biota samples and water physical and chemical measurements, each repeated three times at the inlet, middle, and outlet. The following is a research map for the location of Penambangan Village, Cilongok Sub-district, Banyumas District, Central Java Province with four different stations representing each of the *mina padi* groups in the village.

Gastropod samples were collected using a transect tool of 1x1 m^2. First, the gastropod samples were collected by hand-picked method without specific tools, then the specimens were observed in the laboratory for species identification. Next, the identification data obtained was calculated for the diversity index (H'), uniformity index (E), and dominance index (C) using the following formula (Odum 1971) (Tables 1, 2, 3). The results of the calculation of gastropod composition are used to determine diversity, uniformity, and dominance, which illustrates the stability of an ecosystem.

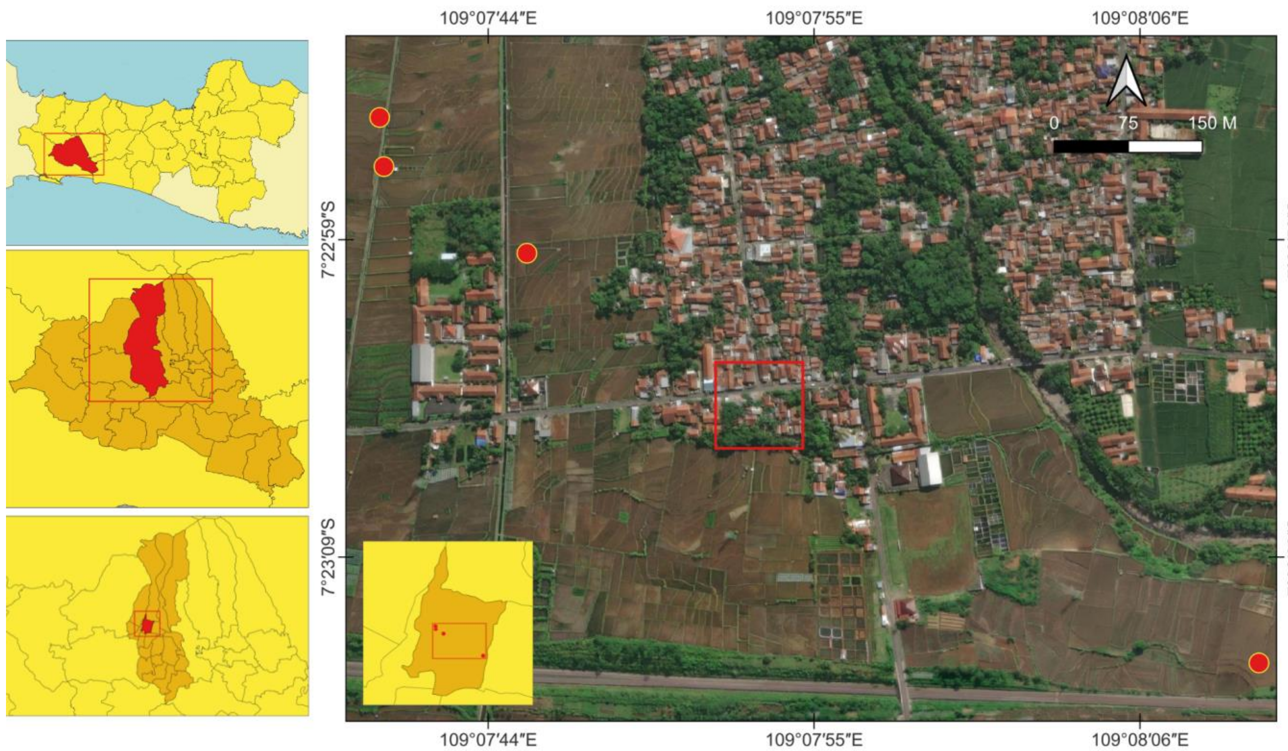

Figure 1. Map of research location in Panembangan Village, Cilongok Sub-district, Banyumas District, Central Java Province, Indonesia

$$H' = -\sum_{i=1}^{s} 0\, Pi\ ln\ Pi$$

Where, H': Shannon-Wiener diversity index; Pi: The number of individuals of each species (Pi = $\frac{ni}{N}$); ni: The number of individuals in the i-th species; N: The total number of individuals in a community.

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

6Where, E: Uniformity index; H': Shannon-Wiener diversity index; S: The number of types of genera or species.

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

Where, C: Dominance Index; ni: The number of individuals in the i-th species; n: The total number of individuals.

Water quality measurements can be conducted directly at the research location without laboratory analysis, using a water quality checker to read several parameters directly, such as temperature, salinity, DO, pH, and Total Dissolved Solids (TDS) (Figure 4).

Table 1. Diversity index value (Odum (1971)

Uniformity value	Category
H' < 1	Low diversity
1 < H' < 3	Medium diversity
H' > 3	High diversity

Table 2. Uniformity index value (Odum (1971)

Uniformity value	Category
0.00 < E < 0.50	Low uniformity
0.50 < E < 0.75	Moderate uniformity
0.75 < E < 1.00	High uniformity

Table 3. Dominance index value (Odum (1971)

Uniformity value	Category
0.00 < C < 0.50	Low dominance
0.50 < C < 0.75	Moderate dominance
0.75 < C < 1.00	High dominance

Table 4. Water quality measurement parameters

Parameter	Unit
Temperature	°C
Salinity	ppt
pH	-
DO	mg/L
TDS	mg/L

RESULTS AND DISCUSSION

Water quality

Based on research on the physical and chemical quality of the waters conducted in Penambengan Village, the values are presented as follows (Table 5).

Based on Government Regulation No. 22 of 2021 for class III water quality standards, the water quality in the four locations meets the standard quality values. Class III is water that can be used for freshwater, fish cultivation, animal husbandry, water for irrigating plants, and/or other uses that require the same common water quality. The results above show that Total Dissolved Solids (TDS) in stations 1, 2, and 3 are higher than in station 4, which is above 50 mg/L. This can be caused by the location of the three stations, which are close to residential areas compared to station 4. An increase in TDS causes a decrease in DO content, which is agreed by research data results where station 2 has the highest TDS value (53.8 mg/L), but the lowest DO value (3.4 mg/L). Temperature measurements obtained at the four rice-fish farming system stations were very uniform. They did not differ much (ranging from 27-28°C) because the vegetation acting as a canopy is less dense; those are included in warm waters.

Furthermore, the pH values obtained at each station are not much different, ranging from 7.0-7.2, included in neutral. Regarding the average salinity value, there was not much difference between the four observation stations, which ranged from 0.03-0.04 ppt, included in the low salt content category and is suitable for fresh waters. The same measurement can be observed in the Total Dissolved Solid (TDS) value obtained, where the amount of dissolved substance is uniform and ranges from 48.9-53.8 mg/L, which is quite high for water. Unlike the case with the oxygen levels obtained, some differences occur, namely values ranging from 3.4-7.7 mg/L, with the lowest value at station 2 and the highest at station 1.

Gastropod composition

Gastropod observations taken at four different rice-fish farming system locations at Panembangan Village obtained a composition of 5 species; the results are presented in Table 6. Generally, each data collection station has a similar arrangement, consisting of three to four different types of gastropods. The fundamental difference between each station is the total number of individuals of all species obtained. The station with the highest number of gastropods is located at station 1, with 250 individuals of total species. Then, at stations 2 and 4, 77 individual gastropod species were obtained. Station 3 had the lowest number of individual species, with only around 73 individuals.

Table 5. Water quality

Parameter	Stations			
	1	2	3	4
Temperature (°C)	27	28	28	28
pH	7.2	7.1	7.2	7.0
Salinity (ppt)	0.04	0.04	0.04	0.03
TDS (mg/L)	50.8	53.8	50.6	48.9
DO (mg/L)	7.7	3.4	6.6	7.0

Table 6. Gastropod identification results and density

Species	Specimens found (individual)				Total	Density (ind/m^2)			
	1	2	3	4		1	2	3	4
Pomacea canaliculata	69	38	10	30	147	23.0	12.7	3.3	10.0
Melanoides tuberculata	18	1	17	1	37	6.0	0.3	5.7	0.3
Radix rubiginosa	163	38	40	35	276	54.3	12.7	13.3	11.7
Pila ampullacea	0	0	0	11	11	0.0	0.0	0.0	3.7
Melanoides turricula	0	0	6	0	6	0.0	0.0	2.0	0.0
Total	250	77	73	77	477	83	26	24	26

Figure 2. Species obtained in Panembangan Village, Banyumas District, Indonesia: A. *Pomacea canaliculata;* B. *Melanoides tuberculata;* C. *Radix rubiginosa;* D. *Melanoides turricula;* E. *Pila ampullacea*

Table 7. Diversity index (H'), Uniformity index (E), and Dominance index (C) values

Station	H'	Category	E	Category	C	Category
1	0.82	Low	0.74	Moderate	0.51	Moderate
2	0.75	Low	0.68	Moderate	0.75	High
3	1.11	Moderate	0.80	High	0.34	Low
4	1.06	Moderate	0.76	High	0.38	Low

Calculating individual density values per area obtained the highest density value at station 1 of 83 ind/m^2. Meanwhile, stations 2 and 4 have the same value of 26 ind/m^2; and station 3 only has a density value of 24 ind/m^2. The composition of gastropod species obtained at each station was *P. canaliculata, M. tuberculata, R. rubiginosa, P. ampullacea,* and *M. turricula*. The highest number of specimens was found in *R. rubiginosa,* with 276 individuals, followed by *P. canaliculata,* commonly known as rice field snail or golden snail, with 147 individuals. Then, followed by *M. tuberculata* with 37 individuals, *Pila ampullacea* with 11 individuals, and the lowest number, namely the *M. turricula,* with 6 individuals. The calculation results of the individual density values per area obtained the highest density value at station 1 at 83 ind/m^2. Meanwhile, stations 2 and 4 have the same value of 26 ind/m^2, and station 3 has only a density value of 24 ind/m^2.

Radix rubiginosa species had the highest density at all stations, ranging from 11.7-54.3 ind/m^2, followed by *P. canaliculata* species between 3.3-23 ind/m^2. The *M. tuberculata* species occupies the third position with an individual density of 0.3-6.0 ind/m^2. Furthermore, the next density was *P. ampullacea,* with densities ranging from 0.0 to 3.7 ind/m^2. In addition, *M. turricula* was the least common species, as evidenced by a very low density from 0.0-2.0 ind/m^2. The results of the documentation for each species are shown in Figure 2. The value of the index is shown in Table 7.

The results of calculations from the four stations obtained Diversity Index values ranging from 0.75-1.11. The value at station 3 was 1.11, and station 4 was 1.06, with the moderate category. In contrast, station 1 has a value of 0.82, and station 2 has a value of 0.75, which puts it in the low category. Therefore, Gastropod diversity index values obtained at each rice-fish farming system station do not differ or tend to be almost similar, meaning no significant difference dominates except at station 2. Based on the uniformity value calculation results for each station, it was determined that the uniformity value ranged from 0.68-0.80, with station 2 having a moderate value of 0.68. While station 3 also has a moderate value of 0.80, which is fairly high. These results follow the calculation of the dominance value obtained at each station. The highest value obtained was obtained at station 2 with a value of 0.75 which is in the high dominance category due to the abundance of *Radix rubiginosa* species. Therefore, the diversity, uniformity, and dominance index values result not differ much, and the rice-fish farming system waters of Panembangan Village could be quite stable.

Discussion

Based on research at four rice-fish farming system locations, five species of gastropods were found: *P. canaliculata, M. tuberculata, R. rubiginosa, P. ampullacea,* and *M. turricula*. These five species are easy to find because they can adapt and survive in rice field freshwaters, including rice-fish farming system ponds (Paller et al. 2019; Purnama et al. 2022). According to the observation result, station 1 had the highest number of gastropods reaching 250. This is presumably because the area at station 1 is considered the most extensively used, has calmer water conditions, and is far from settlements. The water conditions at station 1 are calmer than the other station mostly because of its location far from the irrigation canal, which causes a weaker water flow and does not cause much movement in the water surface. The larger area size and calm water conditions allow gastropods to reproduce and survive more due to reduced competition and better growth conditions (Suartini and Sudatri 2022). In addition, being far from settlements makes station 1 more protected and safer for gastropods inhabitants (Fusco et al. 2021) in contrast to station 3, which had a much smaller number of gastropods than the others. This can be caused by its location in the input of irrigation canals, which makes the water quite hard, making it impossible for gastropods to grow and develop (Yu et al. 2019). Besides, this location also has lower DO levels (6.6 mg/L) compared to station 1, which has the highest DO levels (7.7 mg/L); the lower the DO level, the fewer organisms will be found because DO plays an important role in the organisms respiration (Abdullah et al. 2021).

This study showed that *Radix rubiginosa* was the most common species. The total number of species of *R. rubiginosa* in all stations reached 273 individuals. The speed at which *R. rubiginosa* reproduces and adapts is considered to be the reason this species is often found (Bunchom et al. 2020). Moreover, their small size makes this species less attractive to the public for consumption, in contrast to the gastropod species *P. canaliculata,* which has a larger size. *P. canaliculata* is a type of gastropod commonly collected by the public. Apart from being considered a pest, *P. canaliculata* has quite good nutritional content, which humans can consume or use as food for livestock such as ducks (Ghosh et al. 2022; Li et al. 2022). That is thought to cause the total number of *P. canaliculata* found less than the *R. rubiginosa*.

The collected and processed species data resulted in a moderate diversity index obtained at stations 3 and 4 and a low diversity index at stations 1 and 2. The high or low value of diversity is determined based on the type of species found; this is evident at stations 3 and 4, species found are more varied compared to stations 1 and 2, namely four species. In addition, unlike the case with stations 1 and 2, which have low diversity because only three species were found. Furthermore, at each station, the distribution is quite even, and no conditions suppress naturally, so it is reasonable to conclude that natural conditions are still well maintained (Salwiyah et al. 2022). These results are supported by the uniformity values that are not much different. A high uniformity value indicates that no single species dominate and the composition is quite even (Melati et al. 2021). However, there is an anomaly at station 3, which has a high dominance value. That indicates some species cannot adapt well and only species with good abilities can survive, namely *P. canaliculata* and *R. rubiginosa* (Bunchom et al. 2020).

Environmental factors, including gastropods, are important factors that function as limiting factors for an organism. As benthic organisms can not move too fast, environmental changes greatly affect the life of gastropods (Neubauer and Georgopoulou 2021). The results of field measurements obtained environmental factors in the form of a fairly stable temperature, which ranges from 27-28ºC. Each station has a stable temperature due to the absence of significant differences between its characteristics. Furthermore, due to the location at the foot of Mount Slamet and the time of data collection, the temperature is quite uniform (dry season), resulting in optimal irradiation (Ansari et al. 2021). Stable conditions are also thought to cause the gastropod distribution in the rice-fish farming system study site to be uniform and not much different. Following opinion of Okumura and Rocha (2020) stated that the optimal temperature suitable for the growth of gastropods in rice fields is around 24-32ºC.

Furthermore, measurements of other environmental factors, such as pH, showed uniform results. The pH obtained in this study ranged from 7.0-7.2, which will indirectly affect the life of the biota, especially gastropods. A pH that is too low will be acidic and become corrosive; a pH that is too high will be toxic and cause death in gastropods (Wang et al. 2020). According to Fatmawati et al (2020), the optimal acidity for freshwater biota, including gastropods, is around 7-8.0. These results indicate that the rice-fish farming system study site has an optimal habitat for the growth of gastropods, as evidenced by the many species found, such as *R. rubiginosa* and *P. canaliculata*. In addition to pH, salinity is also a critical factor in the water being measured in this study. Salinity is a limiting factor because salinity is directly related to metabolism and water oxygen levels (Mo et al. 2021). Generally, the optimal salinity value for gastropods in fresh waters is 0-1 ppt (Jankowski et al. 2020). Salinity values obtained in this study ranged from 0.03-0.04, which is optimal for freshwaters. Salinity that is too high can cause freshwater biota, such as gastropods, to get hyperosmotic, which causes death (Fadliyah et al. 2021). On the other hand, the water's high salinity means that the dissolved oxygen levels in the water will be lower (Hintz and Relyea 2019).

Dissolved oxygen is another factor that also plays a vital role in the life of aquatic biota because it has a biological growth function in water (Putri et al. 2019; Lukmantoro and Rahardja 2020). Many factors, such as temperature and salinity, influence high or low water oxygen levels (Mo et al. 2021); the higher the two factors, the lower the oxygen level in the water (Galang et al. 2019). The data collection results showed that the oxygen levels ranged from 3.4-7.7 mg/L. Generally, gastropod biota can live where minimum oxygen is above 4 mg/L (Tahir et al. 2021), which means that in this study site, the values obtained are sufficient to support the survival of gastropods. The last physical water factor measurement is the Total Dissolved Solid (TDS) value, one of the indirectly important factors for the survival of gastropods. Based on the measurements, the TDS value in Penambangan Village ranged from 48.9-53.8 mg/L, which is quite high. This high value is closely related to the condition of the study site in rice fields with substrate conditions in the form of mud (Binta et al. 2019). Mud substrate tends to produce high TDS values if supported by a sufficiently strong water input (Nurdin et al. 2020). This is a good influence on the growth of gastropods because some gastropods tend to like living in mud substrates such as *R. rubiginosa* and *P. canaliculata* (Ng et al. 2020)

In conclusion according to the research, five gastropod species were found at the four sampling sites. This species are *P. canaliculata, M. tuberculata, R. rubiginosa, P. ampullacea*, and *M. turricula*. At the same time, the gastropod diversity index data shows that the gastropod diversity level in the rice-fish farming system area of Panembangan Village is in the low to moderate category, with a diversity index value from 0.75-1.11. Furthermore, Gastropod uniformity index values range from 0.68-0.80, categorized as medium to high. And the gastropod dominance index value ranged from 0.34-0.75 in the low to high category. The water quality at the four sampling stations is still at the standard quality and is ideal for the life of organisms. Furthermore, the high TDS values at the four stations ranged from 48.9-53.8 mg/L, categorized as high; the study site condition in the rice fields with mud substrates can cause this.

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