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RESEARCH ARTICLE

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Study of Population Dynamics Silver Rasbora (*Rasbora argyrotaenia* Bleeker, 1849) in PB. Soedirman Reservoir, Banjarnegara

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Abstract

Silver rasbora (*Rasbora argyrotaenia* Bleeker, 1849) is one of the native species found in Panglima Besar (PB.) Soedirman Reservoir. High economic value of silver rasbora causes fishermen to tend overfishing. This over-exploitation threatens the native species of fish. Therefore, this study aims to determine several parameters of fish population dynamics so that they become the basis for fisheries management. Sampling was carried out at the PB. Soedirman Reservoir in November 2021, January 2022, and March 2022 using a survey method. The result of this research is, the population of silver rasbora was 3097 individuals dominated by male and small-size fish 0.5-8.5 cm. Length and weight relationship obtained b value <3 which means it is negative allometric. The condition factor ranged from 1.005 to 1.068. Total mortality value (Z) 6.21 per year, natural mortality (M) 1.69 per year, fishing mortality (F) 4.52 per year, with exploitation rate (E) 0.73 per year. The total length of silver rasbora fish obtained ranged from 0.5 to 8.5 cm. The maximum length ($L\infty$) = 12.93 cm and K = 0.62 per year with the Von Bertalanffy growth equation, $Lt = 12.93\ (1-e(-0.62(t-0.3291)))$. The yield value per recruit analysis showed that the optimum exploitation was 0.224 and the current exploitation rate was 0.73. The population of silver rasbora was over-exploitation, especially in small-size fish.

Keywords: *Rasbora argyrotaenia, Fish Population Dynamics, PB. Soedirman Reservoir*

Introduction

Panglima Besar (PB.) Soedirman Reservoir is located in Bawang District, Banjarnegara Regency, Central Java. This reservoir accommodates the flow of water from the Serayu, Lumajang, Merawu, and Kandangwangi rivers[1]. Silver rasbora (*Rasbora argyrotaenia* Bleeker, 1849) is one of the native species of fish found in the PB. Soedirman Reservoir. Silver rasbora from PB. Soedirman Reservoir is distributed in a fresh condition to the Banjarnegara area and outside the city, namely Purbalingga, Purwokerto, Bandung, and Jakarta. Sentosa and Djumanto[2] stated that the silver rasbora is used as a target fish for

fishermen because it has a high selling value and is liked by the public because it tastes delicious, savory, and contains a high source of protein. Rukayah & Lestari[3] stated that fresh silver rasbora in the PB. Soedirman reservoir reached a price of Rp. 60,000/ kilogram and those that have been processed reach Rp. 150,000/ kilogram.

This high economic value silver rasbora causes fishermen to tend overfishing. This over-exploitation threatens the native species of fish[4]. The decrease in the number of fish can be caused by two factors, namely natural mortality and fishing mortality. The higher the fishing mortality rate (F), the higher the exploitation rate (E). Exploited fish species will have an impact on reducing the number of adult fish caught before spawning. This can have an impact on the absence of recruitment into stock and in the end the stock will run low[5].

Information about population dynamics of silver rasbora in the PB. Soedirman Reservoir which includes sex ratio, length-weight relationship, condition factor, mortality rate, exploitation rate, and yield per recruit is still not widely done so this research is very important to do. Therefore, the study of the dynamics parameters of the silver rasbora population in the PB. Soedirman Reservoir is intended to preserve the fish resources of silver rasbora as a native species so that it can be used sustainably.

Materials and methods

This research applied the survey. The fish sampling was conducted by purposive random sampling technique in 3 stations of PB. Soedirman Reservoir, the inlet, Karangkemiri, the middle, Wanadadi, and the outlet, Karangjambe. The fish was captured by using gill nets, that were installed from 3.00 p.m. to 6.00 a.m. The fish sampling was carried out in November 2021, January, and March 2022.

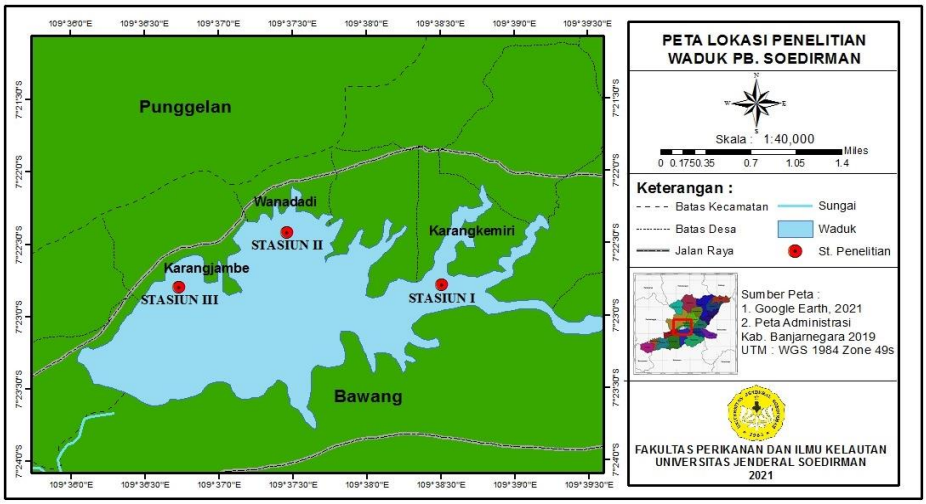

Figure 1. Location of Stations in PB. Soedirman Reservoir, Banjarnegara, Central Java.

Research Variables and Parameters

The variables observed in this study were the population of silver rasbora with parameters: length, weight, and sex of silver rasbora. Then another variable was the water quality of PB. Soedirman Reservoir with parameters: temperature, light penetration, depth, current velocity, pH, DO, CO_2.

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Data analysis

The data of sex ratio, the relationship between length and weight, condition factors, distribution of length frequency, the rates of growth (Von Bertalanffy), mortality, and exploitation, and the yield per recruit calculated by FISAT II.

Fish Sex Ratio

The sex ratio calculation refers to Effendie[6] :

$$\textbf{Sex Ratio} = \frac{\textbf{Number of male fish}}{\textbf{Number of male+female fish}} \boldsymbol{x}\ \mathbf{100}\%$$

Fish Sex Ratio

The length-weight relationship refers to Effendie[6]:

$$\mathbf{W = aL^b}$$

Information :
W = Fish Weight (gr)
L = Fish Length (cm)
a,b = constant

Condition Factor

Condition factor refers to Effendie[7]. If the value of b = 3 (isometric), then the formula used:

$$\mathbf{K} = \frac{\mathbf{10^5 W}}{\boldsymbol{L^3}}$$

If the value of b 3 (allometric), then the formula used:

$$\mathbf{K} = \frac{\mathbf{W}}{\mathbf{a}\boldsymbol{L^b}}$$

Information:
K = condition factor
W = Weight of fish (grams)
L = length of fish (cm)
(a&b) = Constant

If the K value is 2-4 it means the fish's body is slightly flat, and if the K value ranges from 1-3 it means the fish's body is less flat[7].

Fish Mortality Rate

The frequency distribution of total length was calculated by the Sturges formula[8]. The first is determining the maximum and minimum values of the entire data. Then, counting the number of size classes K = 1 + (3,32 log n). Next, calculating data range; Range = Largest – Smallest Data. Then, calculate interval class: Interval Class= range/size class. After that, determine the first class by using the shortest of fish plus the interval length. Then calculate the average of the class. After that, determine the frequency length of classes.

Length frequency distribution data were analyzed using FISAT-II software (FAO-ICLARM Stock Assessment Tools-II) to obtain the estimate of the growth parameters of the von Bertalanffy model. Estimation of von Bertalanffy growth parameters (Asymptotic length (L∞) and the growth coefficient (K)) were calculated using the ELEFAN-I program in the FISAT II software package, by projecting several possible combinations of the desired von Bertalanffy growth parameters. Estimation (t0) is obtained from Pauly's[9] empirical equation, namely:

$$\mathbf{Log\ (-t_0) = -0{,}3922 - 0{,}2752\ (Log\ L\infty) - 1{,}038\ (Log\ K)}$$

So that the growth curve can be made by entering the values of K, L∞, t and t0 in the Von Bertalanffy equation[9], that is :

$$\mathbf{Lt = L\infty[1 - e^{(-K(t-t_0))}]}$$

Information :

t0 = The theoretical age of the fish when the length is equal to zero (years)
Lt = length of fish at age t (cm)
L = length of fish asymptote (cm)
K = Coefficient of growth rate (per year)
t = age (years)

Estimates of the total mortality rate (Z) were analyzed using the length converted catch curve method[9]. The calculations were carried out computerized using the FISAT II program package[10].

Estimation of natural mortality rate (M) using Pauly's[9] empirical model, namely:

$$\mathbf{Log(M)= -0{,}0066 - 0{,}279*Log(L\infty)+0{,}6543*Log(K)+ 0{,}4634*Log(T)}$$

Estimated fishing mortality rate (F) is calculated from the equation:

$$\mathbf{Z = F + M}$$

So that the equation is obtained:

$$\mathbf{F = Z – M}$$

Information:
L∞ = Fish asymptote length (cm)
K = Coefficient of growth rate
T = Average water surface temperature (°C)
F = Fishing mortality rate (per year)
Z = Total mortality rate (per year)
M = Natural mortality rate (per year)

Fish Exploitation Rate

Estimation of the exploitation rate can be known through the comparison of the fishing mortality rate (F) and the total mortality rate (Z)[9], as follows:

$$\mathbf{E = \frac{F}{Z}}$$

Information:
E = Exploitation rate
F = Fishing mortality rate (per year)
Z = Total mortality rate (per year)

If the value of E > 0.5; indicates a high level of exploitation (overfishing), if the value of E < 0.5 indicates a low level of exploitation (underfishing), and E = 0.5 indicates optimal utilization[9].

***Yield per Recruit* Beverton & Holt (Y/R')**

Primary data were analyzed in the FISAT II program (FAO-ICLARM Stock Assessment Tools II) using the Beverton and Holt Y/R yield per recruitment model. The following is the yield per recruitment model of Beverton and Holt[11]:

$$\left(\frac{Y}{R}\right) = E \,.\, U^{M/K}\left(1 - \frac{3.U}{1+m} + \frac{3.U^2}{1+2m} + \frac{U^3}{1+3m}\right)$$

where:

$$\mathbf{U = 1 - \frac{Lc}{L\infty}}$$

$$m = \frac{1-E}{M/K}$$

Information :
E = Exploitation rate
M = Natural mortality rate (per year)
Lc = Smallest size of fish caught (cm)
L = length of fish asymptote (cm)
K = Coefficient of growth rate (per year)

Results

Silver rasbora is a small fish species that belongs to the Cyprinidae family, the Rasbora genus. Silver rasbora has Indonesian names, there are wader pari, lunjar padi, lunjar pari, lunjar andong, paray, cecereh, seluang, and bada. Silver rasbora in West Java is known as the Paray fish, while in West Sumatra it is known as the Bada fish. This fish is spread in fresh waters in Sumatra, Kalimantan, and Java[12].

Figure 2. Silver rasbora (*Rasbora argyrotaenia*)

Catches during research

The fish obtained during the study was 3,097 individuals (**Table 1**).

Table 1. Data of Silver rasbora caught during the research.

Month	Number of Fish Caught (ind)	Length Range (cm)	Weight Range (g)
November 2021	1069	0.5 – 8.5	0.33 – 5.83
January 2022	948	3 – 7.4	0.19 – 3.59
March 2022	1080	2.5 – 7.6	0.1 – 6.6
Total	**3097**	**0.5 – 8.5**	**0.1 – 6.6**

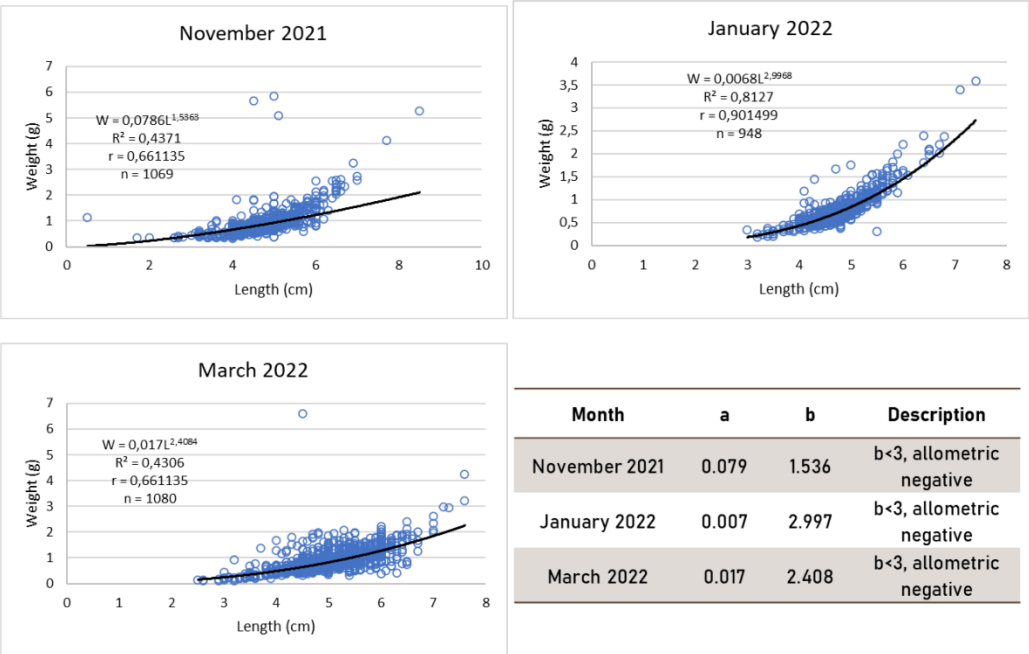
Sex Ratio

The sex ratio of fish is displayed in **Table 2**.

Table 2. Sex Ratio of Silver rasbora

Month	Frequency		Total	Percentage (%)		Sex Ratio
	Male	Female		Male	Betina	Male
November 2021	1048	21	1069	98%	2%	50 : 1
January 2022	923	25	948	97%	3%	37 : 1
March 2022	1034	46	1080	96%	4%	22.5 : 1
Total	**3005**	**92**	**3097**	**97%**	**3%**	**33 : 1**

Length and Weight Relationship



Month	a	b	Description
November 2021	0.079	1.536	b<3, allometric negative
January 2022	0.007	2.997	b<3, allometric negative
March 2022	0.017	2.408	b<3, allometric negative

Figure 3. Graph of Length & Weight Relationship of Silver rasbora

Condition Factor

The condition factor of the silver rasbora is displayed in **Table 3**.

Table 3. Condition Factor of Silver rasbora

Month	FK		
	Male	Female	Mix
November 2021	1.057	1.005	1.068
January 2022	1.013	1.006	1.013
March 2022	1.057	1.024	1.056

Mortality and Exploitation Rate

The results of the mortality and exploitation rates were displayed in **Table 4**.

Table 4. Mortality and Exploitation Rate of Silver rasbora

No.	Parameter	Value
1.	Total Mortality (Z)	6.21
2.	Natural Mortality (M)	1.69
3.	Arrest Mortality (F)	4.52
4.	Exploitation Rate (E)	0.73

Yield per Recruit

The results of the analysis of length frequency distribution silver rasbora are displayed in **Figure 4**.

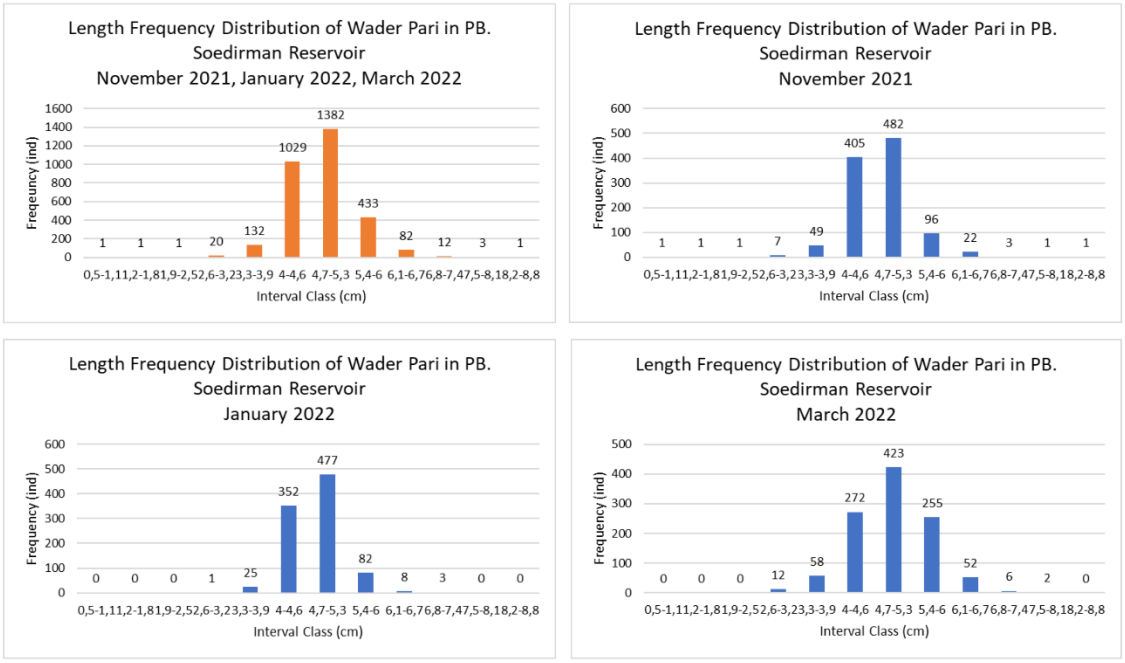


Figure 4. Graph of Length Frequency Distribution of Silver rasbora in PB. Soedirman Reservoir Total Month of Observation and Every Month of Observation

The **Figure 5** shown that the L∞ value obtained was 12.93 cm and the K value was 0.62/year.

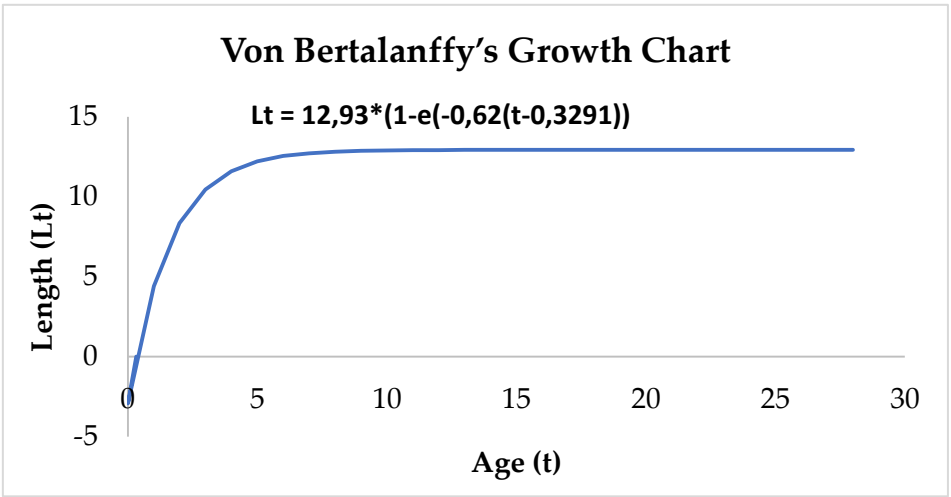


Figure 5. Von Bertalanffy's Growth Chart

Figure 6 showed the results of the Y/R analysis of silver rasbora.

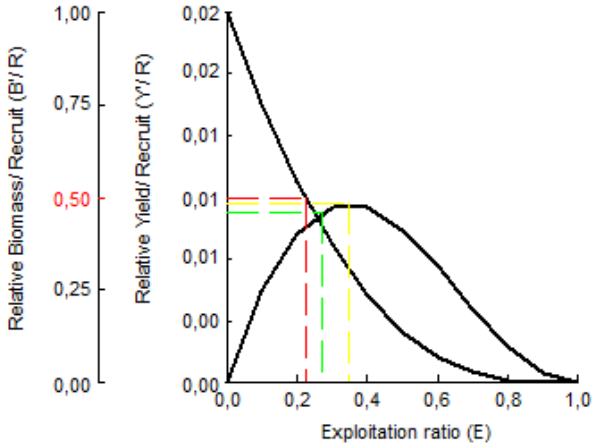


Figure 6. Yield per Recruit of Silver rasbora in PB. Soedirman Reservoir

Discussion

Sex Ratio

These results (**Table 2**) show that the population of silver rasbora was dominated by males. It could be related to the mobility of males that resulted in the wider distribution consequently the males were easier to be caught than female fish.

Length and Weight Relationship

The b value of silver rasbora were 1.536; 2.997; 2.408 respectively it means the type of growth silver rasbora in PB. Soedirman Reservoir was negative allometric (**Figure 3**). This result is supporting Herawati *et al.*,[13] at Jatigede Reservoir (October 2016). The growth of fish is influenced by internal factors including heredity, sex, age, and disease, and external factors including parasites, food and water temperature[7].

Condition Factor

The condition factor indicates that silver rasbora is in health condition. Herawati *et al.*,[13] reported the same result they were 1.08-1.24 in the Jatigede reservoir and Prasiska[14] reported the same result they were 1.037-1.058 in PB. Soedirman reservoir.

Mortality and Exploitation Rate

These results (**Table 4**) show that fishing mortality is greater than natural mortality. This shows the death of silver rasbora in PB. Soedirman Reservoir is more caused by intensive fishing activities. According to Prihatiningsih *et al.*,[15] the variation of the total mortality rate (Z) from year to year is much influenced by the mortality rate due to fishing (F). While the natural mortality rate is caused by the

presence of predation processes including cannibalism, disease, stress due to spawning, starvation, and aging.

The value of the exploitation rate (E) of fish is strongly influenced by the value of the rate of fishing mortality (F). The higher the fishing mortality rate, the higher the exploitation rate. According to Gulland (1971) referred to by Pauly[11], the value of the optimal exploitation rate is 0.50/year. This figure shows that based on the analysis that has been carried out, there has been an overfishing of silver rasbora in the PB. Soedirman Reservoir because the value of the exploitation rate has reached 0.73/year.

Yield per Recruit

Based on Suryani categories[16], the population of silver rasbora caught in the PB. Soedirman Reservoir is dominated by young/small-sized fish. This condition can influenced the sustainability of population of silver rasbora and it will towards to overfishing as stated by Okfan[17].

The growth curve (**Figure 5**) showed that the silver rasbora length increased fastly at the age of 0-5 months, then at the age of 5-30 months, the growth slightly. The length of fish caught was 0.5-8.5 cm, in growth phase and juvenile stage. The graph shows the silver rasbora in the PB. Soedirman Reservoir was able to reached maximum length (L∞) up to 12.93 cm theoretically with the growth rate (K) of 0.62 per year. The maximum length in this research was shorten than silver rasbora in Maninjau Lake, West Sumatra with L∞ 18 cm with a K value of 1.2 per year[18]. It is caused by the differences in the length range and maximum length size of fish samples taken at the time of sampling, as well as due to the influence of environmental conditions. Pauly (1983) in Sentosa[2] states that the value of L∞ is related to the maximum length of the fish sample (LMAX) obtained during sampling. These differences can also occur due to differences in habitat.

Figure 6 showed that the optimum exploitation was 0.224 and the current exploitation rate was 0.73. It seems that the number of fishing caught is higher than the optimum exploitation rate. The population of silver rasbora was over-exploitation, especially in small-size fish.

Conclusions

The population of silver rasbora was 3097 individuals dominated by male and small-size fish 0.5-8.5 cm. The growth pattern was negative allometric, in health condition (K = 1.005-1.057), and in over exploitation (E = 0.73).

Acknowledgments

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Conflicts of Interest

The authors state that there is no conflict of interest.

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