

Biological Parameters of Flowerhorn Cichlid in Panglima Besar Soedirman Reservoir, Indonesia

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Abstract Flowerhorn cichlids are potentially invasive fish species because of their wide ranged in trophic level and reproductive properties. This study aims to analyze several biological parameters of flowerhorn cichlids in Panglima Besar Soedirman Reservoirs that consist of many native fishes from Serayu River. Fish were collected from the fisherman that operated using multiple gears and landed the flowerhorn fish in Seakong Fish Market, Wanadadi, Banjarnegara, Indonesia from August to October 2025. Fish were then analyzed in Pescica Marina Laboratory of Fisheries and Marine Science, Universitas Jenderal Soedirman. Biological aspects that were assessed consist of morphology, length-weight relationship (LWRs), relative condition factor (Kn), gonadosomatic index (GSI), length at the first capture (Lc), and maturity (Lm). The results showed that males have a higher condition factor (1.05), although with a negative allometric growth pattern ($b < 3$). Conversely, the female was heavier (444.34 ± 26.34 g) and longer (117.58 ± 22.84 mm). The mean gonadosomatic index for male (0.75) and female (4.70) are related to the gonad maturity stage in which the male are mostly immature to maturing but females are dominantly mature. The length of maturity of female is 91 mm while male is 219.2 mm, and their length at the first capture is 107.9 mm and 109.5 mm, respectively.

Keywords: Cichlids, Gear Selectivity, Introduced Fish, Midas Cichlids, Serayu River.

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Received: 24 Nov. 2025
Accepted: 7 Jan. 2026

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Introduction

The Panglima Besar Soedirman Reservoir, located in Bawang District, Banjarnegara Regency, was built for several purposes by damming the Serayu River Basin and became the habitat for many aquatic organisms (Anggraini *et al.*, 2019; Samudra *et al.* 2024). The P.B. Soedirman Reservoir functions as a hydroelectric power plant (PLTA) that supplies electricity to the Java and Bali regions. In addition, this reservoir can be used as a water source for capture fisheries with a floating net cage system and as a tourist attraction (Alfianto, 2014; Samudra *et al.* 2024). Since, the water originally came from Serayu River, the fish composition in the P.B. Soedirman Reservoir consists of fish native to the Serayu River such as bream (*Puntius orphoides* Valenciennes, 1842), Asian redbtail catfish (*Mystus nemurus* Valenciennes, 1840), twospot catfish (*Mystus nigriceps* Valenciennes, 1840), Hampala barb (*Hampala macrolepidota* C.V. 1823), and bonylip barb (*Osteochilus hasselti* Valenciennes, 1842) as well as introduced fish such as snakehead fish (*Channa striata* Bloch, 1793) tilapia (*Oreochromis niloticus* Linnaeus, 1758), flowerhorn fish, and marble goby (*Oxyeleotris marmorata* Bleeker, 1852) (Rukayah & Lestari, 2021).

The presence of alien fish such as flowerhorn fish in the P.B. Soedirman Reservoir is feared to have a negative impact on various sectors. Alien species can cause a decline in biodiversity and habitat degradation as well as economic losses (Evangelista *et al.*, 2015). The flowerhorn fish was originally an ornamental fish that was a cross between various Cichlidae families originating in Central America (Sari *et al.*, 2023). Currently, flowerhorn fish are found in many parts of Southeast Asia, including Indonesia. The presence of flowerhorn fish in Indonesian waters is very dangerous because they have the potential to become invasive fish with characteristics such as high adaptability, aggressiveness, omnivorousness, and fast reproduction (Knight, 2010). These characteristics make flowerhorn fish competitors for food and habitat, predators, and even a source of parasites and disease (Hedianto & Satria, 2018). The potential damage to biological resources by the flowerhorn fish has been extensively studied in Lake Matano because it is suspected to be the cause of the decline in the population of endemic fish in the lake. In Lake Matano, based on the research results of (Hedianto & Satria, 2018) it was reported that this fish has dominated more than half of the catch.

The negative impact of the presence of flowerhorn fish on Java Island has not been studied intensively. However, the presence of alien fish has been widely found in various water bodies on Java Island. Several studies related to flowerhorn fish that have been conducted on Java Island are in the Sempor Reservoir, which shows a decline in the number of economically valuable fish catches replaced by flowerhorn fish, which have low economic value (Hedianto & Satria, 2018). Due to the potential damage to biological resources caused by the introduction of flowerhorn fish into various waters, one control measure that can be taken is to estimate the population parameters of flowerhorn fish. This study aims to determine the resilience of the flowerhorn fish population and determine control measures based on the condition of the fish population in its new habitat.

The presence of flowerhorn fish as an invasive species with an abundant population in this reservoir poses a serious threat to the sustainability of native fish biodiversity in the P.B. Soedirman Reservoir. One scientific approach to evaluating the impact of fish invasion on the ecosystem is to study its population dynamics to understand its potential for expansion, population resilience, and its role as a competitor and predator in its new environment (Detmer *et al.*, 2025). Population parameter estimates can be used to design effective control strategies, including selective capture of gonadally mature individuals, thereby suppressing the reproductive potential of flowerhorn fish (Fadlovich *et al.*, 2025) to reduce their numbers in the P.B. Soedirman Reservoir.

Studies on the presence of flowerhorn fish in Indonesia have been conducted in several regions because flowerhorn fish invasions have been widely found in Indonesia. However, most studies on flowerhorn fish in Indonesia have been conducted in Lake Matano (Hedianto & Satria, 2018; Sentosa & Hedianto, 2019). On the island of Java, studies on flowerhorn fish have been conducted in the Sempor Reservoir by Hedianto *et al.*, 2014). At the P.B. Soedirman Reservoir, studies have been limited to the composition and abundance of fish (Humanica *et al.*, 2024) and biological aspects, which show that flowerhorn fish have great potential as invasive fish. Therefore, in order to obtain comprehensive information regarding the impact of flowerhorn fish invasion in the P.B. Soedirman Reservoir, it is important to conduct a study on the reproductive biology of flowerhorn fish.

Materials and Methods

Study Sites and Sample Collection

Sample collection of flowerhorn fish was carried out in Panglima Besar Soedirman Reservoir, Banjarnegara Regency, Indonesia from August to September 2025 with three frequencies of sampling. As many as 249 fish were gathered from fishermen that landed their captured fish from P.B. Soedirman Reservoir to Seakong Fish Market (Figure 1) using multiple gears such as gillnets, umbrella fishing net trap, and fishing rod while laboratory analyses were performed at Pescica Marina Laboratory, Faculty of Fisheries and Marine Science, Universitas Jenderal Soedirman.

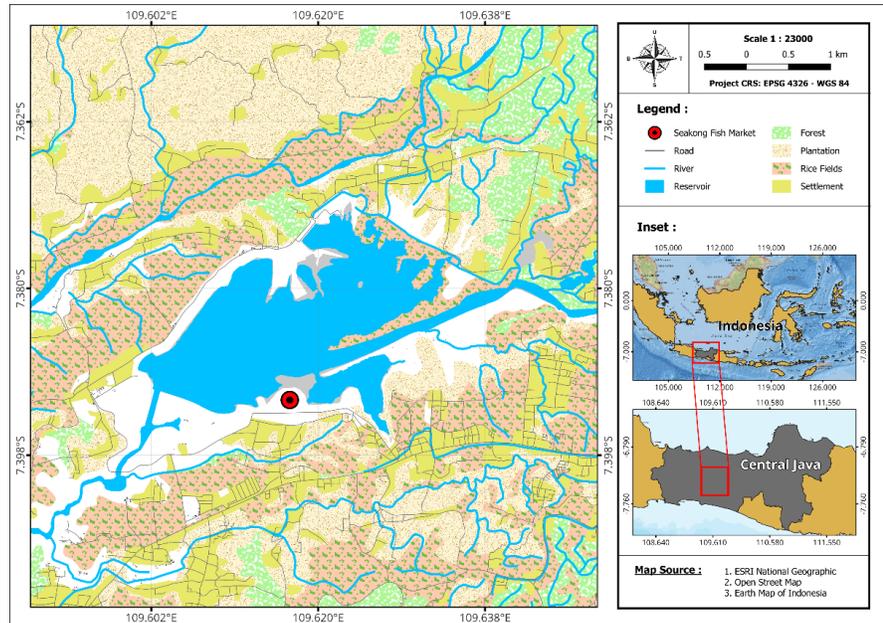


Figure 1. Location of Panglima Besar Soedirman in Wanadadi District, Banjarnegara Regency, Central Java Indonesia

Sample Preparation and Gonad Identification

Fish sample were measure for their length and weight before being dissected to ascertain their sex and stage of gonadal maturity. The collected fish were measured the total length with 1 mm digital caliper and the weight was measured by digital scale with an accuracy of 0.01 gram. Fish gonad was examined for sex differentiation by dissecting the gonad. The shapes and color of testes and ovaries were used to determine the gonadal maturity stages. Gonad weight (GW) was measured by using 0.001 g to gonadosomatic index (GSI).

Data Analysis

The total length of fish will be used to create the length frequency distribution for both male and female. Besides, it is also used for analyzing the length-weight relationship (LWRs) that was performed using linear regression. The formula that is used to analyze the length-weight relationship is $BW = aL^b$, BW for the body weight, L is the total length (mm). The value of slope (b) will be used to determine the growth pattern of the fish which showed positive allometry if $b > 3$, negative allometry if $b < 3$ and isometric if the b is equal to 3 then the T-test will be applied to confirm if the $b = 3$ or $b \neq 3$, statistically. The value of a (intercept) and b (slope) for LRWs also used for determining the relative condition factor (Kn) based on (Le Cren, 1951) where $Kn = W/W^*$. W represents the observed weight of fish (g) while W^* is the expected weight that is obtained from LRWs. Both Length-Weight Relationships and relative condition factor will be performed for both male and female flowerhorn cichlids.

The ovaries and testes that have been collected were analyzed their maturity stages by comparing with the description of gonadal maturity of cichlid fish based on (Araújo *et al.*, 2012). The weight of the ovaries and testes also used to calculate gonadosomatic index (GSI) following the formula that $GSI = GW/BW$. GW is defined as gonad weight (g) while BW is body weight (g). Length and maturity data were combined to analyze the length at the first maturity (Lm) which is defined as the size when 50% of observed fish reach gonadal maturity. Lm was calculated using the Spearman-Kaber Method proposed by Udupe, (1986) as follows:

$$m = Xk + \frac{X}{2} - (X \sum P_i)$$

the Lm value obtained by applying the antilogarithm of m value. Xk is defined as the logarithm of the length of the last fish that has reached maturity. X value is the logarithmic of the median, and Pi refers to the proportion of fish that have matured in each length-classes. Length at the first capture (Lc) is represent the length at which 50% of collected fish retained in the gear. Lc was estimated by plotting the

the cumulative frequency against length-class. This method follows the formula by Spare & Veneme (1992) SL define as the estimated of fish retained, L is the median of length-class, while S1 and S2 are constants that are used in the logistic curved formula.

$$SL = \frac{1}{1 + \exp^{(S_1 - S_2 * L)}}$$

Results and Discussion

Morphometric Characters

A total of 249 flowerhorn fish were collected which consists of 87 female and 162 male fish. Female fish consist of immature which range in size from 55 mm to 141,1 mm while mature female fish ranged are between 57,1 mm and 145,8 mm. Immature male fish range in size between 52 mm to 200 mm while it is only one individual of fish that had reached mature stages with size was 150,4 mm. In several location in Indonesia, such as in Lake Mahalona, where this fish became successfully invasive, this fish was recorded to have length 10-18 cm varied by observed area (Nasution *et al.*, 2022). While in their native environment, in Central America the length can reach up to 35 cm (Magalhães *et al.*, 2017). Overall, the male fish are larger than female both the mature and immature fish (Table 1). That is also similar to the results from Hediando *et al.*, (2018) which found that male are larger than female fish also found in other cichlids such as *Amphilophus citrinellus* (Oldfield, 2005). The different size between male and female are due to the consequences of male in sexual selection which favors larger size to attract female fish. The difference size that obtain from those several research showed that Cichlids, as well as flowerhorn cichlids underwent adaptive spectacular capability in response to the changes in the environmental, sexual and social selection (Araújo *et al.*, 2012).

Table 1. Ranged and average of Length (mm) and weight (g) of female and male flowerhorn cichlid from Panglima Besar Soedirman Reservoir arranged by length-classes interval (mm). Standard deviation (SD) also provided for both length and weight data

Female				
No.	Length-Classes (mm)	Number	Average Length ± SD (mm)	Average Weight (g)
1	52-71	2	62.60 ± 10.75	5.420 ± 3.16
2	71.01-90.01	11	85.31 ± 3.43	14.12 ± 5.18
3	90.02-109.02	14	101.74 ± 5.10	26.12 ± 4.00
4	109.03-128.03	45	125.04 ± 14.90	53.09 ± 22.71
5	128.04-147.04	13	135.89 ± 4.51	60.30 ± 17.68
6	147.05-166.05	0	-	-
7	166.06-185.06	0	-	-
8	185.07-204.07	2	174.10 ± 5.52	76.54 ± 78.59
9	204.08-223.08	0	-	-
Total		87	117.58 ± 22.84	44.34 ± 26.34
Male				
No.	Length-Classes(mm)	Number	Average Length (mm)	Average Weight (g)
1	52-71	2	53.25 ± 1.77	16.97 ± 19.90
2	71.0-90	14	79.66 ± 4.25	16.13 ± 10.96
3	90.0-109	61	102.02 ± 4.47	27.66 ± 9.93
4	109.-128	59	117.99 ± 5.15	38.74 ± 8.45
5	128.-147	16	134.50 ± 4.44	63.25 ± 11.87
6	147.-166	3	155.24 ± 8.46	93.61 ± 23.89
7	166.-185	1	182 ± 0	165.00 ± 0
8	185.-204	4	195.30 ± 3.40	134.48 ± 75.97
9	204.-223	2	216.60 ± 9.05	242.23 ± 30.81
Total		162	113.70 ± 25.05	41.43 ± 35.42

Growth and Condition Factor

The analysis of growth based on length and weight relationships is provided in Table 2 and Figure 2 which depicted that the weight of female only determined by the length by 65% although the correlation between the length and weight as many as 80%. However, male flowerhorn cichlid revealed higher determination of length to the weight by 80% and its correlation reaches 89%. Based on the regression model and t-test analysis, male flowerhorn fish have negative allometric growth pattern with $b=2.334$ ($t_{5,11} > t_{tab 1,97}$) while the female exhibited an isometric growth pattern with b value at 2.875 ($t_{0,67} < t_{tab 1,98}$). In Lake Mahalona, Indonesia, the LWR of *Amphilopus trimaculatus*, the ancestor of flowerhorn hybrid, reported to have negative allometric growth pattern which means that the fish will grow longer compare to their weight and resulting slimmer body shapes (Nasution *et al.*, 2022)

The difference in growth pattern between male and female growth pattern is the responsibility of their role in ecology and reproductive activity. Male cichlids mostly experience intense sexual selection for features such larger heads, bodies, or ornamentation, which can result in disproportionate increases in length in relation to weight (negative allometry) (Novikova, 2025; Tsuboi & Takahashi, 2024). On the other hand, females fish exhibit isometric growth pattern or their increase in length and weight are proportional. This finding is also in accordance with the result from Baldauf *et al.*, (2010) which state that flowerhorn cichlids revealed proportional growth in several traits. The results might be associated with the reproductive investment of female fish since mature stages will store their energy which will be allocated for somatic and gonad development which results in increasing length and weight (Dinh *et al.*, 2022). Besides, as many female cichlids are multiple spawners, they will invest energy in both somatic and gonadal growth which leads to isometric growth (Silva *et al.*, 2015)

Table 2. Value of Length-Weight Relationships (LRWs) resulted from regression analysis with intercept (a), slope (b), coefficient determination (R^2), coefficient correlation (r) and type of growth pattern

Sex	a	b	R^2	r	Growth Pattern
Female	0.00004	2.875	0.650	0.80	Isometric
Male	0.00057	2.334	0.801	0.89	Negative Allometric

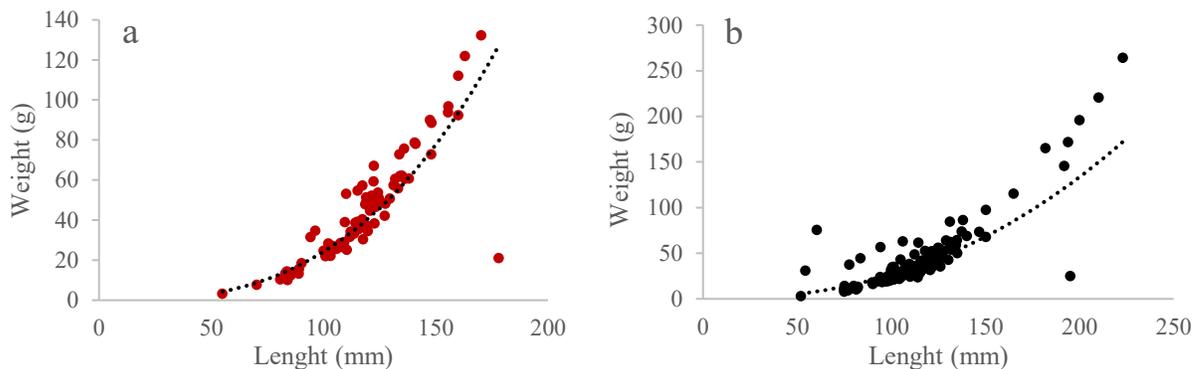


Figure 2. Linear regression of length and weight of female (a) depicted by red and male in black dots (b).

The condition factor of male and female based on length-classes is provided in the Figure 3 which showed that the relative condition factor of male overall is greater than female in all length-classes and different statistically based on the Mann-Whitney Test (P -value < 0.05). The ranged of relative condition factor of male is 0.99-2.67 with the highest condition factor of male fish found in the fish that grouped into length 52-71 mm while the rest of the group are below 2. Female fish exhibited lower value in which the average is only accounted for 0.83 from all length-classes. The higher relative condition factor of female is correlated with the mean weight (g) for male in all classes which depicted higher value than female due to female having a slower somatic growth rate for reproduction efficiency. It also supported by Mlingi *et al.* (2024) & Okuda (2001) that generally female fish will experience severe condition factor during or prior to spawning since they will used up the maintained energy for gonad and egg production. For example, the reduction of condition factor in *C. menezesi* is due to the decline in metabolic and feeding activity (Araújo *et al.*, 2012). Both female and male GSI that were correlated by using Spearman's Rank Correlation reveal negative correlation between GSI and Kn although in female the p -value is not significantly different (p -value > 0.05). Thus, it explained that the reserved energy will be activated for gonad development.

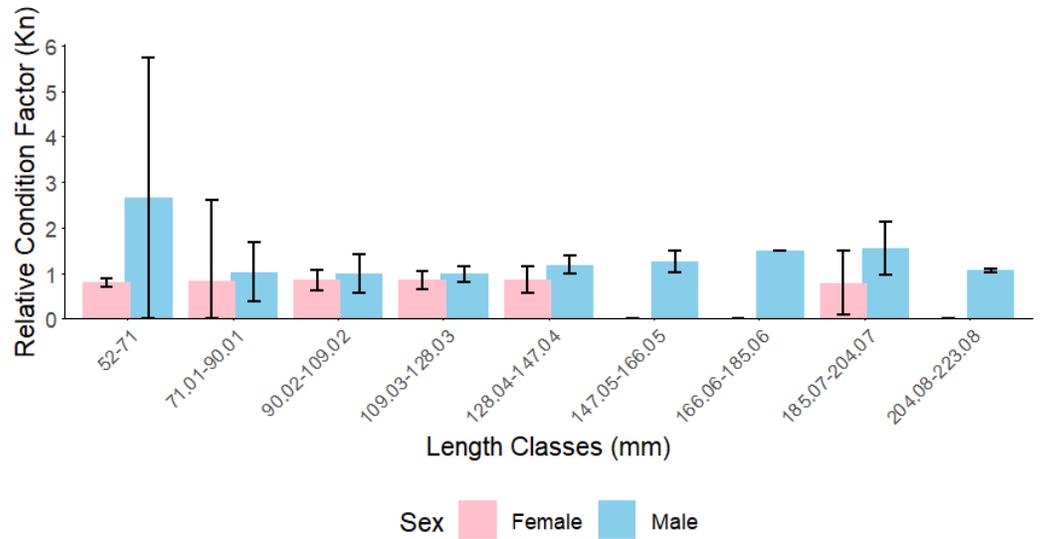


Figure 3. Relative condition factor (Kn) for male illustrated in pink bars and male in blue bars according to length-class interval (mm) with the error bar

Reproduction

Gonadosomatic Index (GSI) is a commonly used metric to evaluate reproductive investment. The mean value of gonadosomatic index (GSI) of male and female depicts higher in female. Figure 4-5 showed that ranged of male median GSI from 0,28 to 3,44 which the modus found in 0,67 until 1,07 of median GSI that counted for 55 and 61 individuals respectively. The frequency of individual continued to decline as the GSI increased which explained that male mostly have lower GSI. The median for female, whereas, depicted higher proportion as it ranged started from 1,06 to 14,75. Female that their median GSI ranged from 1,06 to 8,88 is accounted for more than ten individuals, while the rests is below 5 individuals. Thus, its illustrate that female fish will spawn earlier to the male fish since male fish will spend smaller energy budget for gonad development than female and devoted bigger portion for somatic growth. Similar report come from *A. citrinellus* that collected from Lake Cilodong (Indonesia), showed that female will exceed the male in term of GSI which is typical for various fish (Akhadiana *et al.*, 2023). Female fish will also have higher GSI because the collected fish in this study constituted of mostly mature female, which have heavier ovarium mass that resulting in greater GSI than male. Ohee *et al.*, (2020) stated that higher GSI in female compare to male indicate that majority of female is in gravid phase.

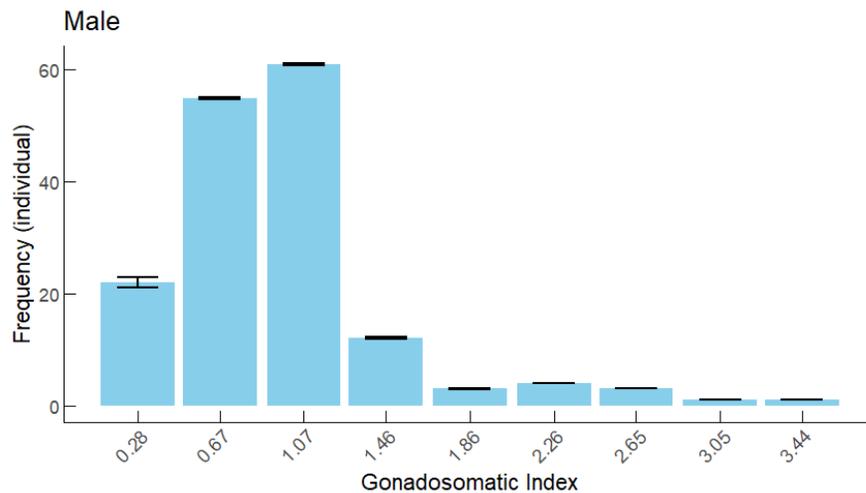


Figure 4. Gonadosomatic Index of male fish. The x-axis value is the median of gonadosomatic index-class interval

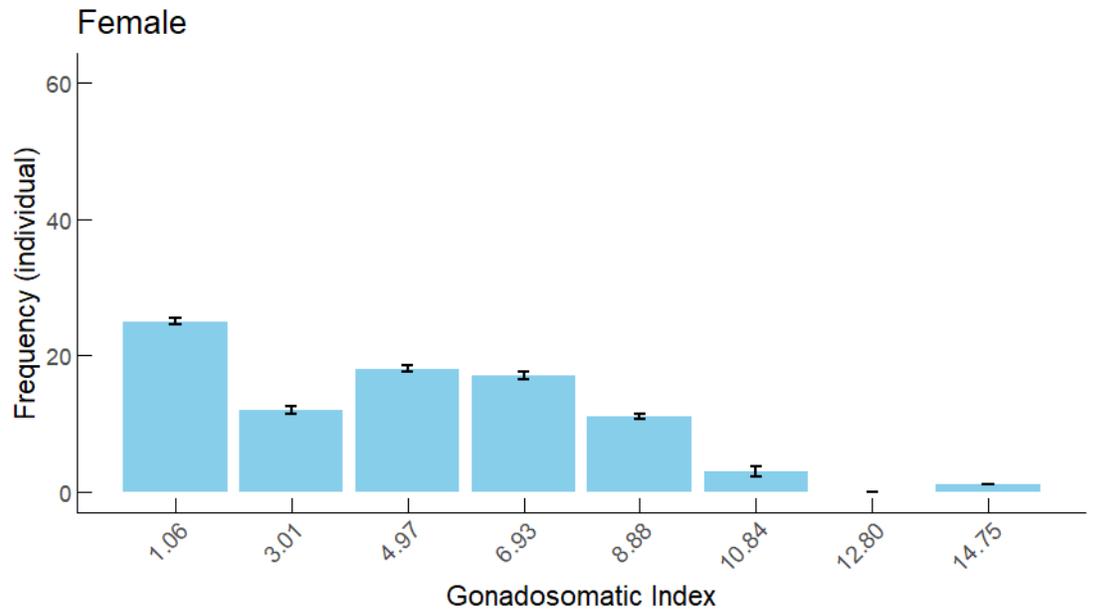


Figure 5. Gonadosomatic Index of male fish. The x-axis value is the median of gonadosomatic index-class interval

This finding is also supported by the gonad maturity stages of female and male fish which exhibit that males are dominated by fish that in immature to maturing stages while female show varied maturity stages (Figure 6). Although, there is one individual that has reach mature stages in 147.05-166.05 mm. The proportion of immature male fish is decreased as the length increases and replaced by the maturing male which proportion started to escalate from 128.04-147.04 to 204.08-223.08 mm. The gonad maturity stages of female fish are varied from immature to partially spawn although they are dominated by mature female. Mature individual has already appeared in the first length-classes (52-71mm) and their proportion remained high in all length-classes. The partially spawn fishes also appeared in the second length-classes may indicated that the female fish spawn all years round and can be categorized as partial spawner.

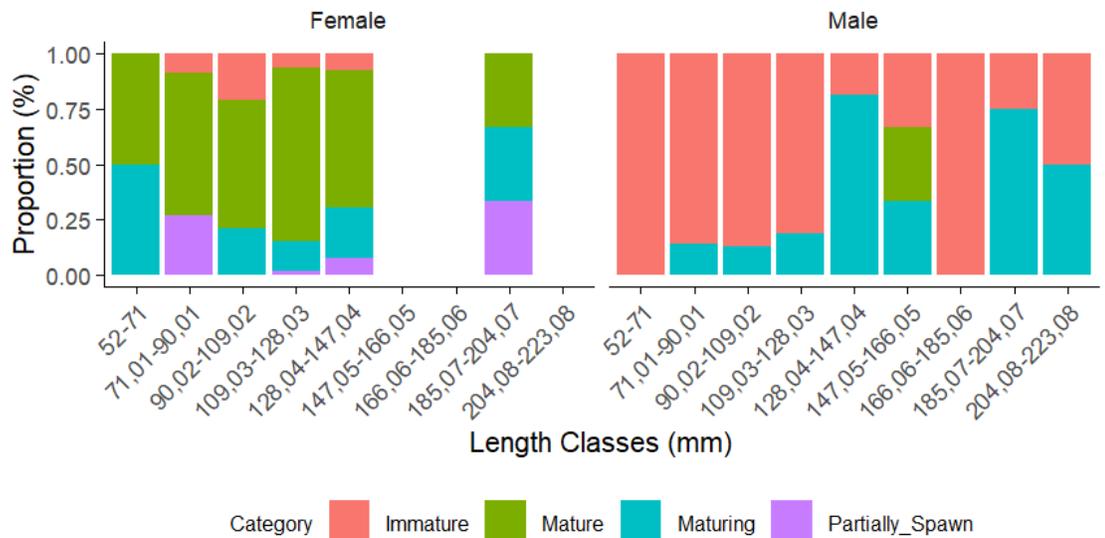


Figure 6. Gonad maturity stages of both male and female fish based on interval length-classes (mm)

Length at the First Catch and Maturity

The length at first capture of female fish is 107.9 mm while male fish are 109.5 mm which revealed that the size of male fish that were caught is larger than female fish (Figure 7). However, female fish reach their first maturity earlier than male at 91 mm, while male is 219.2 mm which indicated the reproductive aspect of female fish develop earlier than male. Similar pattern is also displayed from the flowerhorn fish in Lake Matano, Sulawesi, Indonesia in which male mature at 126 mm while female mature at 102 mm (Hedianto *et al.*, 2018). Male cichlids mostly allocate energy for growth, especially somatic growth when they are not in the reproduction phase (Santos *et al.*, 2023). Somatic growth is advantageous for male because larger male cichlids will win the competition for female in male-male competition in the wild which is common in most cichlids (Rogers, 1995; Thünken *et al.*, 2011). Thus, this pressure led to male take longer period for reaching maturity than female. Besides, female will also reach maturity earlier than males since they will save their energy for gonad development onward from somatic development.

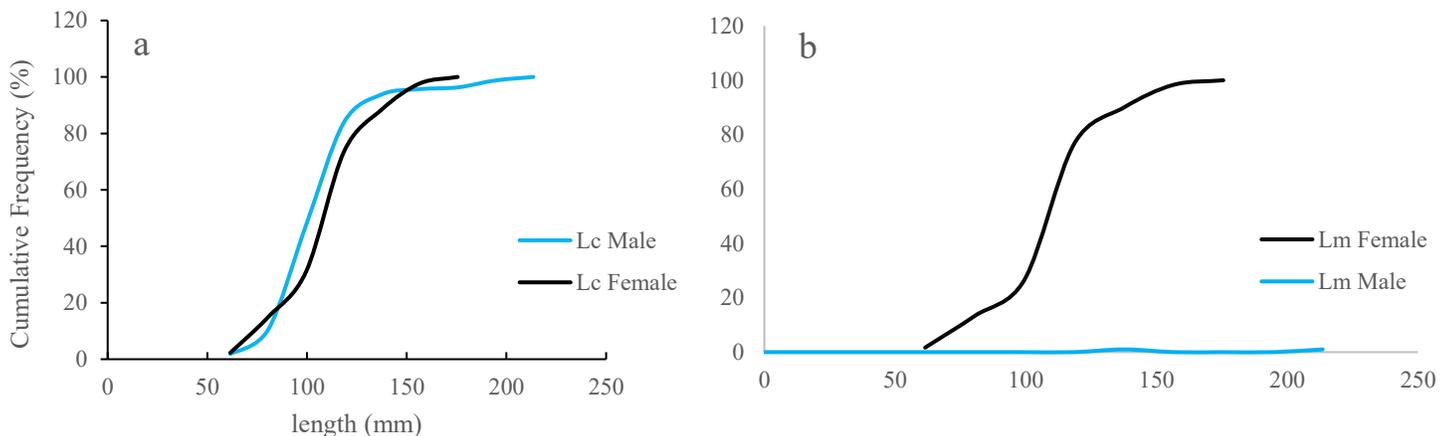


Figure 7. Length at the first capture of female depicted by black and male in blue line (a). Male and female length at the first maturity length depicted in figure (b) with the blue line indicate the male while the black depicted the female

Flowerhorn cichlids and other cichlids fish in Indonesia have been reported as the invasive species in several water bodies such as Lake Mahalona and Lake Matano, which abrupt the population of the endemic fish species. Although there is no record of endemic fish in this study site, but Panglima Besar Soedirman Reservoir harbor the fish native from Serayu River. Thus, the length of maturity can be the insightful information to govern the population of this fish. The length at the first maturity of flowerhorn cichlids in this study is similar to other species whose belongs to the *Amphilopus citrinellus* in Lake Panjalu, Indonesia mature in 11-17 cm (Warsa & Purnomo, 2013). Moreover, the length at first capture for flowerhorn cichlids using experimental gillnet in Lake Matano, Indonesia showed that the fish mature at 12-14.2 cm (Sentosa & Hedianto, 2020). The correlation of Lm and Lc in case of managing invasive species is that can be a useful information for instance, creating mesh size that can caught the fish effectively before it matures. Hence, according to this study to cope with the invasion of this fish, physically removing the flowerhorn fish from this reservoir can be performed by designing gear that can capture the fish under the Lm, 91-219.2 mm.

Conclusions

The male flowerhorn fish that are collected in this current study are larger in length (mm) but the female outweigh male in weight (g) which is also supported by the relative condition factor due to male invest more energy on somatic growth especially for sexual selections. The growth pattern of male is also negative allometric ($b < 3$) while the female exhibited isometric growth pattern ($b = 3$) which has balanced growth in length and weight. Reproduction aspect of flowerhorn fish revealed female GSI exceed the value of males since most female is found in mature stages with gravid phase, while majority of male is immature to maturing. In order to manage wild potentially invasive species, such as flowerhorn cichlids, in Panglima Besar Soedirman Reservoirs, length at the first maturity and length at the first capture in this report can be used as basic information for exploiting flowerhorn fishes below the length at the first maturity of male and female flowerhorn cichlids.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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