Population dynamics of keureuling fish (*Tor* spp.) in Lokop River waters, East Aceh District, Indonesia

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Abstract. Keureuling fish is a freshwater fish, consumed by the Gayo people in Lokop, East Aceh, and has a high economic value. Research on population dynamics of keureuling fish needs to be done considering that there is no adequate information about it in the Lokop River, until this research. The purpose of this study was to analyze the frequency distribution of fish length, relative abundance, diversity, evenness, and dominance index of keureuling fish in the Lokop River. This research used purposive sampling method. Sampling was carried out at three stations. The results figured four species of keureuling fish. The frequency distribution of the keureuling fish length caught during the observation at the three stations was included in the low/small frequency category. The highest relative abundance was found at the upstream station, while the lowest was at the downstream station. Diversity index (H') at the three stations was included in the medium category. The evenness index (E) is included in the high category, and the dominance index (D) is included in the low category.
Key Words: diversity, evenness, dominance.

Introduction. Keureuling fish (*Tor* spp.) species that exist in Lokop River, Serbajadi Subdistrict, East Aceh District, Indonesia, commonly live in fast-flowing waters with rock substrate (Persada et al 2022). Keureuling fish can grow well in highly oxygenated clear waters, with medium to fast flow (Wibowo 2012).

Lokop Village is a settlement situated at high altitude (BPS Aceh Timur 2015). Lokop River, which is flowing into Lokop Village, is threatened by human activities that harm the environment, such as forest logging in upstream area, land use change on river shores and sand and gravel mining which threaten the keureuling fish population to decrease. Also, there is no cultivation yet for these fish species in the area. The existence of keureuling fish in Lokop River is threatened by extensive fishing as well (Haryono 2006).

Keureuling fish are consumed by the Gayo People in Lokop, and has a high economic value of 100.000/kg to 200.000/kg IDR (Serambi News 2019). This determines the people in there to overharvest the species without thinking about their population and sustainability. Sustaining fish populations in waters can be done by not constructing buildings that damage the river enviroment, saving on the use of groundwater, catching fish using environmentally friendly tools, and so on. If this happens the consequences can damage the sustainability of fish resources and the surrounding environment (Syahputra et al 2023).

Research about population dynamic of keureuling fish consists of length frequency distribution, relative abundance, diversity index, evenness index, and dominance index. This research is expected to provide information about population dynamic of keureuling fish in Lokop River and be the initial foundation towards the cultivating of these species. Cultivation is important to start, so it will decrease overhasvesting in nature to protect the native populations. Appropriate enviromental conditions must be provided for the cultivation of these species, to replicate as much as possible the natural conditions of their enviroment and the availability of indoor hatcheries is favourable (Prihadi et al 2022).

Material and Method

Location and time of research. This research conducted in February to May 2022, in Lokop River, East Aceh District. Position of the stations and map of research site can be seen in Table 1 and Figure 1.

Table 1

Position of three stations on Lokop River

Stations	*Positions*
Station 1	N 04°25'49.958″ and E 97°30'34.555″
Station 2	N 04°24'51.288″ and E 97°31'22.796″
Station 3	N 04°24'00.000″ and E 97°32'04.164″

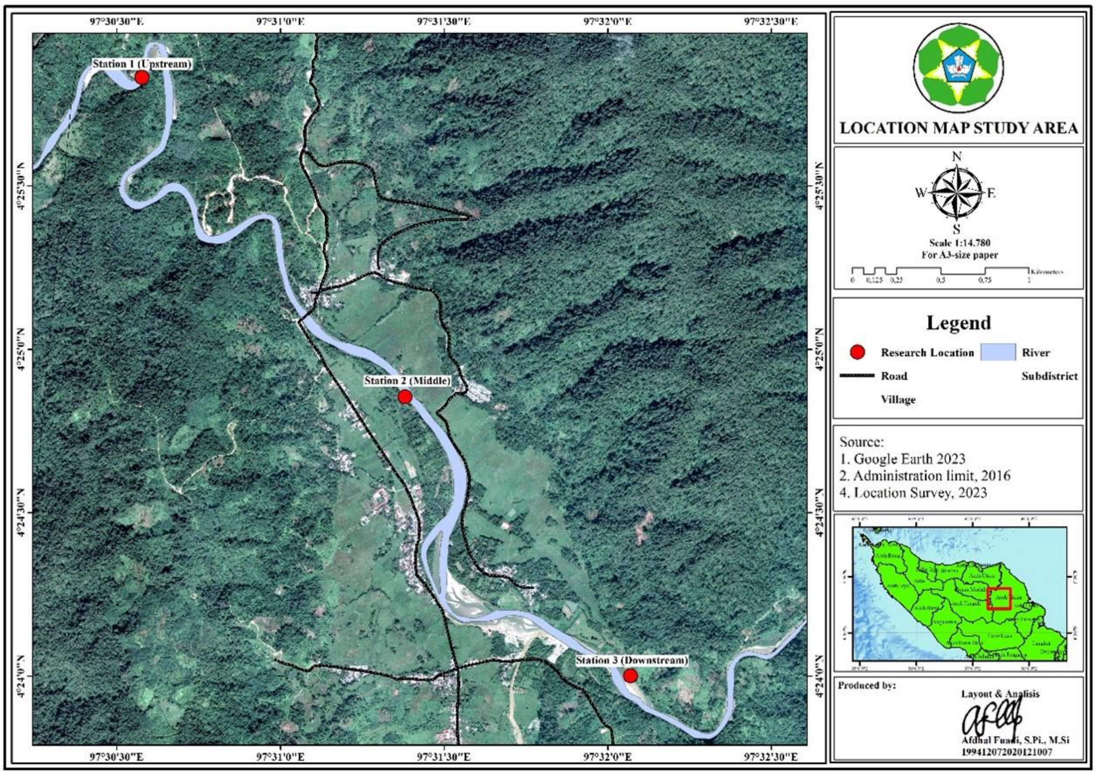

Figure 1. Map showing the location of research sites on Lokop River (map generated using ArcGIS).

Station 1 has unpolluted waters, rocky substrate, clear waters, and dense tree line on the banks of the river (Figure 2). In Station 2, the banks of the river are eroded, because of sand and gravel mining (Figure 3). Station 3 has rock and sand substrate and has fast flowing and murky waters because of continuous sand and gravel mining (Figure 4).

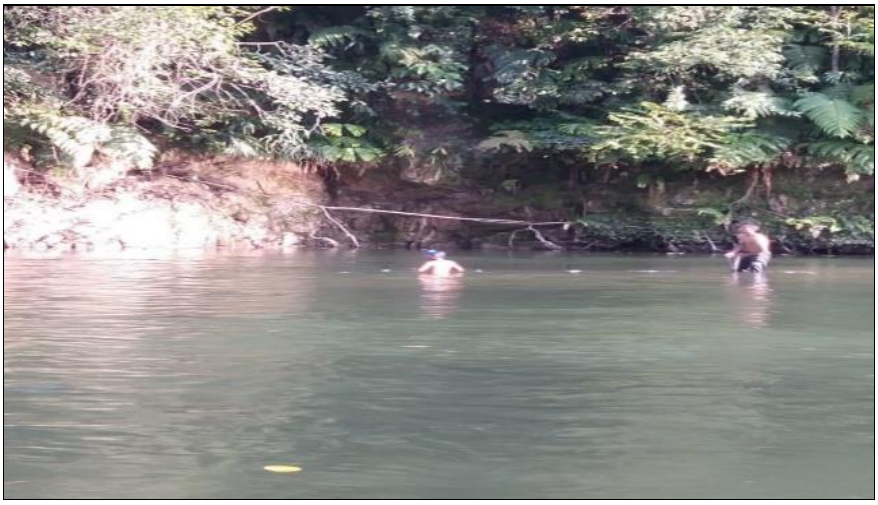

Figure 2. Station 1 (upstream section).

Figure 3. Station 2 (middle section).

Figure 4. Station 3 (downstream section).

Data analysis. This research used purposive sampling. Sampling was done using nets with 3 m length and 3 m width with 2-inch mesh. Water depth ranged between 0.5-2 m. This research was conducted in 4 steps: (1) determination of research locations, (2) sampling of keureuling fish, (3) recording of water quality parameters regarding current, depth, temperature, brightness, dissolved oxygen (DO) and pH, (4) identification of fish species. Identification of species was done using the book guide from Kottelat et al (1993). Observations of water quality parameters were carried out in-situ, in the morning. Current parameters are measured using a current meter; depth is measured with a Peil scale; temperature is measured with a thermometer; brightness is measured with a Secchi disk; DO is measured with a DO meter; and pH is measured with a pH meter.

The data obtained were described quantitatively. Community indices are calculated, which include the length frequency distribution, relative abundance (RA), Shannon-Winner index (H'), evenness index (E), and dominance index (C). Steps for length frequency distribution (Ludwig & Reynolds 1988) were the following:

1. Determining the number of size groups by the formula:

$$n=1+3.33 \text{ LogN}$$

Where: n = number of size groups; N = number of observed fish.

2. Determining the class width for each size group with the formula:

$$C=(a-b)/c$$

Where: C = class width; c = class; a = maximum length of fish; b = minimum length of fish.

Relative abundance calculation was done using the Simpson formula (Ludwig & Reynolds 1988):

$$\mathbf{RA} = \frac{\mathbf{ni}}{\mathbf{\Sigma N}} \, x \, \mathbf{100\%}$$

Where: RA = Relative abundance; ni = the total number of individuals of each species; N = the total number of individuals of all species.

The diversity index aims to determine the diversity of fish species in the waters. The analysis uses the Shannon-Wiener diversity index seen from the H' value. If the value of H' > 3 = high diversity, 1 < H' < 3 = medium (moderate) diversity and H' < 1 = low diversity (Ludwig & Reynolds 1988):

$$H^{`} = -\sum_{i=1}^{s} \mathbf{pi \ln pi}$$

Where: H' = Shannon-Wiener diversity index; pi = comparison of the number of individuals of a species "i" with all species; ln = natural logarithm; s = total species; i = the number of individuals of "i" species.

The evenness index is used to determine the uniformity of the number of individuals from a community. Evenness index values range from 0-1. If the evenness index value is close to 0, it means that the distribution is unequal among species, whereas if it is close to 1, the distribution is equal among species. Following formula was used (Ludwig & Reynolds 1988):

$$E = \frac{H^{`}}{Hmax}$$

Where: E = evenness index; H' = Shannon-Wiener diversity index; H max = maximum evenness (lnS); S = number of species.

Dominance index is used to determine the dominance of a species of fish among the species in the community. If the value of D is close to 0, then the dominance is low.

If the value of D is close to 1, then the dominance is high. Dominance analysis uses dominance index (Ludwig & Reynolds 1988):

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

Where: C = dominance index; ni = the total number of individuals of one species; N = the total number of individuals of all species.

Results

Length frequency distribution. The frequency distribution of the keureuling fish length in the Lokop river at each station can be seen from Figure 5. The length distribution at the downstream station for *Tor douronensis* was dominated by sizes 70 – 87.67 mm and by sizes 107.34 - 125.01 mm (2 fish each), while the smallest sizes 126.01 - 143.68 mm and 182.02 - 199.69 mm (1 fish each). The length frequency distribution of *Tor tambroides* fish length was dominated by sizes 70 – 87.67 mm (4 fish), while the smallest size was 107.34 - 125.01 mm and 144.68 - 162.35 mm (1 fish each). The length frequency distribution of *Tor tambra* fish length was dominated by sizes 88.67 - 106.34 mm and 126.01 - 143.68 mm (2 fish each). The frequency distribution of *Tor soro* fish length was dominated by 70 - 87.67 mm (4 fish), while the smallest size was 88.67 - 106.34 mm, 107.34 - 125.01 mm, 144.68 - 162.35 mm and 163.35 - 181.02 mm (1 fish each).

The frequency distribution of fish length in the middle station for *Tor douronensis* was dominated by sizes 88.67 - 106.34 mm (4 fish), while the smallest sizes were 126.01 - 143.68 mm and 163.35 - 181.02 mm (1 fish each). The frequency distribution of *Tor tambroides* fish length was dominated by 70 - 87.67 mm (10 fish), while the smallest size was 144.68 - 162.35 mm (2 fish). The frequency distribution of *Tor tambra* fish length was dominated by 88.67 - 106.34 mm (17 fish), while the smallest size was 107.34 - 125.01 mm and 126.01 - 143.68 mm (1 fish each). The frequency distribution of *Tor soro* fish length was dominated by size 88.67 - 106.34 mm (10 fish), while the smallest size was 144.68 - 162.35 mm (3 fish).

The frequency distribution of the fish length at the upstream station for *Tor douronensis* was dominated by sizes 88.67 - 106.34 mm (9 fish), while the smallest frequency was for sizes 238.03 - 255.7 mm (1 fish). The frequency distribution of *Tor tambroides* fish length was dominated by 88.67 - 106.34 mm (18 fish), while the smallest size was 219.36 - 237.03 mm (1 fish). The frequency distribution of *Tor tambra* fish length was dominated by sizes 107.34 - 125.01 mm (5 fish), while the smallest were sizes 88.67 - 106.34 mm and 126.01 - 143.68 mm (2 fish each). The frequency distribution of *Tor soro* fish length was dominated by sizes 88.67 - 106.34 mm (15 fish), while the smallest sizes were 200.69 - 218.36 mm and 219.36 - 237.03 (1 fish).

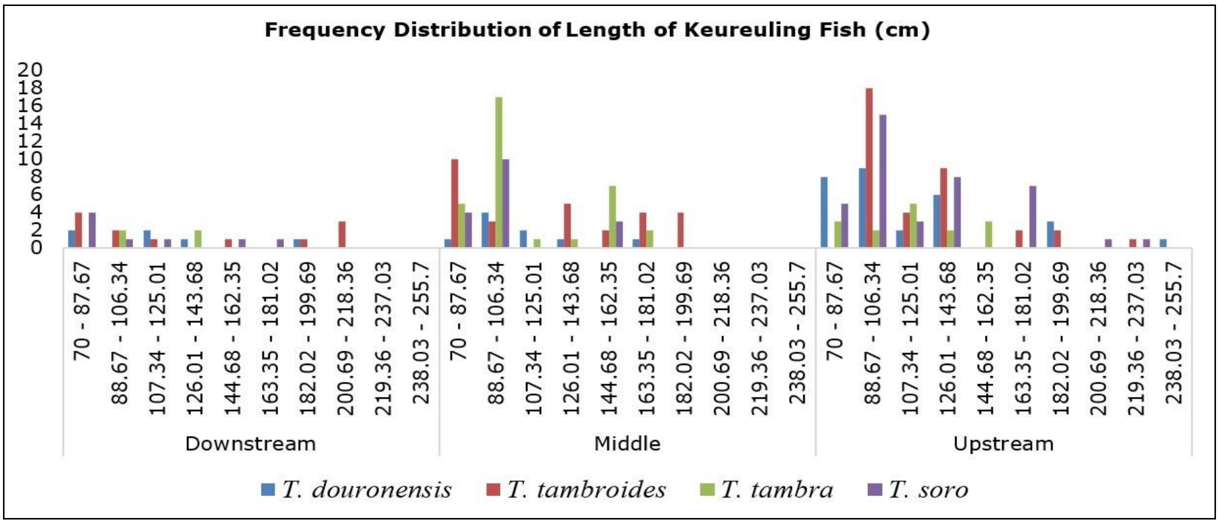

Figure 5. Length frequency distribution of keureuling fish (*Tor* spp.).

Relative abundance. The results showed that the highest relative abundance for *Tor douronensis* was at the upstream station (76.13%) and the lowest was at the downstream station (20.05%). For *Tor tambroides* the highest relative abundance was at the upstream station (86.13%) and the lowest was at the downstream station (37.43%). For *Tor tambra*, the highest abundance was at the middle station (80.77%) and the lowest at the downstream station (18.15%). For *Tor soro* the highest abundance was at the upstream station (88.77%) and the lowest was at the downstream station (28.17%). The relative abundance of *Tor* spp. can be seen in Figure 6.

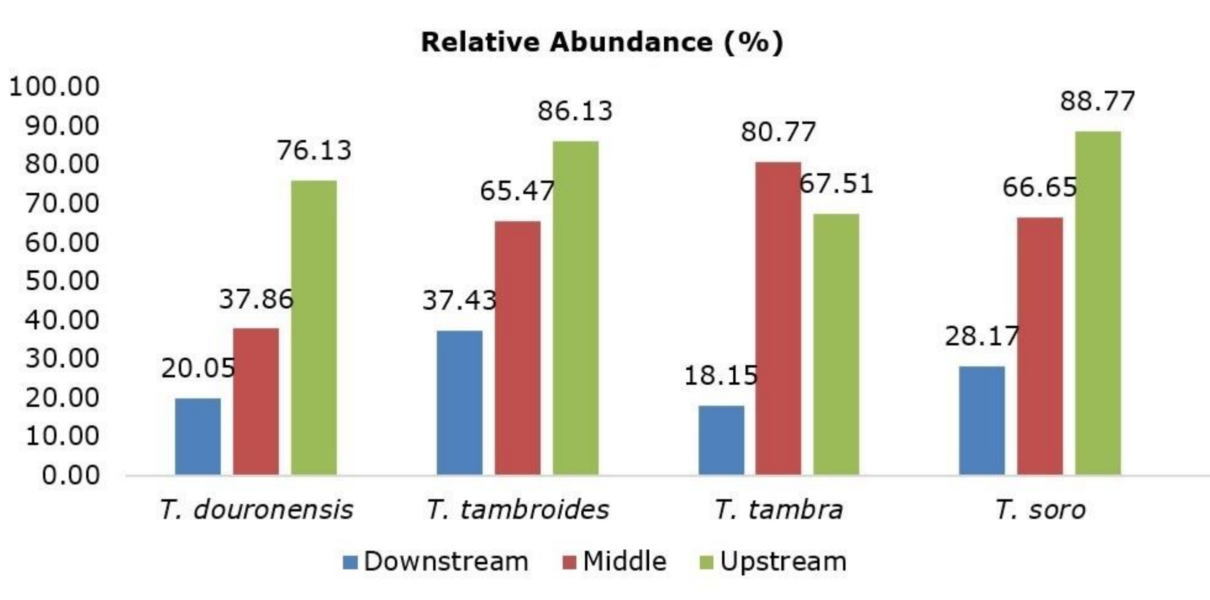

Figure 6. Relative abundance of keureuling fish (*Tor* spp.).

Diversity, evenness, and dominance index. The diversity (H'), evenness (E) and dominance index (C) showed different values at each station on Lokop river. The highest diversity index was found at the upstream section (H' = 1.601), while the lowest at the downstream section (H' = 1.201). The highest evenness index was found at the upstream section (E = 0.66) while the lowest was at the downstream section (E = 0.64). The highest dominance index was found at the upstream section (D = 0.36) and the lowest at the middle section (D = 0.26).

The diversity index is categorized into the moderate category, which means the habitat has sufficient productivity, fairly balanced ecosystem conditions, and moderate ecological pressure. The evenness index is categorized into the high category, in other words, the uniformity of the species of *Tor* spp. is high. Furthermore, the dominance index is also categorized into the low category, which means that no fish species dominates the species structure (Table 2).

Table 2

Diversity (H'), evenness (E) and dominance index (D) of *Tor* spp. in Lokop River

Index	*Stations*					
	Downstream	*Category*	*Middle*	*Category*	*Upstream*	*Category*
H`	1.201	Medium	1.522	Medium	1.601	Medium
E	0.64	High	0.53	High	0.66	High
C	0.33	Low	0.26	Low	0.36	Low

Water quality parameters. General condition of water quality at each station doesn't strongly differ between stations. Water quality parameters can be seen in Table 3.

Table 3

Water quality parameters

Parameters	Stations		
	Downstream	*Middle*	*Upstream*
Current (m/s)	1.01	1.05	1.22
Depth (cm)	58.4	67.11	73.46
Temperature (°C)	25.66	24.74	24.4
Brightness (cm)	60.01	58.43	59.67
DO (mg/L)	7.32	7.14	7.25
pH	6.43	7.03	6.85

The current speed at the research locations ranges from 1.01-1.22 m/s. The highest current speed is at the upstream section (1.22 m/s) and the lowest is at the downstream section (1.01 m/s). The water depth at each station ranged between 58.4 cm – 73.46 cm. The highest depth is at the upstream section (73.46 cm), while the lowest depth is at the downstream section (58.4 cm). The water temperature at each station ranges between 24.4 - 25.66°C. The highest temperature was found at the downstream section (25.66°C), while the lowest water temperature was found at the upstream section (24.4°C). The brightness of the water at each station ranges from 58.43 to 60.01 cm. The highest brightness is at the downstream section (60.01 cm), while the lowest brightness is at the middle section (58.43 cm). Dissolved oxygen (DO) content at each station is in the range of 7.14 - 7.32 mg/L. The highest dissolved oxygen value was obtained at the downstream section (7.32 mg/L), while the lowest value was obtained at the middle section (7.14 mg/L). The results of pH measurements that have been carried out at each station obtained a pH value in the range of 6.43 – 7.03. The highest pH value is in the middle section (7.03) while the lowest is in the downstream section (6.43).

Discussion

Length frequency distribution. Based on the frequency distribution of the keureuling fish length found in the Lokop River, it showed that the length frequency of the fish depends on the location and type of fish. At Station 3 (downstream section) many fish length frequencies were obtained at low class intervals with a deficiency in larger fish sizes. This occurs due to the influence of sand and gravel mining activities that occur in the lower reaches of the Lokop River, thus larger fish migrate to better locations such as the middle and upper reaches of the river (Figure 7). According to Prihadi et al (2022), fish with small/young fish size after reaching adult size will migrate to the upper reaches of the river to find a better place (in this case with larger rocks).

Figure 7. Sand and gravel mining activities on the Lokop River.

At Station 2 (middle section) and Station 1 (upstream section) the frequency distribution of keureuling fish length was better than at Station 3 (downstream section). The length frequency of the fish obtained belongs to the sufficient category where the length frequency is dominated by size 255 mm or more. However, this size is still very far away when compared to the statement of Smith (1945) in Septiono (2006), which states that *Tor* spp. can reach 30 kg with a length of 100 cm. This occurs due to the large number of fishing activities carried out by the community regardless of the size of the fish caught which are still small in size so that the opportunity for the fish to grow large is never achieved.

Relative abundance. The relative abundance of keureuling fish (*Tor* spp.) from each station is different. This is influenced by water quality factors and the existence of fishing activities. The results showed that the highest relative abundance was obtained at the upstream station while the lowest was at the downstream station. The upstream part of the water is located between mountain slopes with lots of shady trees growing around it. Also, the upstream section is far from residential areas and the waters are still unpolluted. Whereas the downstream station is located close to settlements and there are sand and gravel mining activities carried out by companies and the local community which disrupts the habitat for the keureuling fish due to the low quality of the turbid waters. According to Haryono and Subagja (2008), the habitat of small to medium/juvenile keureuling fish is in waters with the characteristics of having a rocky bottom with a diameter of rocks <50 cm, gravel and sand, moderate to swift water currents, clear water color, water depth <1 m, and 50-75% canopy closure.

Diversity, evenness, and dominance index. The differences in the value of H' is due to behavior in the selection of habitats causing the abundance, diversity, and presence of fish at each location to be different. Fish tend to forage in areas rich in food resources. This is corroborated by Muchlisin et al (2010), stating that the highest abundance of plankton is found in areas that have a build-up of nutrients in the waters, causing it to be productive for plankton growth.

The dominance index (D) value in these waters is below 0.5 indicating that there is no fish species that dominates significantly. It can also be seen from the relative abundance. The smaller the relative abundance range of each species in a location will also show a lower dominance value. A low dominance index value indicates that all of these species are able to adapt well to their environment.

Water quality parameters. All three stations have swift and clear water flows with substrate conditions in the form of rocks and sand. Overall, from the three stations, the water parameters (current speed, depth, temperature, brightness, DO, pH) are still in good condition based on Decree of the Minister of Environment No. 51 of 2003.

The current speed at the research location ranges from 1.01-1.22 m/s. The speed of the water is classified as very fast where the speed of the water exceeds 1 m/sec (Nuriya et al 2010). According to Haser et al (2022), the habitat of small to medium sizes *Tor* spp. are waters with moderate to heavy water current. The current speed is appropriate to support the life of *Tor* spp. who tend to like fast waters (Ali et al 2014).

The ability of fish to swim in very fast currents will determine which fish species can survive and dominate the river. This makes it possible for *Tor* spp. to survive in these current conditions with a distribution based on the size of the fish. According to Fadir et al (2022), fish diversity and abundance are also determined by the characteristics of aquatic habitats which are strongly influenced by river flow velocity. The speed of the flow is determined by the difference in the slope of the river, the presence of forests or plants along the watershed which will be associated with the presence of the animals that inhabit it.

The water depth at each station ranged from 58.4 cm – 73.46 cm. This depth is classified as suitable for supporting the life of *Tor* spp. dominated by medium sized fish with a length ranging between 70-80 cm. This is in accordance with Haryono and Subagja (2008), the habitat of small to medium/juvenile keureuling fish is in waters with a water depth of less than 1 m.

The highest temperature was found at the downstream section (25.66°C), while the lowest water temperature was found at the upstream section (24.4°C). The low temperature in the upstream section is caused by lower light penetration due to the many shady trees along the banks compared to other sections. However, this temperature is appropriate to support the life of *Tor* spp. This is in accordance with Esa et al (2011), which states that the range of water temperature that is good for the life of keureuling fish (*Tor* spp.) is <30°C.

The brightness of the water at each station ranges from 58.43 to 60.01 cm. This shows that the water at all stations is very clear, and light can penetrate to the bottom of the waters. The brightness is appropriate to support the life of *Tor* spp., that like clear water. This is in accordance with Fadir et al (2022), which states that the habitat of *Tor* spp. small to medium/adolescents are in waters with clear water conditions. Also based on Norfatimah et al (2014), these conditions will facilitate the movement of fish in search of food.

Dissolved oxygen (DO) content at each station is in the range of 7.14 - 7.32 mg/L. The high dissolved oxygen comes from photosynthetic activity and also high water currents. This value is appropriate to support the life of *Tor* spp. This is in accordance with De Silva et al (2004) which states that the dissolved oxygen content which is good for the life of keureuling fish (*Tor* spp.) is around >5mg/L.

The results of pH measurements that have been carried out at each station obtained a pH value in the range of 6.43 – 7.03. The pH value can be categorized as good for the life of *Tor* spp. According to Haryono (2006) the pH range is good for the life of *Tor* spp. between 6.5-8.5. Furthermore, Fadir et al (2022) stated that the point of fish death usually occurs at pH 4 (acid) and pH 11 (alkaline). This shows that the pH in the waters at all stations supports the life of *Tor* spp.

Conclusions. The diversity index of keureuling fish (*Tor* spp.) at the three stations is included in the medium category. The evenness index is included in the high category and the dominance index is included in the low category. Furthermore, the distribution of the frequency distribution of keureuling fish length at the three stations is included in the low/small frequency category. The highest relative abundance was found at the upstream station for the four types of keureuling fish (*Tor* spp.), while the lowest was at the downstream station.

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Conflict of interest. The authors declare that there is no conflict of interest.

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