

POPULATION BIOLOGY OF SNAKEHEAD FISH *Channa striata* (BLOCH, 1793) IN WAY TULANG BAWANG RIVER, LAMPUNG

Biologi Populasi Ikan Gabus *Channa Striata* (Bloch, 1793) di Sungai Way Tulang Bawang, Lampung

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ABSTRACT

Channa striata (Bloch, 1793) is a valuable freshwater fish that has been highly exploited in Way Tulang Bawang River, Lampung. Increased fishing pressure if not properly managed can threaten the sustainability of the population. The objective of this research was to study the population biology of *C. striata* in the Way Tulang Bawang River, Tulang Bawang Regency, Lampung. A total of 623 fish samples were collected from local fish traders representing the catch from the study area from October to December 2025. The population parameters were estimated based on length–weight relationship, condition factor, von Bertalanffy growth model, mortality, exploitation rate, recruitment pattern and length-based spawning potential ratio (LB-SPR). The fish ranged from 120 to 394 mm in total length and exhibited a negative allometric growth ($W = 0.0119 * L^{2.8894}$) with a mean condition factor of 1.014. The growth parameters were estimated as $L_{\infty} = 49.4$ cm, $K = 0.51 \text{ year}^{-1}$ and $t_0 = -0.555$. The estimated total mortality (Z), natural mortality (M) and fishing mortality (F) were 3.53, 0.54 and 2.99 year^{-1} , respectively, which led to a high exploitation rate ($E = 0.85$). July was the peak of year-round recruitment. The estimated SPR was only 7%, indicating that the stock is overexploited to a great extent and its reproductive capacity is greatly reduced.

Keywords: *Channa striata*, population biology, spawning potential ratio

ABSTRAK

Channa striata (Bloch, 1793) merupakan salah satu jenis ikan air tawar bernilai ekonomi tinggi yang banyak dieksploitasi di Sungai Way Tulang Bawang, Lampung. Peningkatan tekanan penangkapan ikan tersebut jika tidak dikelola dengan baik dapat mengancam keberlanjutan populasinya. Penelitian ini bertujuan untuk mempelajari biologi populasi *C. striata* di Sungai Way Tulang Bawang, Kabupaten Tulang Bawang, Lampung. Sebanyak 623 sampel ikan dikumpulkan dari pedagang ikan lokal yang mewakili hasil tangkapan dari daerah penelitian dari Oktober hingga Desember 2025. Parameter populasi diestimasi berdasarkan hubungan panjang-berat, faktor kondisi, model pertumbuhan von Bertalanffy, mortalitas, tingkat

eksploitasi, pola rekrutmen, dan rasio potensi pemijahan berdasarkan panjang (LB-SPR). Ikan tersebut memiliki sebaran panjang total antara 120 hingga 394 mm dengan pola pertumbuhan alometrik negatif ($W = 0,0119 \cdot L^{2,8894}$) dan faktor kondisi rata-rata 1,014. Parameter pertumbuhan diperkirakan sebagai berikut: $L_{\infty} = 49,4$ cm, $K = 0,51$ tahun⁻¹, dan $t_0 = -0,555$. Estimasi mortalitas total (Z), mortalitas alami (M) dan mortalitas penangkapan ikan (F) masing-masing adalah 3,53, 0,54 dan 2,99 tahun⁻¹, yang menyebabkan tingkat eksploitasi yang tinggi ($E = 0,85$). Bulan Juli adalah puncak perekrutan yang berlangsung sepanjang tahun. Estimasi SPR hanya 7% yang menunjukkan bahwa stok tersebut dieksploitasi secara berlebihan dan kapasitas reproduksinya sudah sangat berkurang.

Kata kunci: *Channa striata*, biologi populasi, *spawning potential ratio*

INTRODUCTION

The Way Tulang Bawang River is one of the rivers in Tulang Bawang Regency, with a total length of 96.07 km and the catchment area of 1,468.78 km² (Cambodia et al., 2021). The Way Tulang Bawang River has a large fishing field which supports a high diversity of fish. One of the fish living in these waterways is the snakehead. The snakehead fish is a freshwater species which has great economic worth, ranging from IDR 40,000–85,000 per kg depending on size and season. Furthermore, snakehead fish has an added value in the form of high protein and albumin content that accelerates wound healing and improves nutritional status and resilience of youngsters (Mustafa et al., 2012). Some factors causing snakehead fish to have high fishing activities include: 1. High economic worth

Capture fisheries is one of the main livelihood sources for the inhabitants around Way Tulang Bawang River. Increased fishing activity may increase fishing mortality and rate of exploitation which may lead to the reduction of size, quantity and productivity of wild fish populations (Allan et al., 2013). The trend of the diminishing catch production in the previous several years indicates that the pressure of the exploitation of snakehead fish in Tulang Bawang Regency is increasing. Based on the Ministry of Maritime Affairs and Fisheries (KKP, 2026), the output of snakehead fish in Tulang Bawang Regency has declined from 312.17 tonnes in 2019 to 115.3 tonnes in 2024. The volume of catches is also affected by fishing intensity and environmental conditions, but the decrease of catches is an indicator of the exploitation strain on wild fish stocks (Triharyuni et al., 2012). Sustainable fishing without proper management may disturb the population balance, diminish recruitment success and lead to overfishing (Sangaji et al., 2014).

Several studies have been conducted in Indonesia on the length-weight relationship, condition factors, and population dynamics of snakehead fish, including in the Musi River (Anggraeni et al., 2023; Makmur et al., 2003; Nurdawati et al., 2014; & Nurhayati et al., 2016), the Panggang Lake Swamp (Sofarini et al., 2018), the Aopa Swamp (Bahrin et al., 2020), and Lubuk Lampan (Fahmi et al., 2013). However, to date, information regarding the condition of the snakehead fish population in the Way Tulang Bawang River is still very limited. There has not been a comprehensive study that integrates population biology parameters, including the length-weight relationship, condition factors, growth parameters, mortality, exploitation rates, recruitment patterns, and length-based-spawning potential ratio (LB-SPR) to evaluate the stock status of snakehead fish in these waters. This limited information means that the actual condition of the snakehead fish and its utilization levels cannot yet be scientifically explained as a basis for developing fisheries management strategies.

In this study, a population biology approach combined with length-based spawning potential ratio (LB-SPR) was used to provide a comprehensive assessment of the status of the snakehead fish population in the Way Tulang Bawang River. Unlike previous studies that usually considered only separately reproduction, length-weight relations and condition factors

or population dynamics, this study includes different population biology parameters such as length-weight relations, condition factors, growth parameters, mortality, exploitation rates, recruitment patterns and the length-based-spawning potential ratio (LB-SPR) in one analytical framework. The method is expected to give a more comprehensive picture of the condition of snakehead fish stock and will be a scientific basis for the formulation of sustainable fisheries management strategies in Way Tulang Bawang River.

Based on the description, this study aims to analyze the biological aspects of the snakehead fish population *Channa striata* (Bloch, 1793), including the length-weight relationship, condition factors, growth parameters, mortality, exploitation rate, recruitment patterns, and length-based-spawning potential ratio (LB-SPR) to evaluate the utilization status of snakehead fish stocks in the Way Tulang Bawang River, Lampung. The results of this study are expected to be a scientific basis in developing strategies for the management and utilization of snakehead fish resources in a sustainable manner.

METHODS

Study Area and Fish Sampling

This study used a quantitative method, sample collection was conducted using a fish landing sampling approach, specifically collecting samples at fish landing sites. Samples were selected using a simple random sampling method, based on the study by Kresnasari (2020). All samples used have been confirmed to originate from the Way Tulang Bawang River, based on interviews with fishermen and fish traders. Field sampling was carried out in the Way Tulang Bawang River, Lampung Province, Indonesia during October to December 2025. Fish samples were taken from local market “Putri Agung” in Menggala, which directly gets fish from local fisherman in the study region. The study investigated 623 specimens of striped snakehead (*Channa striata*). Total length (cm) was measured with a measuring board to the nearest 0.1 cm and body weight (g) was measured using a digital balance. Primary data and interviews were collected throughout the sample period and water temperature data were received from Yudha (2015). Temperature data from Yudha (2015) were used because the river water temperature data from that study were sufficiently comprehensive, covering monthly temperatures over the course of a year, whereas the data in the present study were incomplete, and water temperatures were assumed not to have undergone significant changes.

Data Analysis

The length–weight relationship and condition factor were analysed using Microsoft Excel. Biological population parameters such as growth, recruitment pattern, mortality and exploitation rate were estimated using FAO–ICLARM Stock Assessment Tools II (FISAT II). The length-based spawning potential ratio (LB-SPR) was estimated using the Barefoot Ecologist’s Toolbox.

The general form of the length-weight relationship (LWR) is $W = aL^b$, with W being the weight of the fish (g), L being the length of the fish (cm), and a and b being regression constants of intercept and slope (Santoso et al., 2023; Agustina et al., 2019; Sunarni & Maturbongs, 2018). A t-test was performed to test whether the value of b is 3 (isometric) or b is different from 3 (allometric) using the following equation: $t\text{-value} = |(b-3)/S_b|$ where b is the growth coefficient of fish and S_b is the standard error. In addition, the relative condition factor (K_n) is also calculated, that is, an index that compares the real weight (W) with the estimated weight from the length-weight relationship (W^*) obtained for the species. The commonly used general formula is $K_n = W / W^*$, where W^* is calculated from the length–weight relationship equation estimated from sample data (Agustina et al., 2019; Sitompul et al., 2021; Aryansyah et al., 2023).

The growth characteristics of *Channa striata* were described using the von Bertalanffy Growth Function (VBGF) according to Sparre and Venema (1999) as follows: $L_t = L_\infty(1 - e^{-K(t-t_0)})$

$t-t_0$)] and the theoretical age at which fish length is zero (t_0) was subsequently estimated using Pauly's (1984) empirical equation as $\text{Log}(-t_0) = -0,3992 - 0,2752 (\log L_\infty) - 1,038 (\log K)$; where L_t = length of fish at age t (cm); L_∞ = asymptotic length (cm); K = constant growth rate of length per year; t = age of fish in years; t_0 = theoretical age of fish when length equals zero (years).

The rate of utilization of *C. striata* is predicted by first determining the natural mortality rate (M) estimated using Pauly's (1984) empirical equation as follows $\text{Log}(M) = -0,0066 - 0,279 \log(L_\infty) + 0,6543 \log(K) + 0,463 \log(T)$; and the total mortality rate is calculated using the following equation as $Z = K \left(\frac{L_\infty - L}{L - L_0} \right)$; then the fishing mortality rate (F) is obtained by calculating the difference between the total mortality rate and natural mortality as follows: $F = Z - M$. Ultimately, the exploitation rate is determined by comparing fishing mortality (F) to total mortality (Z) (Pauly 1984) as follows: $E = \frac{F}{Z}$; (where M = natural mortality rate; L_∞ = asymptotic length (cm); K = von Bertalanffy growth coefficient (year⁻¹); T = average water temperature (°C); Z = total mortality rate; L_∞ = asymptotic length (mm); L = average length of fish caught (cm); L_0 = smallest length of fish caught (cm)). According to Sparre & Venema (1999), the optimal exploitation rate of fish resources is 0.5. If $E > 0.5$ indicates a high exploitation rate (overfishing), and $E < 0.5$ indicates a low exploitation rate (underfishing).

Moreover, the spawning potential ratio (SPR) could be estimated using the length-based spawning potential ratio (LB-SPR) method. LB-SPR is a data-limited assessment method that estimates the reproductive capacity remaining at the current level of exploitation relative to an unfished population (Hordyk et al. 2015). The method relies more on the length-frequency distribution of the fish population than on age-structured data. This makes it especially useful for fisheries where conventional information such as catch, fishing effort and age composition is scarce or unavailable. The main inputs required for the analysis include length-frequency data, asymptotic length (L_∞), the ratio of natural mortality to growth rate (M/K) and the lengths at which 50% and 95% of individuals are mature (L_{50} and L_{95}) (Hordyk et al., 2014; Hordyk et al., 2015; Shephard et al., 2022). The Barefoot Ecologist Toolbox can help in processing length frequency data, setting life history assumptions and estimating the demographic parameters needed for calculating LB-SPR when applied (Hordyk et al., 2014; Dick et al., 2014; Sarker et al., 2024).

RESULTS

Length Frequency Distribution

The length distribution presented 623 individuals in the length range of 120-394 mm (Figure 1). The length class with the largest frequency was 170–194 mm with 144 individuals, followed by 195–219 mm with 128 individuals and 220–244 mm with 113 individuals. Most individuals (61.8%) were 170–244 mm in length. The lowest frequency was in the 370–394 mm class with 2 individuals. The majority of the caught *C. striata* were larger than their initial maturity size (L_m) of 180 mm although 91 fish were caught below maturity (14.61%).

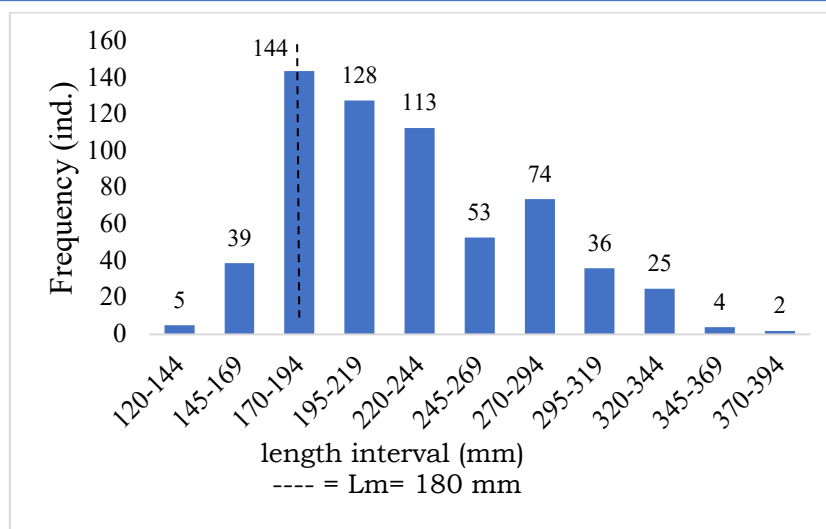


Figure 1. Distribution of the length frequency of *C. striata* in the Way Tulang Bawang River

Growth Pattern

The length-weight relationship of *C. striata* was described by the equation $W = 0.0119 \cdot L^{2.8894}$ with a coefficient of determination $R^2 = 0.948$. Figure 2 demonstrates that fish weight increases with increasing body length. Observation points distributed very near to the curve show a strong link between fish length and weight. The growth coefficient b value of 2.8894, which is lower than 3, revealed that *C. striata* exhibits a negative allometric growth pattern. These results suggest that body length increases more rapidly than body weight. The figure of $R^2 = 0.948$ also implies that about 94.8% of the variance in fish weight can be explained by changes in body length.

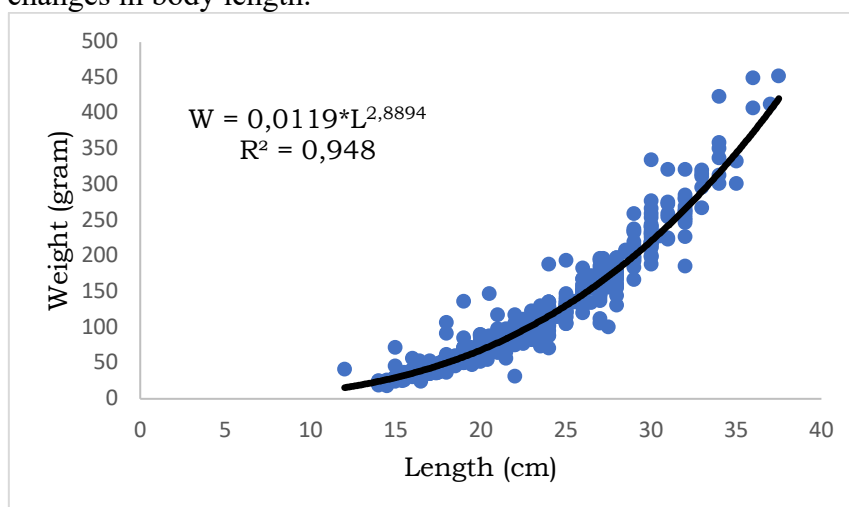


Figure 2. Length-weight relationship of *C. striata* in the Way Tulang Bawang River

Relative Condition Factor

The relative condition factor for *C. striata* fish was generally around 1 in all months of observation ranging from 0.994 to 1.036 (Figure 3). The temporal trend is characterized by a rise in fish condition from October to November and a decrease in December. The lowest value was in October, then it grew to its peak value in November. The condition factor again fell to 1.011 in December, although was still higher than in October.

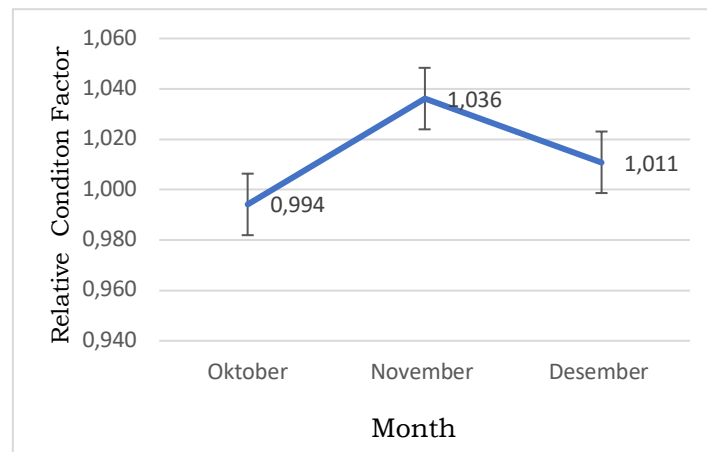


Figure 3. Relative condition factor of *C. striata* in Way Tulang Bawang River

Growth Parameters

The von Bertalanffy growth curve for *C. striata* is given by the equation $L_t = 49.4 * [1 - e^{-0.51(t+0.56)}]$. From this equation, the asymptotic length (L_∞) of the fish is estimated at 49.4 cm, with a growth coefficient (K) of 0.51 per year, and an initial theoretical age (t_0) of -0.56 years. The curve indicates a quick growth on the first years of life and a slow decline of growth with age. By about the seventh year the fish has attained its asymptotic length so that length increase in subsequent years is quite minimal and the growth rate slows down.

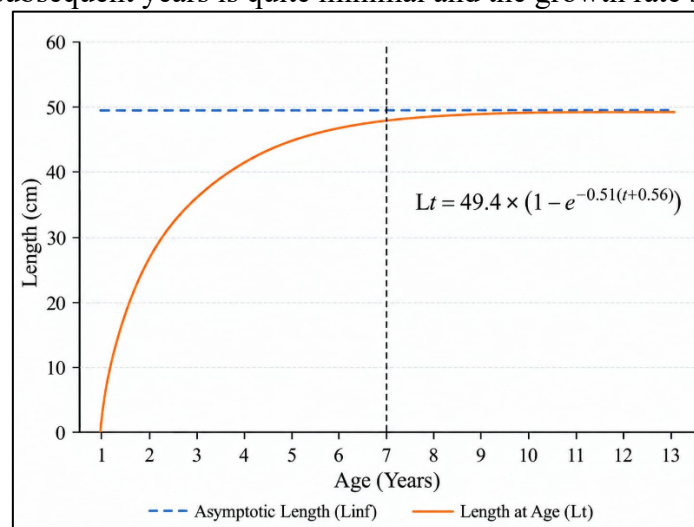


Figure 4. VBGF curve of *C. striata* in the Way Tulang Bawang River

Mortality and Exploitation Rate

The length-based catch curve illustrates a trend of decreasing number of individuals with rising relative age. The declining portion of the curve (black dot) was utilized to estimate total mortality and resulted in a Z-score of 3.53 years⁻¹ (Figure 5). The estimated natural mortality (M) was 0.54 year⁻¹ and estimated fishing mortality (F) was 2.99 year⁻¹. The exploitation rate (E) was 0.85, indicating that about 85% of total population mortality was associated with fishing activities. The value of fishing mortality is greater than natural mortality, which implies that the main cause of fish mortality in the population is fishing pressure.

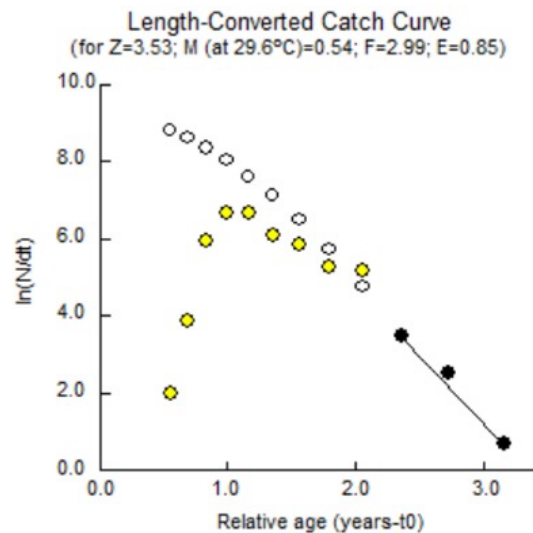


Figure 5. Length-converted catch curve to determine total mortality and exploitation rate of *C. striata* in the Way Tulang Bawang River

Recruitment

Recruitment rate of snakehead in the Way Tulang Bawang River was determined using the FISAT II application in the subprogram Recruitment Pattern. The recruitment pattern of *C. striata* occurs over virtually the entire year with different intensity (Figure 6). Recruitment rate slowly grew from the beginning of the year, reaching 19.52% in July. Recruiting rate peaked and then fell from August to the end of the year. Recruitment was lowest in December and the model curve shows that there is just one significant recruitment phase in the middle of the year.

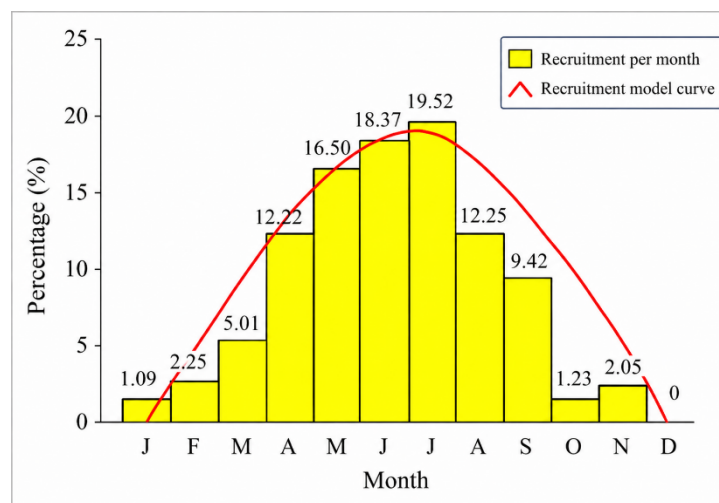


Figure 6. Recruitment pattern of *C. striata* in the Way Tulang Bawang River

Length-Based Spawning Potential Ratio (LB-SPR)

Fish stock assessments are an important part of the management of fisheries resources. The results of the fish stock status analysis utilizing the length-based spawning potential ratio (LB-SPR) approach are given in Table 1. The spawning potential ratio (SPR) of *C. striata* was 7%. This value is in the red zone, below the reference limit of 20%. Thus, the reproductive capacity of the remaining *C. striata* stock is only about 7 percent of that which it would be without fishing. This SPR is also well below the management target of 40%.

Table 1. Estimated spawning potential ratio of *C. striata*

SPR (%)	F/M	SL ₅₀	SL ₉₅
7	3.67	172.73	206.03

Note: SPR = spawning potential ratio; F = catch percentage; M = natural mortality; SL₅₀ = Length at 50% selectivity ; SL₉₅ = Length at 95% selectivity

The curves show that the selectivity and maturity proportions increase with increasing fish length. The length at which 50% of individuals are captured or selected is estimated to be around 172.73 mm, while the length at which 50% of individuals reach maturity is around 180 mm. The selectivity curve lies to the left of the maturity curve, so fish begin to be caught at a smaller size than their maturity size (Figure 6). The selectivity proportion increases sharply in the length range of approximately 150–210 mm, while the maturity proportion increases most markedly in the range of 180–225 mm. At lengths greater than approximately 230–240 mm, both curves approach 1, indicating that nearly all individuals in that length group have been selected and reached maturity.

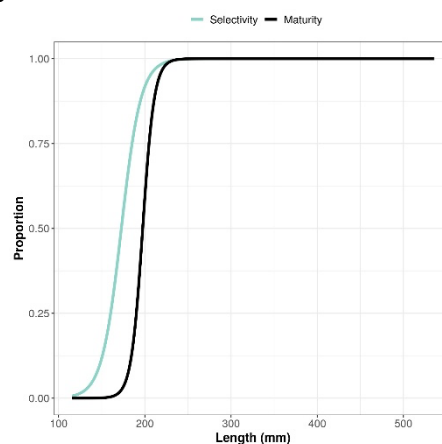


Figure 6. Comparison of length at first capture (SL₅₀) and length at first sexual maturity (Lm₅₀) of *C. striata* in the Way Tulang Bawang River.

DISCUSSION

The length-frequency distribution of *C. striata* exhibited a pattern dominated by the middle-sized group with mode falling between 170 and 194 mm length. The concentration of individuals in multiple neighbouring length classes suggests that the population or catch is dominated by a particular size group. The reduction in frequency in the higher length classes could be the result of a steady decrease in the number of individuals within a cohort due to natural and fishing mortality. In populations under fishing pressure, a limited number of huge fish might potentially signal a reduced survival of individuals to older adult sizes. Increased fishing mortality usually results in a change in population structure with a higher proportion of smaller fish due to fewer individuals surviving to the larger size classes.

The first gonadal maturity (Lm) of 180 mm is within the length class with the highest frequency. This means the majority of collected individuals are in the transition from immature to reproductive maturity. The occurrence of fish in length classes below and around Lm is interesting since fishing at these sizes can restrict the possibility for fish to reproduce before capture. If this situation prolongs, it can lead to a lower number of broodstock contributing towards the creation of the new generations and a higher danger of recruitment overfishing. This is essential since the contribution of fish to reproduction normally increases with body size. Fecundity has also been shown to tend to increase with increasing length and weight of the broodstock. The length class 270-294 mm shows a continued increase in frequency and there may be a further size group or cohort present in the population. However, this pattern is

not a separate cohort because the distribution of length is also impacted by the recruitment season, changes in growth rates, habitat shifts and gear selection (Djumanto et al., 2019).

The size of *C. striata* in this study was considerably bigger than that of Makmur et al. (2003) in Musi River which was 140–189 mm, but still smaller than that of Nurdawati et al. (2014) in Musi River with dominant size of 200–280 mm. The maximum length of *C. striata* in our study (375 mm) was lower than that of *C. striata* in the Musi River (575.9 mm) and Aopa Swamp (470 mm) (Nurdawati, 2014; Bahrin et al., 2020). Several factors, like as water productivity, food availability, habitat quality, hydrological features, gear selectivity, seasonal variation and sampling periods have an effect on these disparities in size structure (Aziz, 1992).

The analysis of length-weight relationship of *C. striata* in Way Tulang Bawang River resulted in the equation $W = 0.0119 * L^{2.8894}$. Growth pattern was negative allometric ($b = 2.8894$) This trend indicates that the increase of body length is more than that of weight, so the fish tends to be longer than fatter during its growth. The coefficient of determination (R^2) of length-weight relationship was found to be 0.948. The value of R^2 is 0.948. This shows that the weight data of *C. striata* living in the Way Tulang Bawang River can be described by the length data of 94.8%. The results are consistent with other previous studies that also reported a negative allometric growth pattern (Asyahari & Machrizal, 2022; Muthmainah, 2013; Sofarini et al., 2018; Fahmi et al., 2013). In contrast, a positive allometric growth pattern of *C. striata* was reported in Lengkwai Island (Kutty & Munajah, 2017) while isometric growth pattern was observed in Rawa Aopa (Bahrin et al., 2020). Growth patterns in aquatic bodies are often different and are controlled by a number of factors including environmental circumstances, food availability, habitat characteristics, gonad maturity, population density, season and size mix of fish collected (Jenning et al., 2001; Froese, 2006).

The relative condition factor in this study was 1.014, indicating that the captured *C. striata* were in good condition. This value is higher than the results of research in the Lebak Mariana Swamp and the Lebak Sekayu Swamp (Muthmainah, 2013), the Tanjung Haloban Village Swamp (Asyahari & Machrizal, 2022), the Pening Swamp (Djumanto et al., 2019), and the Lubuk Lampan Floodplain (Fahmi et al., 2013), but lower than the Belanti Swamp (Helmizuryani et al., 2025). Differences in condition factor values between waters are prevalent and are affected by some elements such as environmental conditions, nutrition, food availability, gonad maturation, age, sex and habitat characteristics (Gustiarisanie & Raharjo, 2016). Effendie (2002) reported that condition factor value close to or greater than 1 shows that the fish are in relatively good physical condition and the aquatic environment is still adequate to support the growth of fish. In the present study the maximum value of condition factor was observed in November (Figure 2). This rise is believed to be linked to changes in the physiological state of the fish, including probable gonad development prior to spawning, but reproductive features were not directly examined in this study.

The growth parameters of *C. striata* in the Way Tulang Bawang River determined by the von Bertalanffy model were $L_{\infty} = 49.4$ cm, $K = 0.51$ year⁻¹, and $t_0 = -0.555$ year⁻¹. The von Bertalanffy growth model for *C. striata* in the Way Tulang Bawang River is $L_t = 49.4 * [1 - e^{-0.51(t+0.555)}]$. Based on those factors, the growth curve indicates that *C. striata* is relatively fast growing at young ages and the growth rate declines with age and size until the fish reaches the asymptotic length. This pattern is a common characteristic of fish growth because in the early stage the majority of energy is required for growth, but in the mature stage more energy is used for maintenance and reproduction, therefore the growth rate is sluggish (Effendie, 2002; Rauf et al., 2019). The value of L_{∞} in this study was higher than Bahrin et al. (2020) in Aopa Swamp, but lower than Sofarini et al. (2018) in Panggang Lake Swamp, and Fahmi et al. (2013) in Lubuk Lampan Floodplain. The K value is within the range of prior study, demonstrating that the growth rate of *C. striata* in the Way Tulang Bawang River is moderate. Differences in the growth parameters between water bodies are common and are driven by habitat factors, food

availability, water temperature, population characteristics, gear selectivity and fishing intensity (Dwiponggo, 1982; Zedta et al., 2017). Negative t_0 are a common feature of the von Bertalanffy growth model, which suggests that growth is faster in early life stages (Figure 3) (Sparre & Venema, 1999).

Total mortality rate (Z) of *C. striata* in the Way Tulang Bawang River was estimated at 3.53 year^{-1} . The value comprised of a natural mortality rate (M) of 0.54 year^{-1} and a fishing mortality rate (F) of 2.99 year^{-1} . The much higher fishing mortality shows that fishing was more responsible for population losses than natural causes. This is a result of the high fishing pressure on the *C. striata* in the river. Likewise, Ahmad et al. (2018) explained that fishing pressure is observed when the fishing mortality is more than the natural mortality. Conversely, natural mortality is usually determined by the patterns of biological growth and environmental conditions such as water temperature (Pauly, 1980). The projected rate of exploitation (E) was 0.85, significantly above the generally regarded optimum. According to Sparre and Venema (1999) a stock of fish is overexploited when the exploitation rate is higher than 0.5. The high exploitation rate found in this study is in accordance with the high fishing mortality rate. It proves that fishing activity is the key factor impacting the population dynamics of *C. striata* in the Way Tulang Bawang River. If this situation persists, the number of mature fish contributing broodstock would decrease perhaps leading to a fall in recruitment success and a disruption in population sustainability.

The study shows that recruiting happens practically all year around with a substantial recruitment peak in July (19.52%) (Figure 4). This pattern illustrates that the process of adding new members to the population is slow, but is most intense in the middle of the year. This is different from the research of Sofarini et al. (2018) in the Panggang Lake Swamp which showed two recruitment peaks and Fahmi et al. (2013) in the Lubuk Lampan Floodplain which showed three recruitment peaks. Thus, recruitment of *C. striata* varies among water bodies depending on habitat characteristics and local environmental conditions. Changes in recruitment patterns are assumed to be driven by hydrological conditions, availability of spawning habitat, reproductive success and survival of fish larvae and juveniles. Kusmini et al. (2015) reported that the reproductive success of fish depends not only on gametogenesis but also on reproductive behaviour such as migration to spawning grounds, habitat selection, nest construction, spawning season, and partner presence.

The results of the LB-SPR analysis suggest that *C. striata* in the Way Tulang Bawang River is 7% with F/M ratio of 3.67 (Tabel 1). The low SPR values (far below the 20% reference value) suggest that the *C. striata* stock has been overexploited. A high F/M value indicates that the fishing-induced mortality is substantially higher than the natural mortality. Fishing activity is therefore an important element in the reduction of the broodstock biomass in these waters. According to Prasetyo (2019), if the fishing intensity is raised without proper management, it can decrease the biomass of fish stock and the population's ability to sustain itself. It is hypothesized that this issue is related to the use of longline fishing gear that is regularly employed by fishermen in the Way Tulang Bawang River. The small hooks enable for the catching of small or immature fish, limiting the likelihood of fish spawning in the wild.

The research also revealed that the SL_{50} value (170.18 mm) was lower than the initial gonad maturity size ($L_m = 180 \text{ mm}$). This indicates that some *C. striata* were caught before reaching sexual maturity and therefore did not have time to reproduce. Biologically, this condition indicates growth overfishing, that is, the fish were caught before reaching the optimal size (Saputra et al., 2009). Furthermore, the very low SPR value indicates that the remaining broodstock biomass is only about 7% of the unexploited stock condition, so that if fishing pressure continues, it will have an impact on reducing the number of broodstock capable of reproducing and potentially increasing the risk of recruitment overfishing (Figure 6). Therefore, management efforts are needed, such as setting the minimum size of fish that can

be caught, the use of more selective fishing gear, and controlling fishing intensity to maintain the sustainability of the *C. striata* stock in the Way Tulang Bawang River.

CONCLUSION

Population biology of *C. striata* in the Way Tulang Bawang River indicates that the population is dominated by individuals that have not yet reached their theoretical maximum size, with a negative allometric growth pattern. Growth parameters indicate that the population has relatively good growth capacity and relatively good condition. Recruitment occurs year-round, peaking in July, indicating a major period of population replenishment. Mortality is dominated by fishing pressure ($F = 2.99 \text{ year}^{-1}$) with overexploitation ($E = 0.85$), resulting in a low spawning potential ratio (7%).

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