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Diversity and distribution of fish in the Lokop river, Leuser Ecosystem Area, Indonesia

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ABSTRACT

Lokop is one of the villages in Serbajadi District, East Aceh Regency, Aceh Province. The village has a watershed named the river Lokop. This river is located in the Leuser Ecosystem Area which is inhabited by various aquatic biota, especially fish, with the level of diversity and distribution patterns that need to be studied and analyzed conoftened. This study used the purposive sampling method, with the parameters being the level of diversity and distribution patterns of fish in the Lokop river. Data collection was carried out at 5 observation stations based on the typology of river habitat, each station was divided into three substations representing parts of the basin, river bank and river basin approximately 50 m apart. Fish sampling is carried out at each station using a plot of 10 x 10 m2. The number of plots at each station is 9 plots with a total of 45 plots. The results showed that the diversity index (H') value of fish in the Lokop river was 2.39 in the moderate category and the distribution pattern of fish in the Lokop river has a uniform pattern and clusters. Out of a total of 17 species obtained, 8 species (47%) were clustred, 8 species (47%) were uniformly distributed and 1 species (6%) could not be analyzed because only one individual was found.

Introduction

Lokop River is located in Leuser Ecosystem Area, Serbajadi District, East Aceh Regency, Aceh Province. This river flows from the upper reaches of Central Aceh Regency to East Aceh Regency. Information on the existence of fish species and fish distribution in the Lokop River has not been widely published (Mawardi and Yusrizal, 2017). Meanwhile, the existence of these fish is now threatened by various factors, including destructive fishing (toxin and electric shocks), global climate change and environmental pollution resulting in a decline in fish populations (Defira and Muchlisin, 2004; Maghfiriadi *et al.,* 2019).

Fish plays an important role in river ecosystems because it can be used as a food source and bioindicator of water quality (Nurudin *et al.,* 2013). The distribution of fish is also determined by biotic, abiotic and human activity factors. The existence of ecological changes to river waters can affect the diversity of fish in the river. The diversity of fish species is also determined also by habitat characteristics that affect the presence of fish in the aquatic environment (Syafei, 2017). Previous fish diversity studies have been conducted in several areas such as the Kluet River in South Aceh (Mardianti *et al.,* 2017), Alas River in Subulussalam (Maghfiriadi *et al.,* 2019). The results of the study revealed that the level of fish diversity in Aceh waters were in the moderate categorized.

Information about the diversity and distribution of fish in the Lokop River is rare, from previous studies, only one species of fish was studied and generally the type studied was a native species in the river. The study included the meristic and morphometric diversity of Keureuling fish (*Tor* spp.) (Thaib, 2012) and the food habiets of Jurung fish (*Tor soro*) (Mawardi and Yusrizal, 2017). Hence, this study aims to analyze the level of diversity and distribution patterns of fish in the Lokop River in the Leuser

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Materials and Methods

Location and time of research

This research was carried out from June to August 2022. Data collection was carried out using purposive sampling methods, at five stations along the river flow divided according to different habitat typologies. The research locations and descriptions of each research station are presented in Figure 1 and Table 1. The identification of fish samples was carried out at the Biosystematics Laboratory of the Faculty of Mathematics and Natural Sciences, Syiah Kuala University, Banda Aceh.

The method of physical-chemical analysis of water used in the Lokop River uses the in situ method. The physical parameters analyzed are temperature, brightness and current velocity, while the chemical parameters are pH and dissolved oxygen (DO). Water quality parameters such as temperature (°C) were measured using a digital thermometer (MTA-37163967, Made in China), pH and Dissolved Oxygen (mg L^{-1}) were calculated using a digital water quality checker (Lutron WA-2017SD, Made in Taiwan), current water were measured using current meter (FLOWATCH FL-03, Made in Swiss), water brightness is measured using a secchi disk and GPS (Global Position System) which functions to mark the coordinates of observation stations (Garmin 64s, Made in Indonesian).

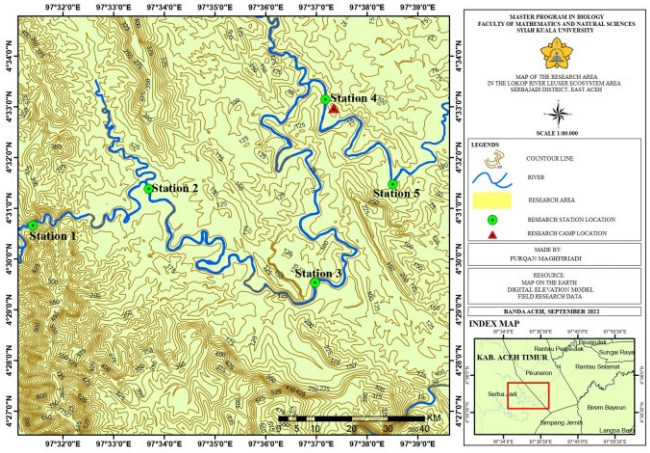

Figure 1. Research location in Lokop River, Serbajadi District, East Aceh Regency, Aceh.

Table 1. Observation station profile.

Station	Location	Coordinates	Fishing Gear	Station Description
1	Belo Uten	N 4°30'44.54" E 97°31'45.47"	Fishing line, gill net, fish net and scoop fish	The location of the river ranges from 10 meters with a river depth range of more than 3 meters, relatively fast currents, high brightness with greenish water conditions, pH ranging from 7-7.5 and dissolved oxygen ranging from 6.5-7.9 mg/L, water temperature 25 °C, vegetation around the river in the form of trees and shrubs.
2	Kuala Panggoh	N 4°31'23.80" E 97°33'40.85"	Fishing line, gill net, fish net and scoop fish	The width of the river ranges from 15 meters with a river depth range of more than 5 meters, relatively fast currents, high brightness with greenish water conditions, pH ranging from 7-7.6 and dissolved oxygen ranging from 6.6-7.4 mg/L, water temperature 24 °C, vegetation around the river in the form of trees.
3	Pulo Alim	N 4°29'32.96" E 97°36'57.76"	Fishing line, gill net, fish net and scoop fish	The width of the river ranges from 15 meters with a river depth range of 10 meters, relatively fast currents, low brightness with greenish-yellow water color, pH ranging from 7.6-8.3 and dissolved oxygen 6.1-7 mg/L, water temperature 25 °C, vegetation cover around the river in the form of trees.
4	Batu Tiga	N 4°33'2.89" E 97°37'10.02"	Fishing line, gill net, fish net and scoop fish	The width of the river ranges from 30 meters with a depth range of 5 meters, relatively slow current, , high brightness with greenish water color, pH ranging from 7.4-8.4 and dissolved oxygen 7.5-8.5 mg/L, water temperature 26 °C, vegetation cover around the river in the form of trees and shrubs.
5	Pasir Kolak	N 4°31'29.35" E 97°38'29.69"	Fishing line, gill net, fish net and scoop fish	The width of the river ranges from 40 meters with a river depth range of 15 meters, relatively slow current, low brightness with brownish-yellow water color, pH ranging from 7.3-7.7 and dissolved oxygen 6.1-6.7 mg/L, water temperature 28°C, dominant vegetation around the river in the form of large trees and grass.

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Sample collection and identification

The study site was divided into 5 observation stations based on the typology of river habitat, each observation station was divided into three substations representing parts of the basin, river bank and river basin approximately 50 m apart. Sampling was carried out at each observation station using a plot of 10 x 10 m^2. The number of plots at each station is 9 plots with a total of 45 plots in total (Sukmono *et al.,* 2013).

The fish samples caught grouped based on the same morphological characteristics to calculate the amount of each species. Before preserving, each large fish species placed on a tray equipped with a contrasting background and a ruler placed at the bottom of the fish as a scale for comparison (Zulfahmi *et al.,* 2022), then photographed using a Canon EOS 1500D camera in a fresh state with the head facing left (Sukmono *et al.,* 2013), while taking pictures for small fish was done after the fish were put in the aquarium and then photographed alive so that the colors captured were clearer (Maghfiriadi *et al.,* 2019). For further identification, each species was taken three individual as an spesimen, then put into a collection bottle containing 4% formalin and labeled (Saanin, 1984). Identification of fish samples based on morphological and morphometric features refers to the identification book belonging to Rachmatika *et al.* (2002), Kottelat and Whitten (2009), Rainboth *et al.* (2012) and fishbase official website https:www.fishbase.se/(Froese and Pauly, 2019).

Research Parameters

The parameters observed in this study are the level of diversity and distribution patterns (Fachrul, 2007). Shannon-Wiener species diversity index calculated by formula as follow:

$$H' = -\sum_{i=1}^{n} pi \ln pi \qquad (1)$$

Information:
H: Diversity index
P_i: n_i/ N
n_i: The number of individuals of fish of the type *-i*
N: Total number of individuals of the whole type
Criteria:
H' < 1 : Low diversity
H' 1- 3 : Moderate diversity
H' > 3 : High diversity

The distribution pattern is calculated by Morisita index formula as follow:

$$Id = n\frac{\sum x^2 - N}{N\,(N-1)} \qquad (2)$$

Information:
ID: Morisita index
n: Number of plots
N: Total number of individuals in a total of n plots
X^2 : Number of individuals on each plot -i
Criteria :
Id = 1, then the distribution is random
Id <1, then the distribution is uniform
Id >1, then the distribution is clustered

Results

Diversity index

The diversity index is divided into three categories, namely low (H'<1), moderate (H'=1-3) dan high (H'>3). Based on the results of the diversity index analysis obtained during the research in Lokop River, overall it is included in the category of moderate diversity index. The diversity index Morisita index formula as follow Table 2.

Table 2. Diversity indeks on the Lokop river.

No	Species	Total Individuals	H'
1.	*Barbonymus schwanenfeldii*	34	
2.	*Channa lucius*	4	
3.	*Clarias batrachus*	2	
4.	*Cyclocheilichthys apogon*	23	
5.	*Hampala macrolepidota*	53	
6.	*Hemibagrus nemurus*	9	
7.	*Macrognathus maculatus*	3	
8.	*Megalops cyprinoides*	17	
9.	*Mystacoleucus marginatus*	30	
10.	*Ompok bimaculatus*	1	
11.	*Osteochilus vittatus*	43	
12.	*Oxyeleotris marmorata*	3	
13.	*Oxygaster anomalura*	53	
14.	*Puntius brevis*	7	
15.	*Rasbora kalbarensis*	12	
16.	*Rasbora sumatrana*	19	
17.	*Tor tambra*	2	
	Totals	**315**	**2.39**

Description: H' = Diversity index

Distribution pattern

The results of the distribution pattern analysis are known that the distribution pattern of fish in the Lokop River has a uniform pattern and clusters. Of the total 17 species obtained, as many as 8 (47%)

were uniformly distributed, 8 species (47%) were scattered in clusters and 1 species (6%) could not be analyzed because only one individual was found. The pattern of distribution of fish species in the Lokop River was presented in Table 3.

Table 3. Fish distribution patterns in the Lokop River

No	Species	Total Individuals	Id	Ip	Distribution Pattern
1	*Barbonymus schwanenfeldii*	34	0.312	-0.015	Uniform
2	*Channa lucius*	4	1.667	0.001	Clustered
3	*Clarias batrachus*	2	5.00	0.003	Clustered
4	*Cyclocheilichthys apogon*	23	0.534	-0.007	Uniform
5	*Hampala macrolepidota*	53	0.002	-0.034	Uniform
6	*Hemibagrus nemurus*	9	0.833	-0.001	Uniform
7	*Macrognathus maculatus*	3	5.00	0.005	Clustered
8	*Megalops cyprinoides*	17	2.426	0.015	Clustered
9	*Mystacoleucus marginatus*	30	0.003	-0.015	Uniform
10	*Ompok bimaculatus*	1	-	-	Undectable
11	*Osteochilus vittatus*	43	0.371	-0.017	Uniform
12	*Oxygaster anomalura*	53	0.385	-0.022	Uniform
13	*Oxyeleotris marmorata*	3	5.00	0.005	Clustered
14	*Puntius brevis*	7	5.00	0.016	Clustered
15	*Rasbora kalbarensis*	12	1.89	0.007	Clustered
16	*Rasbora sumatrana*	19	0.009	-0.012	Uniform
17	*Tor tambra*	2	5.00	0.003	Clustered
	Total	315			
	Clustered	8	47%		
	Uniform	8	47%		
	Undetectable	1	6%		

Description: Id = Morisita spread index, Ip = Standard degree of Morisita Discussion

Table 4. Measurement of environmental factors in the Lokop river.

No	Water Quality Parameters	Unit	Station					Quality Standards *)
			1	2	3	4	5	
1	Current velocity	m/s	0.37	0.48	0.22	0.21	0.16	-
2	pH		7.2	7.3	8	7.8	7.4	6 - 9
3	Temperature	°C	25	24	25	24	28	-
4	Dissolved oxygen	mg/L	7.3	7	6.6	7.7	6.4	> 4
5	Brightness	cm	51	41	51	61	32	-

*)Quality standards for the maximum level of river water based on the Government Regulation of the Republic of Indonesia No.22 of 2021 for class II concerning Water Quality Treatment and Pollution

Discussion

The fish diversity index in the Lokop River is catagorized as moderate category (H'=2.39). The value of the diversity index is influenced by the number of individuals of each species of fish and the total number of individuals of all fish species. The diversity index value is high if the population of each species is almost the same and the diversity index is low if there are certain species that dominate, so that the population of each species is uneven (Arhas *et al.*, 2015). Species diversity is also influenced by environmental factors such as pH, dissolved oxygen, current velocity and brightness. This is in accordance with the opinion of Ulfah *et al.* (2019) which states that the high and low value of diversity in a body of water indicates an influence on environmental factors (temperature, pH, dissolved oxygen, current velocity, brightness) and the availability of fish feed in the waters. In addition, the carrying capacity of environmental factors is also very influential for the growth and development of fish, because each

species of fish has certain environmental limiting factors.

Fish are organisms that have an ecological function in rivers whose existence is influenced by aquatic environmental factors. Table 4 shows that the water temperature of the Lokop River ranges from 24-28^{0}C. Variations are due to differences in the influence of plant vegetation cover levels around river waters. These temperature conditions are still at an ideal level for fish growth. According to Kenconojati *et al.* (2016) the optimum temperature for fish growth ranges from 20-30^{0}C, and the day and night temperature difference in the tropics tends to be smaller by < 5^{0}C.

The highest brightness was obtained at station 4 at 61 cm and the lowest at station 5 at 32 cm. The difference in brightness is influenced by the bottom substrate and material suspended in river water, the brigthness of the river water is getting lower downstream of the river width tends to be wider and the current is relatively slow, so that a lot of material dissolved in the water has the potential to reduce the brigthness of the waters. This is in line with the opinion of Sinambela and Sipayung (2015) that stated the low brigthness is influenced by particels and sediments washed away by river flows from land erosion. According to Fauziah (2022), the brightness level is affected by the turbidity of the water, the low brightness is caused by high turbidity meanwhile low turbidity causes high brightness. Brightness has an important role in the photosynthesis process of phytoplankton organisms, good brightness helps light penetrate more waters and can make it easier for phytoplankton to carry out photosynthesis. According to Suin (2002) light penetration is influenced by the amount of dissolved solids that are in the waters of rivers or water bodies with high dissolved solids causing the water to become cloudy so that the penetration of light into the water is reduced and will decrease the feeding efficiency of aquatic organisms.

The Lokop River has a current velocity ranging from 0.16 – 0.48 m/s. Based on this category, the Lokop River is included in the category of medium-winded. The velocity of currents in a body of water greatly affects the value of diversity, distribution patterns, composition and behavior of fish, where the velocity of currents also has an impact on other abiotic factors. According to Sriwidodo *et al.* (2013) water currents are the movement of a water mass that is very important for aquatic life, because currents have a role in providing transportation of nutrients, plankton and fish larvae and other biota to move from one place to another. This is in accordance with the results of the study Erika *et al.* (2018) expresses the velocity of medium current which is in the range of (0.25 – 0.5 m/s). Current velocity can be influenced by many things including the presence of wind, the slope of the water topography, the type of water bottom substrate, water discharge and rainfall (Kinanti *et al.*, 2014).

The degree of acidity (pH) is a value to determine the acidity level of a water. The pH value in the Lokop River ranges from 7.8 – 8. Human activities along river flows and the amount of organic or inorganic waste that enters the waters can affect the pH conditions in these waters. Acidic or alkaline water conditions can endanger the survival of organisms, because they will interfere with metabolism and respiration. The level of tolerance of aquatic organisms to pH varies greatly, but in general most aquatic organisms are very sensitive to changes in pH (Mainassy, 2017). The influence of pH on the diversity and distribution of fish in waters greatly affects the adaptability of fish to the conditions of the waters they occupy, if there is an increase or decrease in the degree of acidity in the waters will also have an impact on the immune system of fish which can affect fish health so that it will decrease the abundance of fish.

Dissolved oxygen (DO) is a compound that is very important for the life of aquatic organisms, especially for the respiratory process. Dissolved oxygen in the Lokop River in the Leuser Ecosystem Area ranges from 6.4 – 7.7 mg/L. Dissolved oxygen is highest at station 4 and lowest at station 5. Based on the quality standards of the Government Regulation of the Republic of Indonesia. No. 22 of 2021 (Class II), the range of dissolved oxygen for fish farming activities is > 4 mg / L. The presence of dissolved oxygen in the waters is an important factor for the survival of all aquatic organisms. Kenconojati *et al.* (2016) states that good dissolved oxygen levels for fish growth are above 5 mg/L. Low concentrations of dissolved oxygen can result in fish and dead water biota.

The results of distribution pattern analysis generally show clustered distribution patterns. The distribution of fish in a region depends on habitat type, vegetation and environmental factors (current velocity, pH, dissolved oxygen and brightness). The uniform distribution pattern is very common in aquatic environments in fish habitats compared to clustered patterns. The uniform distribution pattern is caused by relatively homogeneous aquatic environmental factors can be detected from temperature, pH and dissolved oxygen conditions and competition between individuals in fighting for

food so that there is an even division of space. According to Odum (1996), organisms with a uniform distribution pattern are thought to be able to utilize all environmental factors so that they are found in all gradients in the habitat. Grouping distribution patterns occur due to the absence of competition between species in meeting the needs of food resources. According to Wahyuni *et al.* (2022), clustering distribution can occur due to the gathering of individuals in a habitat as a strategy to respond to changes in weather and seasons, as well as changes in habitat and reproductive processes. This makes it easier for fish to adapt to changing environmental conditions when in clustered distribution.

Conclusion

Fish diversity in the Lokop River is in the moderate category (H' = 2.39). The distribution pattern of fish in the Lokop River is classified as clusters and uniform and only one species has not detected its distribution pattern, namely *Ompok bimaculatus* fish. The diversity and distribution of fish is strongly influenced by physical-chemical factors including current velocity, brightness, temperature, pH and dissolved oxygen.

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