Biometric Condition of Seurukan Fish (Osteochillus Vittatus Valenciennes, 1842) Exposed to Mercury in Krueng Sabee River Aceh Jaya Indonesia

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BIOMETRIC CONDITION OF SEURUKAN FISH (*Osteochillus vittatus* Valenciennes, 1842) EXPOSED TO MERCURY IN KRUENG SABEE RIVER ACEH JAYA INDONESIA

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Abstract: Mercury is a dangerous contaminant for aquatic organisms. Seurukan fish (*Osteochilus vittatus*) is a type of fish in the Krueng Sabee river that is vulnerable to mercury exposure. The study's purposes were to investigate the effect of mercury on the biometric conditions of Seurukan Fish in the Krueng Sabee River, Aceh Jaya Regency. A total of 90 Seurukan fish consisting of 50 males and 40 females were collected from 3 research stations. The research stations represent the upstream area (Station 1), median river bodies (Station 2), and the downstream area (Station 3). Fish samples were taken from July to August 2019. The main parameters observed included class interval, sex ratio, length-weight relationship, condition factors, mercury concentration in sediment and liver, and hepatosomatic index. The results showed that the mercury content in the sediments of the Krung Sabee River was increased both spatially and temporally. Station 1, located in the upstream area, has the highest mercury content in the sediment was 6.278 ± 0.987 mg/kg. Mercury content in liver of Seurukan Fish ranged from 0.182 ± 0.100 mg/kg to 0.198±0.152 mg/kg. Mercury contamination in the Krueng Sabee river caused a decrease in biometric conditions of Seurukan Fish. Seurukan Fish exposed to mercury tended to have smaller size, an unbalanced sex ratio, low hepatosomatic index value, and negative allometric growth pattern.

Keywords: Length-weight relationship, condition factor, sex ratio, hepatosomatic index, mercury.

Abstrak: Merkuri merupakan salah satu jenis kontaminan berbahaya bagi organisme akuatik. Ikan seurukan (*Osteochilus vittatus*) merupakan salah satu jenis ikan di sungai Krueng Sabee yang rentan terpapar merkuri. Penelitian ini bertujuan untuk mengkaji pengaruh merkuri terhadap kondisi 67actor67e67 ikan seurukan di sungai Krueng Sabee, Kabupaten Aceh Jaya. Sebanyak 90 ekor ikan Seurukan yang terdiri dari 50 ekor jantan dan 40 ekor betina dikoleksi dari 3 stasiun penelitian. Stasiun penelitian mewakili wilayah hulu (stasiun 1), badan sungai (stasiun 2) dan wilayah hilir (stasiun 3). Pengambilan sampel ikan dilakukan pada bulan Juli hingga Agustus 2019. Parameter utama yang diamati meliputi selang kelas, nisbah kelamin dan hubungan panjang bobot ikan, 68actor kondisi, konsentrasi merkuri pada sedimen dan hati serta indeks hepatosomatik. Hasil penelitian menunjukkan bahwa kandungan merkuri di sedimen Sungai Krung Sabee mengalami peningkatan baik secara spasial dan temporal. Stasiun 1 yang terletak di wilayah hulu memiliki kandungan merkuri dalam sedimen paling tinggi yaitu sebesar 6,278 ± 0,987 mg/kg. Kandungan merkuri pada hati ikan seurukan di Sungai Krueng Sabee berkisar antara 0,182 ± 0,100 mg/kg hingga 0,198 ± 0,152 mg/kg. Kontaminasi merkuri pada sungai Krueng Sabee menyebabkan dampak 68actor68 terhadap kondisi 68actor68e68 ikan seurukan. Ikan seurukan yang terpapar merkuri cenderung memiliki ukuran panjang dan bobot yang lebih kecil, nisbah kelamin yang tidak seimbang, dan nilai indeks hepatosomatik yang rendah serta pola pertumbuhan alometrik 68actor68e.

Kata kunci: Hubungan panjang bobot, 68actor kondisi, nisbah kelamin, indeks hepatosomatik, merkuri.

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Introduction

Seurukan Fish (*Osteochillus vittatus* Valenciennes, 1842) is one of the important commercial fish species in Indonesia. The fresh Seurukan market value ranged from USD 3 to 5/kg, and it can reach USD 20/kg after processed (Muthmainnah et al., 2018). Seurukan fish are also known as Nilem Fish or Peres Fish in other regions (Muchlisin and Siti-Azizah, 2009; Muchlisin et al., 2015). Seurukan fish was reported it has a wide distribution, not only in rivers with medium current and clear water but also in swamp water, reservoirs, and lakes (Nur et al., 2019; Maulidyasari and Djumanto, 2020; Jusmaldi et al., 2020). Currently, the population of this fish has a drastic decline due to overfishing, habitat destruction, and pollution (included heavy metal pollution) (Azhari et al., 2017; Kaban et al., 2019; Sari et al., 2016; Soulivongsa et al., 2020).

Krueng Sabee River is a suitable habitat for Seurukan Fish, located in Aceh Jaya District, Aceh Province, Indonesia (Timorya *et al*., 2018; Sari *et al*., 2016). Its main river body length is more than 30 meters. In addition, according to World Wide for Nature (2011), the river is the main river where three streams meet, namely Krueng Teungoh River, Krueng Gapuy River, and Krueng Kusi River. Unfortunately, several previous research reveals that the Krueng Sabee River was contaminated by mercury due to traditional gold mining and milling carried out by people alongside the watershed (Fitri, 2010; Praningtyas, 2014; Purnawan et al., 2017).

A study conducted by Wahidah et al. (2019) reveals that the Krueng Sabee River's mercury level during the rainy season reaches 0.01 µg/L and potentially increases up to 30 times (0.33 µg/L) during the dry season. Mercury in the Krueng Sabee River tends to be accumulated in sediments at the downstream area of the river. Purnawan *et al*. (2017) reported that the mercury content in sediments downstream of the river reaches 0.76 mg/kg, which was higher than the upstream (0.25 mg/kg) and median area of the river (0.70 mg/kg). Furthermore, Praningtyas (2014) states that the mercury content in Pokea Shells (*Batissa violacea*) collected from the Krueng Sabee River was ranged from 0.49 to 0.71 mg/kg.

Exposure to mercury caused numerous adverse effects on the growth, reproduction, and survivability of aquatic organisms. According to Zulfahmi et al. (2020), mercury enters the fish body's tissues via gills, skin, and gastrointestinal systems. Fish exposed to mercury tend to have decreasing growth rate, impaired osmoregulation performance, and decreased feeding ability (Nirmala et al., 2012). Zulfahmi et al. (2014) stated that mercury exposure had a significant effect on reducing the hepatosomatic index and inhibiting the development of fish oocytes. Previous research by Sari et al. (2016) showed the degeneration of liver tissue in mercury-contaminated fish collected from the Krueng Sabee River. The degeneration of the liver cells was indicated by shrinking the cell nucleus, darker in color, and cell vacuolization.

Class interval, sex ratio, hepatosomatic index, length-weight relationship, and condition factors are important biometric parameters in fisheries biology (Froese, 2006; Sarkar et al., 2008; Zulfahmi et al., 2021). These parameters can be used to assess both the fish health and the fish habitat condition (Raharjo and Simanjuntak, 2008). Biometric conditions also indicate a relative growth value. Therefore, alteration in the environment and food availability will affect the biometric conditions of fish. Studies related to Seurukan Fish are still limited to domestication effort and bioecology (Azhari et al., 2017; Mayana et al., 2016; Zulhardi et al., 2016). Research on water pollution (including mercury) and its relationship toward biometric conditions of Seurukan Fish is still rare. Hence, this study aims to investigate the effect of mercury on the biometric conditions of Seurukan Fish (*Osteochilus vittatus*) collected from Krueng Sabee River, Aceh Jaya Regency

Research Methodology

Sampling location

This study was conducted from July to August 2019. Fish and sediment were collected from three sampling stations. The stations were determined according to ecological characteristics. Station 1 was located in the upstream area of the river, which was also the nearest station to the traditional gold mining and milling area (N 04" 41' 54. 74", E 095" 42' 18. 76"). Station 2 was located in Panggong Village alongside the watershed areas and close to agricultural and plantation areas (N 04” 41’ 16. 26”, E 095” 41’ 07. 35”). Station 3 was located in Paya Seumantok Village, close to the river downstream and densely populated area (N 04” 37’ 26. 38”, N 093” 39’ 20. 34”) (Figure 1).

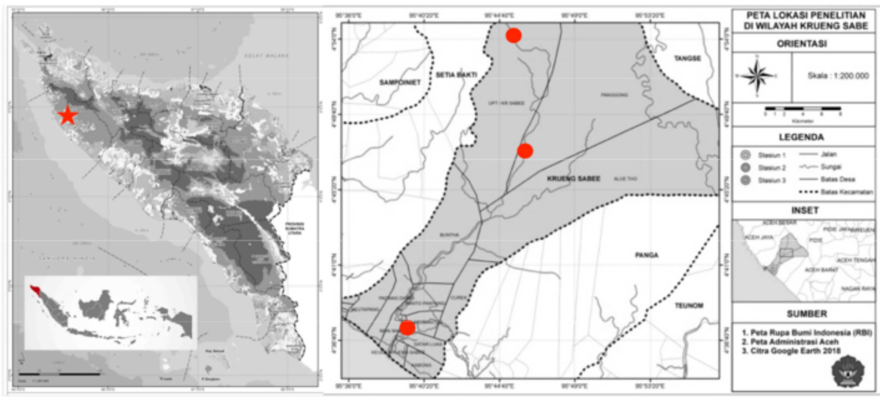

Figure 1. Map of Krueng Sabee River (red dot indicate the sampling location)

Sampling procedure and parameters

Seurukan Fish was caught in each station using selective nets (mesh sizes ranged from 0.5-1 inch). The net was set across the river body and lifted every two hours. Each fish was validated by comparing morphometric and morphologically with the fish identification book (Kottelat et al., 1993). The total length (mm) and weight (g) of collected samples were measured using digital slide calipers and digital scales. Fish samples were documented using a digital camera. For further analysis, the fish liver was preserved in 95% alcohol before transferred to the laboratory. Physical and chemical parameters of water were measured at each station, including current, temperature, pH, brightness, and dissolved oxygen. The current was measured using a Current Meter. The temperature was measured using a digital thermometer. The pH was measured using a pH meter. The brightness was measured using a Secchi disk, and the dissolved oxygen was measured using a Dissolved Oxygen Meter (DO meter). Sediment was collected from each station using Ekman Dredge Sampler, and there were three replications for each sampling site (about 250 g weight/sample)

Several parameters, including class interval, length-weight relationship, condition factor, sex ratio, mercury concentration in the liver and sediment, and hepatosomatic index, were calculated. The length-weight relationship was calculated according to Effendie (1997) as follows:

$$W = aL^b \text{ ....(1)}$$

Where W = body weight (g), L = total length (mm), a = the regression intercept, b = the growth exponent. The value of b = 3 indicated an isometric growth pattern, while b ≠ 3 indicated an allometric growth pattern. The value of b

< 3 is known as allometric negative growth pattern (length growth is more dominant), while, if b > 3, it is known as allometric positive growth pattern (weight growth is more dominant). The condition factor was calculated using the equation as follows (Effendie, 1997):

$$K = \frac{W}{L^3} \times 100 \qquad (2)$$

Where K = Fulton's condition factor, W = body weight (g), L = total length (mm). Effect of mercury on the fish liver condition was analyzed by calculating the hepatosomatic index (HSI) of fish samples using the equation according to Htun-Han (1978) as follows:

$$HSI = \frac{Lw}{Bw} \times 100 \qquad (3)$$

Where HSI is the hepatosomatic index (%), Lw is the liver weight (g), and Bw is the body weight, including the liver (g). Measurement of mercury content in sediment and fish liver was carried out using the atomic absorption spectrophotometry method referring to the Indonesian National Standard (SNI) 6989.78.2011. The analysis was conducted in the Institute for Research and Standardization (Baristand) of Industry Aceh. Briefly, 250 g of sediment and ± 2.0 g of fish liver fillets were put into 100 mL Erlenmeyer and dried in an oven at 110^{o} C for eight hours. The dried test sample was then cooled in a desiccator for 15 minutes and digested by adding 5 mL of nitric acid and 1 mL of perchloric acid and rested for 24 hours. The sample was heated at a gradual temperature level until there was no yellow steam observed. Thereafter, the sample was filtered using filter paper and diluted 50 mL into a measuring flask. Finally, the sample was measured for its mercury levels using an Atomic Absorption Spectrophotometer.

Statistical Analysis

Mercury content in sediment and fish liver, condition factors, and hepatosomatic index between stations were analyzed using one-way ANOVA and Least Significant Difference (LSD). Statistical analysis was carried out with SPSS 22 software. Mercury content was also analyzed temporally by comparing the value with similar previous studies in a similar location. The distribution of fish based on the length and weight class intervals, sex ratio, and weight-length relationship of fish from each station were analyzed descriptively.

Result and Discussion

The mercury concentration in sediment and fish liver, physical and chemical parameter of water

Mercury has been identified as a dangerous contaminant for aquatic organisms (Li et al., 2021; Ramírez-Rochín et al., 2021). Mercury exposure has been reported to disturb the respiratory system, enzyme system, nervous system, and reproductive system of fish (Zulfahmi et al. 2014; Palar et al. 2004; Nirmala et al., 2012; Muliari et al., 2020). Most mercury enters the water body via anthropogenic activities, mainly industrial waste and illegal gold mining (Purnawan et al., 2017; Juhaeti et al., 2017). There are several rivers in Indonesia that have been reported to be contaminated with mercury including the Kuantan River, Riau (Yulis, 2018), the Banyuasin River, South Sumatra (Suteja et al., 2019), the Banyumas River, Central Java (Budianta et al., 2019) and the Cikaniki River, Bogor (Tomiyasu et al., 2017).

Mercury contamination in sediments of Krueng Sabee River was detected from the upstream area (Station 1) to the downstream area (Station 3). Even the mercury content in sediments collected from the upstream area was higher compared to the downstream area. The results of statistical analysis showed a significant different in sediment mercury content between station 1 (6.278 ± 0.987 mg/kg) and station 2 (5.887 ± 1.045 mg/kg) compared to station 3 (2.208 ± 2.292 mg/kg) (Figure 2a). In contrast, the mercury content in Seurukan fish livers between each station did not show a significant difference ($p > 0.05$). The highest mercury content in the fish liver was observed at station 1 (0.198 ± 0.152 mg/kg), while the lowest value was observed at station 3 (0.182 ± 0.100 mg kg) (Figure 2b).

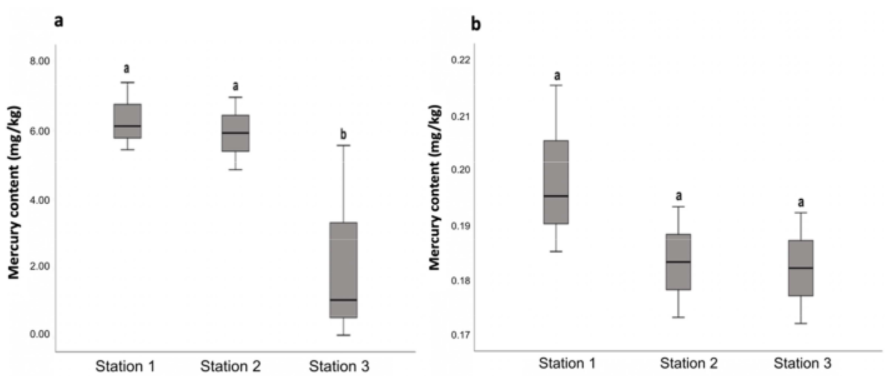

Figure 2. Comparisons of mercury content in sediments (a) and Seurukan Fish livers (b) between sampling stations.

The measurement results of physical and chemical parameters of the Krueng Sabee River waters show that the temperature and pH range between stations tend to be similar, ranging from 29.7 - 32.4°C and 8.15 - 8.43, respectively. Station 2 and station 3 had lower brightness values than station 1, ranged from 29 - 42.5 cm, 19 - 65.5 cm, and 106 - 137.5 cm respectively. Otherwise, station 1 has a lower current speed (16.0 - 18.87 cm/s) than two other stations. Dissolved oxygen content at station 1 and station 2 tended to be identical (5.2 - 5.7 mg/L) and higher compared to station 3 (3.8 - 4.4 mg/L) (Table 1).

Table 1. The range of physical and chemical parameters of waters at each sampling station.

Parameter	Station		
	Station 1	Station 2	Station 3
Temperature (^{o}C)	30.4 – 32.4	30.0 – 30.7	29.7 – 30.7
pH	8.27 – 8.43	8.15 – 8.23	8.15 – 8.20
Brightness (cm)	106 – 137.5	29 – 42.5	19 – 65.5
Current speed (cm/s)	16.0 – 18.87	20.71 – 24.51	19.22 – 39.23
Dissolved oxygen (mg/L)	5.2 – 5.7	5.2 – 5.7	3.8 – 4.4

The highest sediment mercury in the upstream area may partly be ascribed to its location close to illegal traditional gold mining and milling. Based on information from residents, illegal traditional gold mining and milling activities were found in mountains hinterland areas which are still included in the upstream area of the river. In addition, station 1 also has a low current which makes the mercury was more easily deposited to the bottom area of the river. Temporally, the mercury content in the Krueng Sabee River was higher than previously reported by Purnawan et al. in 2017, which was 0.76 mg/kg. This indicates that there is an increase in gold mining activities by local residents.

Condition factors and hepatosomatic index

Seurukan Fish condition factor observed from each station tends to show similar results. The highest value of the condition factor was at station 1 (1.004±0.075), while the lowest value was at station 3(0.975±0.119). Statistical analysis showed that there was a not significant difference of condition factor between stations ($p > 0.05$) (Figure 3a). Otherwise, statistical analysis showed a significant difference between the HSI values at stations 1 and 2 compared to station 3 ($p < 0.05$). The highest mean value of HSI for Seurukan Fish was observed at station 3 (0.447 ± 0.322%), while the lowest value was at station 1 (0.356 ± 0.257%) (Figure 3b).

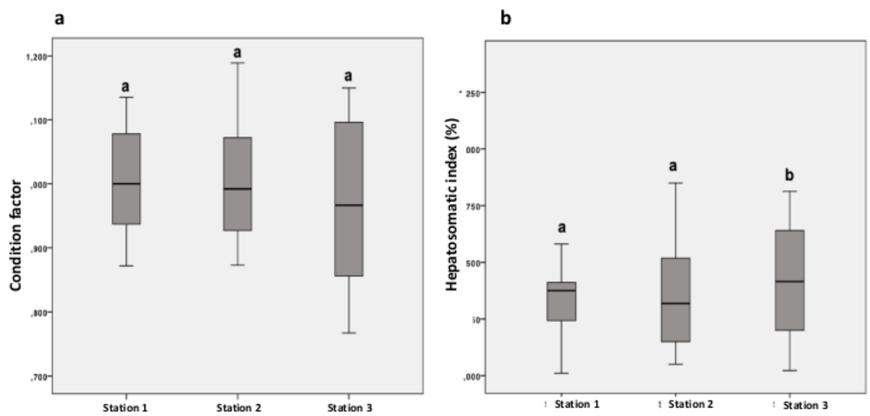

Figure 3. Condition factor (a) and hepatosomatic index (b) of Seurukan Fish in each sampling station.

The mercury contamination may harm Seurukan Fish's health. Although the statistical results did not show a significant difference in the mercury content in fish liver between stations, the HSI value of fish at Stations 1 and 2 was lower than Station 3. It could indicate an alteration in Seurukan fish liver function. A similar previous study by Zulfahmi et al. (2014) also reported an increase and decrease in the HIS value of Nile tilapia after mercury exposure. At low concentrations, mercury exposure can increase the HSI value of Nile tilapia. While, at higher mercury concentrations, the HSI value of Nile tilapia decreased significantly.

A higher value of HSI might occur due to the presence of cytoplasmic vacuolization in liver cells (Zulfahmi et al., 2014; Zulfahmi et al., 2015). Zulfahmi et al. (2017) stated that histologically, the liver of fish exposed to pollutants increased hydrophilic degeneration, resulted in enlargement of liver cells, and increased HSI value. The hydrophilic disturbance of fish liver cells will worsen with the increases in mercury concentration. Therefore, the liver cell nucleus becomes depressed and shrink, resulting in cell death (necrosis) (Zulfahmi et al., 2017). Reducing the HSI value was probably due to the depletion of energy reserves in the liver in response to stressful conditions (Verma & Prakash 2019).

Sex ratio, length-weight relationship, and length-weight frequency distribution

Morphometrically and morphologically, Seurukan Fish have a pinnae dorsalis supported by 3 hard pinnae and 12-18 soft pinnae. The pinnae caudalis was in fork form and symmetrical. The analis pinnae supported by 3 hard and 5 soft spokes. The Pinnae ventralis/abdominalis supported by 1 hard and 8 soft spokes. The pinnae pectoralis supported by 1 hard spoke and 13-15 soft spokes. The female Seurukan Fish has a fat and large body posture, the abdomen was enlarged. There are two pairs of tentacles on the mouth, and the body color is yellowish gray. The pinnae dorsalis and the pinnae caudalis are red. Meanwhile, male Seurukan Fish have long and slender body posture, dark green scales, pinnae caudalis have bright red color, nimble movements, rough pectoral fins, and a hard stomach when touched (Figure 4).

Table 2. Sex ratio of male and female Seurukan Fish at each sampling station.

Station	Male (Individu)	Female (Individu)	Sex Ratio
Station 1	21	9	3:1
Station 2	11	19	1:2
Station 3	18	12	2:1

Stations 1 and 3 have a higher ratio of male Seurukan fish compared to female fish. Otherwise, Station 2 had a higher female fish ratio than male fish, namely 3: 1, 2: 1, and 1: 2 (Table 2). The highest male fish was observed at station 1 (21 individu), while the lowest was at station 2 (11 individu). On the other hand, station 2 has the highest composition of female fish (19 individu), while station 1 had the lowest value (9 individu).

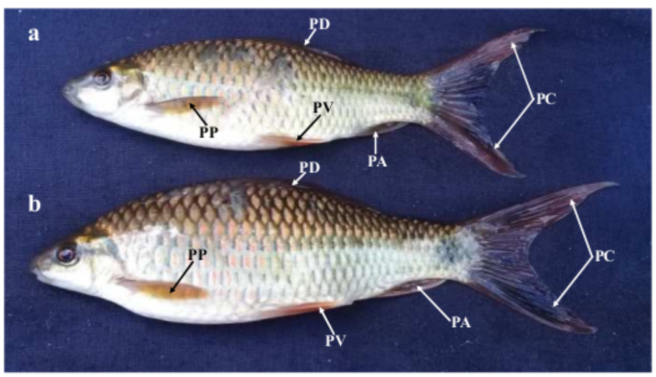

Figure 4. Morphology of male (a) and female (b) Seurukan Fish. Pinnae Dorsalis (PD), Pinnae Caudalis (PC), Pinnae Analis (PA), Pinnae Ventralis (PV), Pinnae Pectoralis (PP).

The equation for the length-weight relationship for each station were calculated as $W = 0.00016L^{2.513}$ for station 1, $W = 0.0006L^{2.729}$ for station 2 and $W = 0.001L^{2.171}$ for station 3 (Figure 5). The fish at all stations have the same growth pattern, which was negative allometric. The highest value of b was observed at station 2 (2.729), while the lowest was at station 3 (2.171) (Table 3).

Table 3. Descriptive statistics and estimated parameters of length-weight relationship for Seurukan Fish in each sampling station

Station	N	a	b	95% Cl (b)	R^2	Growth Pattern
Station 1	30	0.00016	2.513	2.288-2.738	0.949	Negative allometric
Station 2	30	0.00006	2.729	2.534-2.913	0.974	Negative allometric
Station 3	30	0.001	2.171	1.812-2.529	0.845	Negative allometric

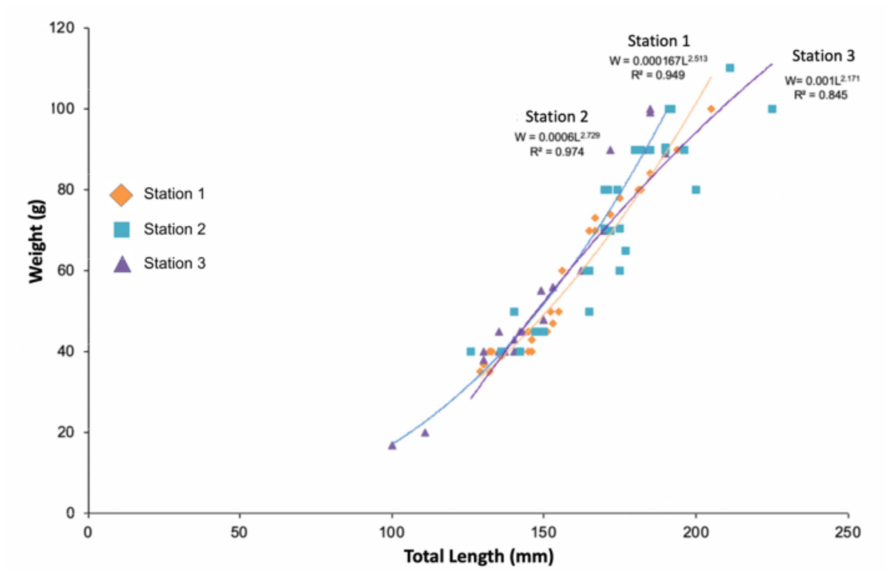

Figure 5. Length-weight relationship for Seurukan Fish in each sampling station.

A total of 90 fish were collected during this study (30 fish of each station). The length of the fish ranged from 100-225 mm. The shortest fish was observed at Station 2, while the longest was at Station 3. The fish specimens at station 1 were ranged from 129-205 mm. The majority of fish at Station 1 had a length range of 132-147 mm (40%). The fish specimens at Station 2 were ranged from 100-190 mm. Similar to station 1, the majority of fish at Station 2 had a length range of 132-147 mm (33.33%). The majority of fish specimens at station 3 (36.67%) had a longer size than Stations 1 and 2, ranging from 164–179 mm (Figure 6).

The total weight of fish specimens was ranged from 17-110 g. The lowest fish weight was found at Station 1, while the heaviest was found at Station 3. The majority of fish caught at Station 1 had a weight range of 39-49 g (43.33%). Similar to Station 1, the majority of fish specimens at Station 2 had the same weight range as Station 1. The majority of fish specimens at Station 3 had a lighter weight range than Stations 1 and 2, 83-93 g (23.00%) (Figure 7).

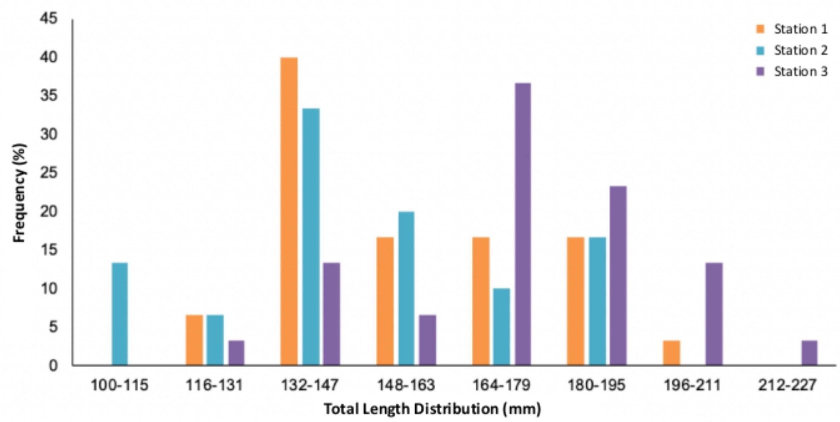

Figure 6. Length–frequency distribution of Seurukan Fish

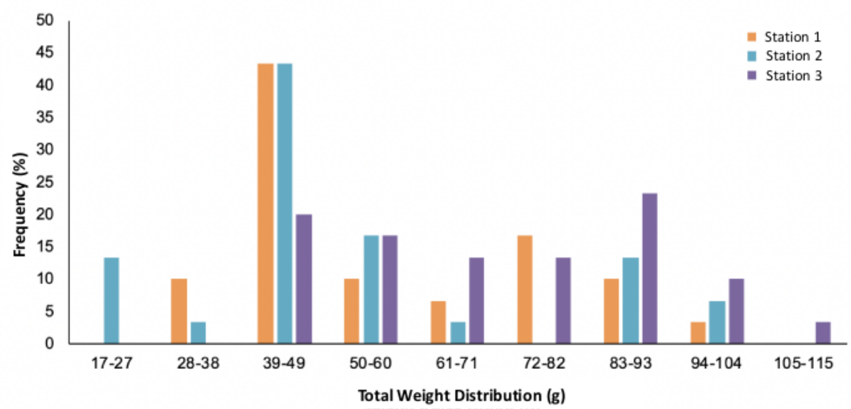

Figure 7. Weight–frequency distribution of Seurukan Fish

Higher concentrations of mercury observed at Stations 1 and 2 might be responsible for a negative impact on length-weight growth and the sex ratio of Seurukan Fish. The majority of fish caught at Stations 1 and 2 tend to have a smaller size (both length and weight) compared to Station 3. These might occur due to disturbances in the digestion and absorption process of food as well as increased energy allocation for detoxification and reproduction (Ezraneti and Wirdanti, 2015; Giari et al., 2008). Ezraneti and Wirdanti (2015) revealed several alterations on the stomach's epithelial layer in white snapper (*Lates calcarifer*) exposed to mercury. It caused a decrease in the feeding ability of fish, resulted in reducing fish growth.

The present data showed that Station 1 tends to have a more unbalanced sex ratio compared to Stations 2 and 3. It might occur due to reproductive hormone dysfunction in fish after mercury exposure. Several researchers reported reproductive hormone dysfunction in fish exposed to several pollutants, for instance, lead (Łuszczek-Trojnar et al., 2014), Bisphenol A (Zahran et al., 2020), and Bifenthrin (Bertotto et al., 2019). This hormonal dysfunction causes sexual differentiation in the form of feminization and masculinization. The unbalanced sex ratio of fish will disrupt the structure of fish populations in an ecosystem.

The Seurukan Fish collected in this study had a negative allometric growth pattern. This growth pattern tends to be different from other Seurukan Fish collected from unpolluted waters. Several studies reported that fish were collected from unpolluted water such as Batang Hari River, Temengor Reservoir, and Lake Singkarak tend to had isometric to positive allometric growth patterns (Kaban et al., 2019; Sekitar et al., 2015; and Uslichah & Syandri, 2003). Similar phenomena were also observed in fish collected from polluted waters, such as the Pening Swamp tend to have a negative allometric growth pattern (Rochmatin et al., 2014). According to Umar and Kartamihardja (2017), the growth and performance of aquatic biota were mainly determined by the availability of food, the size and type of food eaten, environmental quality, and condition of the fish (age, heredity, and genetics).

Conclusion

Results showed that the mercury content in the Krung Sabee River sediments was increased both spatially and temporally. Station 1, located in the upstream area, has the highest sediment mercury content, which was 6.278±0.987 mg/kg. The mercury content in the liver of the fish in the Krueng Sabe River ranged from 0.182±0.100 to 0.198±0.152 mg/kg. Mercury exposure caused a negative impact on the biometric conditions of Seurukan Fish. Seurukan Fish exposed to mercury tend to have smaller sizes, unbalanced sex ratios, low HSI values, and negative allometric growth patterns. However, further research related to the negative impact of mercury contamination on fish digestibility and the reproductive system should be done.

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