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Composition and Diversity of Freshwater Fish in the Upstream of The Bedadung River, Jember District

Rendy Setiawan[1]*, Retno Wimbaningrum[1], Hari Sulistiyowati[1], Arif Mohammad Siddiq[1], Muhammad Agung Setiabudi[1]
[1]Laboratory Ecology, Department Biology, Faculty of Mathematics and Sciences, University of Jember
* Corresponding Author: rendy.fmipa@unej.ac.id

Abstract

The river is an irrational body of water from upstream to downstream. The upstream part of the river generally has a narrow width of the river flow, heavy air currents, the right and left banks of the river have vegetation trees, sandy rocky substrate types, and are located in the highlands or mountains. This character is also found in the Upper Bedadung River in the Argopuro Mountains. Characteristics in the upper reaches of the river are thought to affect the existence of creatures that live in it, such as fish. The purpose of this study was to determine the composition and diversity of freshwater fish in the upper reaches of the Bedadung River, Jember Regency. The research method used was the roaming method. The exploration was carried out at four research stations. The results showed that in the upper Bedadung River, five species of fish were found including *Channa gachua*, *Poecilia reticulata*, *Barbodes binotatus*, *Glyptothorax platypogon*, and *Nemacheilus fasciatus*. The diversity of freshwater fish species in the upper reaches of the Bedadung River is moderate.

Keywords: Bedadung River, Diversity, Freshwater Fish

Introduction

A river is a natural or artificial stream of water that flows from a high place to a lower place and then empties into a lake, sea or river bounded by a borderline on the right and left (Wetzel, 2001; PP RI No. 38, 2011). According to Vannote *et al.* (1980), a river is a continuous body of water from upstream to downstream. The upstream part of the river generally has a narrow stream width, and swift water flow, the right and left banks of the river have tree vegetation, are dominated by rocky and sandy substrate types, and are located in the highlands or mountains. This character is also found in the upper Bedadung River in the Argopuro Mountains. Characteristics in the upper reaches of the river can affect the existence of organisms that live in it such as fish.

Fish are cold-blooded (poikilothermic) animals that have gills and fins and depend on water as their habitat medium (Schultz's, 2003). Most fish require clear, pollution-free waters and no disturbance for the spawning process (Djumanto and Probosunu, 2011). The role of fish in the food chain is as first-level consumers or as herbivores and also as second-level consumers, namely zooplankton, aquatic insects and fish (Zahid *et al*., 2015; Andriani *et al*., 2017). Fish can also be used as a bio-indicator of aquatic environmental status, due to fish being sensitive or tolerant of changes in environmental conditions (Kottelat *et al*. 1993; Alkassabeh *et al*. 2009). In addition, several types of freshwater fish have high economic value, such as being used by the public for sale because they can be consumed, such as Genus *Barbodes*, *Tilapia*, and *Clarias* (Pratiwi *et al*, 2017). The high selling value of fish encourages people to catch fish directly along the upstream of the Bedadung River.

Fishing activity by the community that is not environmentally friendly is one of the factors that influence the presence of fish in the river. Communities in the upper reaches of the Bedadung River mostly catch fish using potash and electric shocks. These activities can reduce fish populations. Apart from fish, other organisms that are also affected will have the same impact and even die. This activity is thought to cause a decrease in the diversity of fish species in the Upper Bedadung River because the number of species and their abundance has decreased. In addition, Sullivan *et al.* (2006) and Duya (2008) state that many factors influence the presence of fish in rivers including biological factors, chemical factors, geographical factors, and physical factors of rivers such as temperature, DO, pH, water turbidity, river depth, water discharge, width watershed, river regularity, river substrate, topography (elevation), and river gradient.

However, until now there is no information about the diversity of fish species in the upper Bedadung River. Most research on fish is carried out in the watershed and estuary area of the river. Based on the important role of fish and the existence of factors that influence the existence of fish in the Upper Bedadung River, it is necessary to research the diversity of freshwater fish species in the Upper Bedadung River area.

Materials and Methods

Time and Place of Research

The research was conducted in July 2020 – January 2021. The research location was in the upper reaches of the Bedadung River which is in Pakel Hamlet, Sucopangepok Village, Jelbuk District, Jember Regency (Figure 1). Identification and description of fish species and data analysis were carried out at the FMIPA Ecology Laboratory, University of Jember.

Figure 1 Sampling Location at Upstream Bedadung River in the Sucopangepok Village, Jelbuk District, Jember

Research Methodology

Fish sampling and abiotic parameter measurements were carried out at four research stations. The first research station is a body of water approximately 100 m long which receives water directly from the Watu Lorek waterfall whose position is the highest, at 1048 meters above sea level. The second research station was located under the first station which is at an altitude of 877 meters above sea level. The third research station is under the second station which is at an altitude of 581 meters above sea level. Station the fourth study is under the third station which is at an altitude of 415 meters above sea level. The position coordinates of each station are determined by using a GPS Garmin 64s.

The Fish sampling at four stations in the upper Bedadung River was carried out using fishing gear in the form of rattan traps and fishing nets. The rattan traps used are 40 cm and 80 cm in diameter and height, respectively. The fishing net used has a frame size of 50x30 cm2 and a mesh area of 0.15 mm2. At each station, one rattan trap is placed. Rattan traps are placed in the part of the river which is estimated to have fish at each station. Before being installed, rice or bread bait is first placed in each rattan trap so that fish are attracted to enter it. This trap is then sunk into the river water. The trap is enclosed in a piece of wood that is stuck into the bottom of the river, then tied with a rope in a circle so that the rattan traps are not carried away by the water currents. The rattan trap installation time is approximately 24 hours. After installing the rattan traps, fish sampling is continued using a fishing net.

Fish sampling using a fishing net scoop is carried out by exploring the river and during the exploration, the presence of fish is observed. During river exploration, if it is known that there are fish, they will be caught with fishing nets. In addition to exploring by observing the presence of

fish, stones were also removed which were suspected to be the spaces between the stones being hiding places for fish. This pattern is carried out at all stations. Fish specimens caught by scooped fishing nets were then grouped based on their morphological similarities. This activity aims to separate one type of fish from another.

The number of individuals in each group (each species) was counted to obtain abundance data. Furthermore, individual fish representing each type were documented using the handphone camera. After that, several samples of the smallest, medium, and largest fish of each type were found in large quantities. The fish sample was then put into a plastic bag containing 70% alcohol and labelled with location data and sample specifications to be identified at the FMIPA Ecology Laboratory, University of Jember. Fish samples that were caught and not brought to the laboratory were released back to preserve the fish in the upper Bedadung River.

The rattan traps that have been placed for approximately 24 hours are then examined for their contents. If there are fish, the fish are removed from the traps and grouped based on their morphological similarity. The number of individuals in each fish group was counted. Data and fish specimens obtained through rattan trap are then combined with the results of fishing using a fishing net.

The abiotic factors measured were DO (dissolved oxygen), pH water, river water depth, river flow velocity, river water turbidity, river water temperature, and river discharge. The water discharge is obtained from the calculation of the multiplication between the channel cross-sectional area (m2) and the speed of the water flow (m/s). The cross-sectional area of the channel is obtained from the calculation of multiplying the width of the river by the depth of the river.

Data Analysis

The collected fish were brought to the FMIPA Ecology Laboratory, University of Jember to describe their morphological characteristics. Morphological recording starts from the head, body and tail. The fish whose morphological characteristics had been recorded were then identified by comparing their morphological characteristics with the identification key referred to by Kottelat *et al*. (1993). One type of fish could not be identified and then verified at the Ichthyology Laboratory, LIPI Biology Research Center, Cibinong, Bogor Regency. Data on species richness and individual abundance that have been collected are then used to determine the value of the species dominance index and the Shannon-Wiener (H') species diversity index using Primer 5 software.

The dominance of the fish community in the upper Bedadung River is determined based on the value of the dominance index (C). The C value is determined based on data on the number of individuals of each type and the number of individuals of all types of fish. Determination of the value of C using the formula below.

$$C = \Sigma (ni/N)^2$$

Note: ni = Number of individuals of each species
N = Number of individuals of all species

Dominance index values range from 0-1. For dominance index value close to one means that the community is dominated by one species (there is only one species at each station), if the index value is close to zero then no species dominates the community (Magurran, 1988).

The status of fish species diversity was determined based on the Shannon-Wiener species diversity index (H'). The H' index value is determined based on data on the number of species, the number of individuals of each type, and the number of individuals of all fish species. Calculation of the value of H' using the formula below.

$$H' = -\Sigma \, pi \ln pi$$

Note: H' = Species diversity index
pi = ni/N
ni = Number of types of type i
N = The total number of species

According to Magurran (1988), the value of the Shannon-Wiener species diversity index is defined as follows:

If H' < 1 then the species diversity is low
If H' = 1-3 then the species diversity is moderate
If H' > 3 then the diversity is high

Parameter data of temperature, pH, DO, water turbidity, current velocity, river depth, river width, and water discharge measured directly at all research stations are tabulated. The data for each parameter is determined by its range value, namely the lowest and highest values and the average value. The range and average values for each environmental parameter describe the water conditions of the upper Bedadung River at the time of the study.

Results and Discussion

Composition of Fish Species in the Upper Bedadung River

The results showed that in the upper Bedadung River five species of fish were found. The five species of fish include *Channa gachua*, *Poecilia reticulata*, *Barbodes binotatus*, *Glyptothorax platypogon*, and *Nemacheilus fasciatus* which are members of five different families (Table 1).

Five species of fish found living in the upper reaches of the Bedadung River are also found living in several other upstream rivers in Indonesia. The species *C. gachua*, *P. reticulata*, *B. binotatus* and *G. platypogon* in the upper Cikaniki River of Mount Halimun National Park were found living together with five other fish species (Ridho et al., 2003). The types of *P. reticulata*, *B. binotatus* and *N. fasciatus* in the upper Opak River were found living together with nine other fish species (Djumanto and Probosunu, 2011). *G. platypogon* species in the upper Cimanuk River were found living together with 13 other fish species (Yuanda et al., 2012). This shows that the composition of fish species in the upper reaches of the Bedadung River is different from the composition of fish in other upstream rivers. The difference in fish composition is probably caused by environmental factors that differ from one upstream to another. According to Duya (2008), abiotic environmental factors can affect the composition and species richness of fish in rivers.

Table 1 Composition of fish species in the upper Bedadung River, Jember Regency

Family	Genus	Species	Local Name	Individual Total
Channidae	*Channa*	*C. gachua*	Gabus	74
Poeciliidae	*Poecilia*	*P. reticulata*	Cethul	53
Cyprinidae	*Barbodes*	*B. binotatus*	Wader Bintik dua	12
Sisoridae	*Glyptothorax*	*G. platypogon*	Kehkel	6
Balitoridae	*Nemacheilus*	*N. fasciatus*	Uceng	4
Total number of individuals				149

The existence of five species of fish in the upper reaches of the Bedadung River is supported by relatively high levels of dissolved oxygen (DO), a pH that supports the presence of fish and low turbidity of river water. Dissolved oxygen levels ranged from 7.03-8.29 mg/L (Table 2). The DO level is within a range that is still able to support fish life. According to Muhtadi et al. (2017), DO levels of more than 6 mg/L are suitable water conditions to support fish survival. The degree of water acidity (pH) shows an average value that supports the presence of fish in the river (7.99) (Table 2). According to PP RI No. 82 of 2001 concerning the Management of Water Quality and Control of Water Pollution, the pH range of fresh water suitable for fish farming is 6 - 9. The water upstream of Bedadung River is classified as clear as indicated by the average water turbidity value of 11.9 NTU. The headwaters of this river are at an altitude of 1048 masl - 406 masl, where the body of the river crosses forests, coffee plantations, rice fields and low-density settlements. Conditions around the river support the river water is not cloudy.

The five types of fish have varied morphological characteristics. Morphological variation is one of the basics in determining its classification. Each type of fish was also found to occupy a certain microhabitat. The morphological and microhabitat characteristics of each fish species in the upper Bedadung River are as follows.

1. *Channa gachua*

Channa gachua has a body with a total length of 5 - 15 cm, cylindrical in shape, and a slightly greyish black ventrally. On the head there is a mouth with a sub-terminal type; no antennae; and slightly protruding eyes. On the body there is a dorsal fin with a yellowish-red tip with a base length of ± 7.5 cm; a pair of round pectoral fins, brownish colour and base length of ± 1 cm; a pair of pelvic fins ± 0.6 cm long at the base which is located just below the pectoral fins; anal fin brownish with red-yellow colour at the tip has a base length of ± 5 cm. This fish has stenoid scales. The caudal fin has a rounded shape with a slightly brownish colour and along the tip a yellowish-red colour with a length of 2.5 cm (Figure 2).

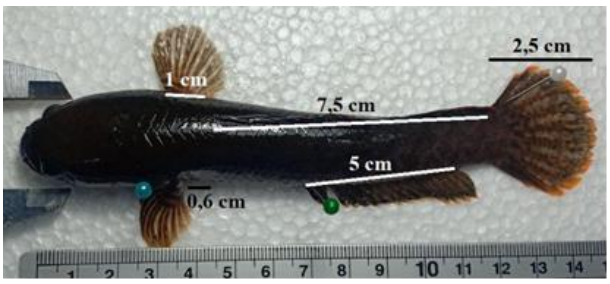

Figure 2 Morphology of *Channa gachua*

Based on research in the Upper Bedadung River, *C. gachua* is often found on rocky bottoms of fast-flowing rivers with water depths ranging from 0.20 m – 0.41 m. The water temperature in the Upper Bedadung river ranges from 18.78 C – 26.17 C. This is in accordance with Kordi's statement (2011), snakehead fish live well in conditions of water temperature > 24 C, while in the temperature range < 24 C snakehead fish are still able to tolerate it to survive. Within the community, this type of fish acts as a predator that preys on small fish or insects and also as a detritivore that eats detritus. According to Bolaji *et al.* (2011), the diet of these fish generally consists of small fish, tadpoles, shrimp, land insects and insect larvae. Lim and Ng (1990) explained that this species is found living scattered from Africa to Asia. In Asia this species of fish is found living scattered in Afghanistan, western Pakistan, southern Nepal, India, Bangladesh, Sri Lanka, Myanmar, China, Japan, Taiwan, Philippines, Malaysia, Singapore and western Indonesia.

2. *Poecilia reticulata*

Poecilia reticulata is small in stature with a total length ranging from 2 - 3 cm, torpedo shape (fusiform), and golden white. On the head, there is a mouth with a superior type, a pair of antennae, and small round black eyes. On the body there is a dorsal fin with a base length of 0.1 cm; a pair of pectoral fins 0.15 cm base length; a pair of pelvic fins base length of 0.1 cm; and an anal fin with a base length of 0.1 cm; with the pelvic fins adjacent to the pectoral fins. The hallmark of this fish is a bulging belly and cycloid type of scales. The tail fin of this fish is 0.5 cm long with a slightly rounded shape (Figure 3).

Figure 3 Morphology of *Poecilia reticulate*

In the upper reaches of the Bedadung River, *P. reticulata* is often found active on the surface of the water near the banks of rivers with moderate water currents. This fish is only found in river bodies with an average water temperature of 22.86 C (Table 2). This fish food was generally plankton, small insects, to mosquito larvae (Wirjoatmodjo, 1993; Rahayu *et al*., 2018). This fish is spread almost all over the world from Africa, China, Turkey, France, Mexico, England, Spain, Portugal, Holland, Denmark, Poland, Russia, Albania, Japan, Vietnam, Malaysia and Indonesia (Tamaru *et al*., 2001).

3. *Barbodes binotatus*

Barbodes binotatus has a silver color with slightly brownish dorsal parts and a flattened body shape with a total length ranging from 7 - 9 cm. On the head, there are black eyes with yellowish-white edges, two pairs of antennae, and a protactile-type mouth. The body has a hard dorsal fin with a base length of 1.3 cm; pectoral, pelvic and anal fins with base lengths of 0.8 cm, 1 cm and 1 cm respectively. The pelvic fins are located close to the pectoral fins. Cycloid-type scales. The tail is shaped like a crescent moon and is 1.6 cm long. The distinctive feature of this species is that it has two black spots, one located below the dorsal fin and one in front of the caudal fin (Figure 4).

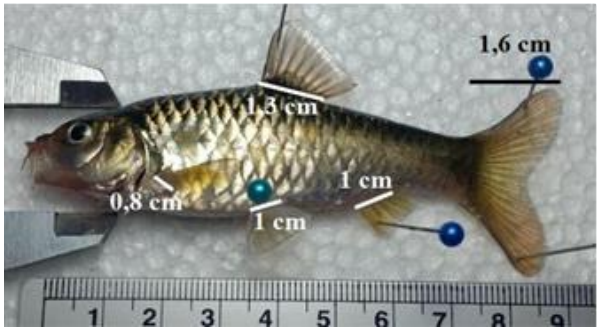

Figure 4 Morphology of *Barbodes binotatus*

Barbodes binotatus are found in river bodies with riparian vegetation. The existence of aquatic plants on the banks of the river makes it easier for *B. binotatus* fish to find food so that these fish and support these fish to reproduce properly. This is in accordance with the statement of Simanjuntak (2012), that *B. binotatus* fish prefer habitats with riparian vegetation for spawning and foraging processes. This fish is found swimming on the surface to the bottom of the river in river bodies where the water temperature ranges from 25.13 C – 26.17 C. The two-spotted wader fish is an omnivore

that eats plankton, insect larvae, and bits of green plants (Roberts, 1989; Raharjo *et al*., 2011). This fish is a type of fish native to Southeast Asia and is widespread in Laos, Vietnam, Cambodia, Myanmar, the Philippines, Thailand and Indonesia (Jenkins *et al*., 2015; Jusmaldi and Nova, 2018).

4. *Glytothorax platypogon*

Glyptothorax platypogon has a total body length ranging from 4 - 6 cm, body shape is flat or flattened down, black on the dorsal side and yellowish white on the ventral side. On the head there are four pairs of antennae; have a mouth type with an inferior type; and small black eyes. This fish has fins that are all black with yellow edges. On the dorsal side, there are dorsal fins and fat fins with base lengths of 0.5 cm and 0.4 cm respectively; a pair of pectoral fins with base length of 0.7 cm; a pair of pelvic fins with base length of 0.5 cm; and a pair of anal fins 0.6 cm long. The pelvic fins are located slightly back from the pectoral fins. This fish has no scales. In addition, there is an adhesive formed from smooth skin folds that extend across the chest and are located between the pectoral fins. The caudal fin is 1 cm long with a crescent shape (Figure 5).

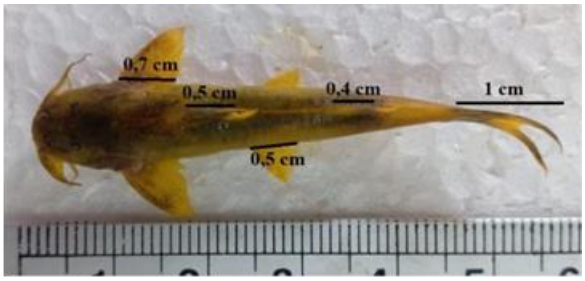

Figure 5 Morphology of *Glyptothorax platypogon*

Glyptothorax platypogon was commonly found in river bodies where the basic substrate is sandstone or gravel with moderate water flow velocity. The temperature range of the water upstream of the Bedadung River, namely 18.78 C – 26.17 C (Table 2) is a temperature condition that can be tolerated by this type of fish. Pratimi et al. (2018) stated that a good temperature for the life of *G. platypogon* ranges from 24 C – 30 C. This fish is spread in Malaysia and parts of Indonesia such as Sumatra, Kalimantan and Java (Banarescu, 1990).

5. *Nemacheilus fasciatus*

Nemacheilus fasciatus has a total body length ranging from 4 cm - 6 cm with a cylindrical and elongated body that is yellowish white. On the head, there are two pairs of antennae; a mouth position with an inferior type; and protruding black eyeballs. On the body, there are 15-16 black spots along the dorsal line and alternate with 11-12 saddle-shaped along the lateral line. On the dorsal side, there is a dorsal fin with a base length of 0.4 cm; a pair of pectoral fins, pelvic fins and anal fins with base lengths of 0.2 cm, 0.2 cm and 0.3 cm respectively. The pelvic fins are located slightly back from the pectoral fins. The caudal fin has a forked shape on each side and has scales that are not sharp with a length of 1.1 cm (Figure 6).

Figure 6 Morphology of *Nemacheilus fasciatus*

Nemacheilus fasciatus is often found swimming between rocks and pebbles at the bottom of the waters. This fish is found at an average water temperature of 26.17 C. According to Prakoso et al. (2016), *N. fasciatus* can adapt well to temperatures ranging from 26.3 C - 27.2 C. This temperature corresponds to the temperature range of the Upper Bedadung River. This fish is spread throughout Asia, especially Indonesia in Sumatra and Java (Fishbase, 2019), and Kalimantan (Kottelat *et al*., 1993).

The Dominance of Fish Species in the Upper Bedadung River

Based on the dominance index value of 0.382 which is low, the five species of fish found living in the Upper Bedadung River are not dominant. Thus the characteristics of freshwater fish communities in the upper reaches of this river are jointly determined by the five species of fish found. The five types of freshwater fish are ecologically successful in determining the conditions needed for their growth. This means that each type of freshwater fish consumes the same amount of feed and occupies the same volume of space for reproduction, shelter and shelter so that each species has the same effect on the freshwater fish community in the upper reaches of the river.

However, this type of snakehead fish (*Channa gachua*) has the potential to become the dominant population in the future because at this time its abundance is the highest (Table 1). If the breeding rate of this population is faster than the other four fish populations, then the abundance will also

experience a significant increase. If this population becomes dominant then the freshwater fish community in the upper reaches of the river will be controlled by the snakehead fish population.

Diversity of Freshwater Fish in the Upper Bedadung River

The Shannon-Wiener (H') species diversity index value of fish in the Upper S. Bedadung was 1.145. This value indicates that the diversity of fish species in the upper reaches of this river is moderate. The status of fish species diversity in the Upper Bedadung River is moderate due to the low number of species or species richness but no dominant species.

In the Upper Bedadung River, only five species of freshwater fish were found (Table 1). When compared to the headwaters of other rivers in Java Island, the species richness of fish in the Upper Bedadung river is relatively low. Nine species of fish were found in the upper reaches of Cikaniki river Gunung Halimun National Park (Ridho *et al*., 2003), 11 species of fish were found in the upper reaches of Opak river (Djumanto and Probosunu, 2011) and 14 species of fish in the upper reaches of the Cimanuk River (Yuanda *et al*., 2012). The low species in upper Bedadung River is caused by abiotic environmental factors and human activities. Abiotic factors that influence the presence of freshwater fish species in rivers are water temperature, river depth, water discharge and dissolved oxygen (DO) (Gustav, 1998; Effendi, 2003).

The water temperature of the Upper Bedadung River ranged from 18.79 C – 26.17 C. This varying temperature caused fish not to be found in all research stations. Fish were not found at station 1 where the average water temperature was 18.79 C. Freshwater fish generally can tolerate water temperatures ≥ 20 C. Nurudin (2013) states that fish are generally able to grow and develop well at temperatures between 20 C - 30 C. At temperatures below 20 C fish metabolism is disrupted, tissues in the fish's body are damaged, fish experience stress and even eventually cause death. Kordi (2000) stated that a temperature change of 5℃ from the temperature that can be tolerated by fish can cause pressure, tissue damage and fish death. Not finding fish at station 1 causes the space occupied by fish to become narrow, namely only three stations (stations 2, 3 and 4).

Station 1 river body is in a secondary forest. The surface of the river is shaded by vegetation that grows thickly in the forest and also the cliffs in this forest. Shade on the surface of the river blocks the penetration of sunlight into the river, causing low water temperatures. In addition, the position of station 1 which is at an altitude of 1048 masl which is the highest position is a factor causing low water temperatures. Altitude affects air temperature. The air temperature affects the river water temperature. The higher the position of the river, the lower the water temperature.

Water depth is also a factor that causes the low wealth or number of fish species in the upper Bedadung River. The average water depth of the upper Bedadung River ranges from 0.23 m - 0.4 m which is relatively shallow (Table 2). According to Djumanto *et al.* (2013), river depths below 40 cm are classified as shallow. The shallow condition of the upper reaches of the Bedadung River is thought to be the cause of the small number of fish species found. This is due to the very limited volume of space which is the habitat and where to find food for fish. In addition, in a narrow volume of space, the chance of fish being caught by predators is very large because the shelter is also limited. Kottelat *et al.* (1993) and Gani *et al.* (2015) stated that the depth of river water affects the number of fish species. The depth of the water also affects the discharge of water. The shallow water depth in the upper reaches of the Bedadung River is one of the factors causing low water discharge. The average discharge of water in the upper Bedadung River ranges from 0.05 - 0.86 m3/s which is relatively low (Table 2). River water discharge greatly affects the number of fish species. According to Afrianto and Evi (2018), a low river water discharge causes a low number of fish species that inhabit it.

Another factor that is thought to affect the low species richness of fish is the activity of fishing by the community using electric shocks and high-intensity potassium salt. This fishing method can kill not only adults but also juveniles and fish larvae. This condition causes the sustainability of fish populations to be disrupted which results in low species richness of freshwater fish in the Upper Bedadung River.

The low species richness of freshwater fish should affect the species diversity category to be low. There are no dominant fish species in the fish community in the upper reaches of this river

causing the species diversity category to be moderate. There is no dominant species in the fish community indicated by a low dominance index value. A low dominance index value means that the individual distribution of each fish species tends to be even. The species diversity of a community is low if there are dominant species in the community (Odum, 1998).

Table 2 The average value of abiotic parameters in the water of the upper Bedadung River

Parameter	Value Range		Average
	Min	Max	
Temperature (^{0}C)	18.78	26.16	22.86
pH	7.86	8.19	7.99
DO (mg/L)	7.03	8.28	7.67
Turbidity (NTU)	3.22	18.13	11.43
Current Speed (m/s)	0.16	0.45	0.24
Depth (m)	0.20	0.41	0.28
River Width (m)	1.42	7.45	3.50
River Discharge (m^3/s)	0.05	0.86	0.29

The upper Bedadung River is inhabited by five species, namely *C. gachua*, *P. reticulata*, *B. binotatus*, *G. platypogon*, and *N. fasciatus*. The fish community dominance index value at all stations is in the low category, while the species diversity index is in the medium category. The diversity category of freshwater fish species is moderate.

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References

Afrianto, E. and Evi L. 2018. *Beberapa Metode Budidaya Ikan*. Yogyakarta: Kanisius.

Andriani, A., Ario D., M. F. Rahardjo., Charles P. H. S., Aries A. dan Reiza M. A. 2017. Kelimpahan Fitoplankton dan Perannya Sebagai Sumber Makanan Ikan di Teluk Pabean, Jawa Barat. *Jurnal Sumberdaya Akuatik Indopasifik* 1(2) 13-19.

Banarescu. 1990. Zoogeography of Freshwater. Vol.I. *General Distribution and Dispersal of Freshwater Animals*. Verlag Wiesbaden: AULA.

Bolaji, B. B., Mfon, T. U. and Di U. 2011. Preliminary study on the aspects of the biology of snakehead fish *Parachanna obscura* (Gunther) in a Nigerian wetland. *African Journal of Food, Agriculture, Nutrition and Development* 11(2): 4708-4716.

Djumanto, N. and Probosunu. 2011. Biodiversitas sumber daya ikan di hulu Sungai Opak. *Jurnal Iktiologi Indonesia* 11(1): 1-10.

Djumanto, N., Probosunu., and Rudy I. 2013. Indek Biotik Famili Sebagai Indikator Kualitas Air Sungai Gajahwong Yogyakarta. *Jurnal Perikanan* 15(1): 26-34.

Duya, N. 2008. Ichtiofauna Perairan di Sungai Musi Kejalo Curup Bengkulu. *Jurnal Gradien* 4(2): 394-396.

Effendi, H. 2003. *Telaah Kualitas Air Bagi Pengelolaan Sumber Daya dan Lingkungan Perairan*. Yogyakarta: Kanisius.

Gani, A., Jusri N. and Achmad R. 2015. Studi Habitat dan Kebiasaan Makanan (*Food Habit*) Ikan Rono Lindu (Oryzias sarasinorum POPTA, 1905). *Jurnal Sains dan Teknologi Tadaluko* 4(3): 9-18.

Gustav, F. 1998. Pengaruh Tingkat Kepadatan Terhadap Kelangsungan Hidup dan Pertumbuhan Benih Ikan Kakap Putih (*Lates calcalifer*, Bloch) dalam Sistem Resirkulasi. [Undergraduate Thesis]. Bogor: Institut Pertanian Bogor.

Jenkins A., Kullander F. F. and Tan H. H. 2015. *Barbodes binotatus*. *The IUCN Red List of Threatened Species*. Available at: www.iucnredlist.org.

Jusmaldi and Nova H. 2018. Hubungan Panjang Bobot dan Faktor Kondisi Ikan Wader Bintik Dua Barbodes binotatus (Valenciennes, 1842) di Sungai Barambai Samarinda Kalimantan Timur. *Jurnal Iktiologi Indonesia* 18(2): 87-107.

Kordi, K. 2000. *Budidaya Ikan Nila*. Semarang: Dahara prize.

Kordi, K. M. G. H. 2011. *Panduan Lengkap Bisnis dan Budidaya Ikan Gabus*. Yogyakarta: Lily Publisher.

Kottelat, M., Kartikasari, S.N., Whitten, A.I. and Wirjoatmodjo, S. 1993. *Freshwater Fishes of Western Indonesia and Sulawesi*. Jakarta: Periplus Editios (HK).

Magurran, A.E. 1988. *Ecological Diversity and Its Measurement*. New York: Chapman and Hall.

Muhtadi, A., Dhuha O. R., Desrita T. and Muammar S. 2017. Kondisi Habitat dan Keragaman Nekton di Hulu Daerah Aliran Sungai Wampu, Kabupaten Langkat, Provinsi Sumatera Utara. *Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan* 6(2): 90-99.

Nurudin, F. A. 2013. Kanekaragaman Jenis Ikan di Sungai Sekonyer Taman Nasional Tanjung Puting Kalimantan Tengah. [*Undergraduate Thesis*]. Semarang: UNS.

Odum, E. P. 1996. Dasar-dasar Ekologi. Yogyakarta: Gajah Mada University Press.

Peraturan Pemerintah Republik Indonesia Nomor 38 Tahun 2011. *Sungai*. Lembaran Negara Republik Indonesia 5230. Jakarta.

Prakoso, V. A., Muhammad H. F. A., Jojo S. and Anang H. K. 2016. Pertumbuhan Ikan Uceng (Nemacheilus fasciatus) dengan Padat Tebar Berbeda Dalam Lingkungan Ex-Situ. *Jurnal Riset Akuakultur* 11(4): 355-362.

Pratimi, V. A. Y., Prabang S. and Sunarto. 2018. Zonasi, Keanekaragaman dan Pola Migrasi Ikan di Sungai Keyang Kabupaten Ponorogo Jawa Timur. *Jurnal Ilmu Lingkungan* 16(1): 78-85.

Pratiwi, A.I., Amir H., Siti A. B. and Bambang R. A. 2017. Karakteristik Mutu Wader Pari Hasil Budidaya Pada Berbagai Suhu Penyimpanan. *Jurnal Hasil Pengolahan Hasil Perikanan Indonesia* 20(1): 123-130.

Raharjo, M. F., Djaya S., Ridwan A. and Sulistiono. 2011. *Iktiology*. Bandung: Lubuk Agung.

Rahayu, D. A., Endik D. N. and Dwi L. 2018. Studi Morfologi dan Fenetik Taksonomi Ikan Introduksi Khas Telaga Sari, Pasuruan. *Borneo Journal of Biology Education* 1(1): 1-20.

Ridho, M. R., Enggar P. and Agus H. T. 2003. Keanekaragaman Jenis Ikan di Hulu Sungai Cikaniki Taman Nasional Gunung Halimun, Jawa Barat. *Jurnal Penelitian Sains* 14(2): 25-33.

Roberts, T. R. 1989. *The freshwater fishes of Western Borneo (Kalimantan Barat, Indonesia)*. California: Memoirs of the California Academy of Sciences.

Schultz's, K. 2003. *Ken Schultz's Field Guide to Freshwater Fish*. New Jersey : John Wiley & Sons, Inc.

Simanjuntak, C. P. H. 2012. Keragaman dan Distribusi Spasio-Temporal Iktiofauna Sungai Asahan Bagian Hulu dan Anak Sungainya. *Prosiding Seminar Nasional USU* 7: 43-60.

Sullivan, S. M. P., Mary C. W. and W. Cully H. 2006. Influence of Stream Geomorphic Condition on Fish Communities in Vermont, USA. *Freshwater Biology* 5(7): 1811-1826.

Tamaru, C. S., Brian C., Rich B., Christopher B. and Harry A. 2001. *A Manual for Commercial Production of the Swordtail Xiphoporus helleri*. Hawaii: CTSA Publication.

Vannote, R. L., Minshall G. W., Cummins K. W., Sedell J. R.and Cushing C. E. 1980. The River Continuum Concept. *Canadian Journal of Fisheries and Aquatic Sciences* 37(1): 130-137.

Wirjoatmodjo. 1993. *Ikan Air Tawar Indonesia Bagian Barat dan Sulawesi*. Jakarta: Periplus Edition (HK) Ltd.

Wetzel, R. G. 2001. *Lymnology Lake and River Ecosytem 3rd Ed*. London: Academic Press.

Yuanda, M. A., Yayat D. and Titin H. 2012. Struktur Komunitas Ikan di Hulu Sungai Cimanuk Kabupaten Garut. *Jurnal Perikanan dan Kelautan* 3(3): 229-236.

Zahid, A., M. F. Rahardjo., and Lenny S.S. 2015. Komunitas Ikan di Perairan Segera Kelautan. *Jurnal Ikhtiologi Indonesia* 20(3): 170-186.