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ESTIMATION OF THE FIRST MATURITY SIZE OF SILVER BARB (*Barbonymus gonionotus*) IN SIDENRENG LAKE, SOUTH SULAWESI

PENDUGAAN UKURAN PERTAMA KALI MATANG GONAD IKAN TAWES (*Barbonymus gonionotus*) DI DANAU SIDENRENG, SULAWESI SELATAN

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ABSTRACT

Silver barb is a popular introduced species in Sidenreng Lake, South Sulawesi. Its presence has been highly beneficial for local fishers due to its significant economic value. Fishers make this fish their primary target for fishing. The fishing activity for the silver barb was carried out year-round using gill nets with various mesh sizes, ranging from small to large (1.5", 2", 2.5", 3", and 3.5"). These activities have led to a decline in the fish population in the Lake. Therefore, information related to the fisheries biology of the fish is crucial. This study aims to determine the length at first capture (Lc), length at first maturity (Lm), and the appropriate gill net mesh size for catching suitable silver barb. The sample data were analyzed using descriptive and comparative statistical tests. The study results showed that the size at capture for the silver barb in the Sidenreng Lake was Lc = 132.66 mm. Male and female fish reach their first length of maturity at fork lengths (FL) of 173.08 mm and 140.95 mm, respectively. The recommended gill net mesh size for catching suitable silver barb was 3", as the average FL caught was larger than the Lm value.

Keywords: gill net, gonad maturity level, mesh size, silver barb

ABSTRAK

Ikan tawes adalah salah satu jenis ikan introduksi yang populer di Danau Sidenreng, Sulawesi Selatan. Keberadaannya sangat menguntungkan bagi nelayan karena bernilai ekonomis penting. Nelayan menjadikannya sebagai target utama penangkapan ikan. Aktivitas penangkapan ikan tawes dilakukan sepanjang tahun menggunakan jaring insang dengan ukuran mata jaring beragam dari kecil hingga besar, yaitu 1,5", 2", 2,5", 3", dan 3,5". Keduanya mengakibatkan populasi ikan tawes di Danau Sidenreng semakin menurun. Oleh karena itu, informasi terkait biologi perikanan ikan tawes menjadi penting untuk diketahui. Penelitian bertujuan untuk menentukan ukuran ikan tawes pertama kali tertangkap (Lc), ukuran ikan tawes pertama kali matang gonad (Lm), dan ukuran mata jaring (*mesh size*) jaring insang yang sesuai untuk menangkap ikan tawes layak tangkap. Data sampel dianalisis menggunakan uji statistik deskriptif dan komparatif. Hasil penelitian menujukkan bahwa ukuran ikan tawes pertama kali tertangkap di Danau Sidenreng adalah Lc = 132,66 mm. Ikan tawes betina dan jantan mengalami kematangan gonad pertama kali pada ukuran panjang cagak FL = 140,95 mm dan jantan 173,08 mm. Ukuran mata jaring insang yang direkomendasikan untuk menangkap ikan tawes layak tangkap adalah 3", karena ukuran rata-rata FL yang tertangkap lebih besar dari nilai Lm.

Kata kunci: ikan tawes, jaring insang, tingkat kematangan gonad, ukuran mata jaring

INTRODUCTION

Sidenreng Lake is a tectonic lake that naturally formed as a result of the movement of Earth's tectonic plates, which caused a fault, creating a basin filled with water. Sidenreng Lake is located in Sidenreng Rappang Regency, South Sulawesi Province (KLHRI 2014). The lake spans an area of approximately ±4,753.30 hectares, with a depth ranging from 10 to 15 meters during the rainy season and only about ±5 meters in the dry season. The position of the Sidenreng Lake borders Tempe Lake to the southeast and Buaya Lake to the east. During the rainy season, these three lakes merge, expanding their combined area to 35,000 hectares (Omar 2010). The lakes separate again during the dry season (Soewaeli and Yuningsih 2014). As a result, most fish species found in the three lakes are relatively similar (Omar *et al.* 2020). Some of these include common carp (*Cyprinus carpio*), climbing perch (*Anabas testudineus*), snakehead (*Channa striata*), manggabai (*Glossogobius giuris*), swamp eel (*Monopterus albus*), snakeskin gourami (*Trichopodus pectoralis*), kissing gourami (*Helostoma temminckii*), Nile tilapia (*Oreochromis niloticus*), walking catfish (*Clarias batrachus*), silver barb (*Barbonymus gonionotus*), and suckermouth catfish (*Pterygoplichthys* sp.) (Ali 1994; Omar *et al.* 2020; Hasrianti *et al.* 2020a). Four of these species are economically valuable for consumption, namely nile tilapia, common carp, snakehead (Rahayu *et al.* 2021), and silver barb (Sumardiyani *et al.* 2020).

Silver barb (*Barbonymus gonionotus*) is a fish species with the fastest population growth, resulting in a higher number of catches compared to other fish species. Dina *et al.* (2019) concluded that silver barb was introduced from Java Island to Tempe Lake in 1937. The habitat of this fish is in the middle to bottom layers of the water (Gustiano *et al.* 2015). According to Buwono *et al.* (2019), silver barb is classified as an herbivorous species. Its diet consists of plankton, including Ankistrodesmus and Ulothrix (Buwono *et al.* 2019), as well as Rhodophyceae, Cyanophyceae, Chlorophyceae, and Bacillariophyceae (Pratiwi *et al.* 2021).

The population of the silver barb in Sidenreng Lake has been declining (Mukhlis *et al.* 2021). According to Hasrianti *et al.* (2020a), one of the causes of this decline is the high fishing pressure throughout the year (Rapi and Hidayani 2016), even though the spawning season for the fish occurs only before the rainy season (Dina *et al.* 2019). Therefore, the best fishing season is during the rainy season after the spawning period ends (Hamka and Naping 2019). Fishing is also carried out using gear capable of catching fish of all sizes, from juveniles to adults. The most commonly used fishing gear by fishermen in the Sidenreng Lake is surface gill nets (Hasrianti *et al.* 2020b), with mesh sizes ranging from 1.5" to 4.7" (Rahmat *et al.* 2024). Fishing operations are typically conducted from evening until morning (Oktaviany *et al.* 2023).

Efforts to conserve silver barb (*B. gonionotus*) resources in Sidenreng Lake must be carried out through a biological approach. Katiandagho and Marasabessy (2017) stated that the sustainability of fish availability is influenced by growth and reproduction. Information on the size of the fish at first gonadal maturity is an important factor to determine as an indicator of the availability of reproductive stock. Estimating the size at first gonadal maturity is a method to understand the population dynamics in a specific water body, related to the spawning period both before and after spawning (Rasdam *et al.* 2023). Gill nets operated by fishermen in Sidenreng Lake are expected to only catch silver barb of a proper catchable size, ensuring the sustainability of this fish resource. The research hypothesis is that the use of different mesh sizes will affect the size at first capture (Lc) of silver barb.

There is currently no literature available on determining mesh size based on the gonadal maturity stage of silver barb. Several studies conducted in Sidenreng Lake examined the characteristics of gill net catches (Oktaviany *et al.* 2023), the impact of restocking on fish production value (Mukhlis *et al.* 2021), the effect of suckermouth catfish (*Pterygoplichthys* sp.) on catch yields (Hasrianti *et al.* 2020a), the identification of ichthyofauna in Sidenreng Lake (Pindan 2022), the population dynamics of tinfoil barb (*Barbodes schwanenfeldii*) (Kudsiah *et al.* 2021), and the reproductive aspects of *Osteochilus hasseltii* (Omar 2010). The purpose of this study is to determine the size at first capture (Lc), the size at first gonadal maturity (Lm), and the appropriate gill net mesh size for capturing silver barb at a sustainable catchable size. This research is expected to contribute to conservation and sustainable fisheries management efforts while supporting fisheries management

policies based on ecosystem principles and natural resource sustainability.

METHODS

Time and location

The research was conducted over 2 months, from April to May 2024. The research activities took place in two different locations. The first location was Sidenreng Lake in Sidenreng Rappang Regency for the collection of silver barb (*B. gonionotus*) samples (Figure 1). The second location was at Muhammadiyah University of Sidenreng Rappang, specifically in the Basic Laboratory of the Faculty of Science and Technology, where the measurement and observation of the silver barb samples were carried out.

Tools and materials

The primary equipment used consisted solely of gill nets with mesh sizes of 1.5", 2", 2.5", and 3". Other tools included a 30 cm ruler, a 1 kg digital scale, a scalpel, a cool box, a cutting board, and tweezers. The materials used comprised 200 samples of silver barb (*B. gonionotus*).

Methods

A total of 200 fish samples were randomly selected from the gill net catch. Each sample was measured for body girth (BG) and fork length (FL). The body girth was measured using a string, which was wrapped around the largest circumference of the fish's body, located behind the operculum. The fork length was measured from the tip of the front head to the base of the caudal fin using a ruler with an accuracy of 1 mm. The determination of gonadal maturity level (GML) was based on the color, shape, and development of the gonads. Effendie (2002) classified gonadal maturity levels using the visual method (Table 1).

The data were analyzed using descriptive and comparative statistical tests. Descriptive statistics were presented in the form of diagrams and histograms. Meanwhile, comparative statistical tests utilized simple linear regression to analyze the relationship between fork length (FL) and fish body girth (BG) using the formula (Steel and Torrie 1982):

$$Y = a + bX$$

Y represents FL (fork length in mm), X represents BG (body girth in mm), a is the intercept (the point where the curve intersects the Y-axis), and b is the slope. The interpretation of the regression analysis results is based on the values of r and R^2. The correlation coefficient (r) measures the strength and direction of the linear relationship between two variables. Its value ranges from -1 for a perfect negative correlation to 1 for a perfect positive correlation. The coefficient of determination (R^2) measures how well a statistical model explains the variation or changes in the dependent variable (y) based on the independent variable (x). The range of R^2 values is from 0 to 1. If the R^2 value approaches 1, the independent variable is considered to have all the information needed to estimate the dependent variable. Conversely, if the R^2 value decreases, the ability of the independent variable to predict the dependent variable also becomes more limited (Ghozali 2016).

Analyzing the length-weight relationship is one way to understand the growth pattern of silver barb. The determination of the length-weight relationship is conducted using the equation provided by Effendie (2002).

$$W = aL^b$$

L represents FL (fork length in mm), a and b are constants, and W is the fish weight (g). A b value greater than 3 indicates a positive allometric growth pattern, meaning the fish's weight increases faster than its length. Conversely, if b is less than 3, it indicates negative allometric growth, where the length increases faster than the weight. A b value equal to 3 signifies isometric growth, where the increase in length is proportional to the increase in weight (Shasia *et al.* 2021).

The estimation of the size of silver barb at first gonadal maturity was performed using the Sperman-Karber method (Udapa 1986):

$$\log M = X_k \frac{X}{2} - (X_i \sum pi)$$

$$\text{antilog}\, m = m \pm 1.96 \sqrt{x^2 \sum \left(\frac{(pi \times qi)}{(ni - 1)} \right)}$$

X_k is the logarithm of the midpoint value of the last class where fish reach full gonadal maturity (100%), X_i is the log of the class midpoint, X is the difference in the log of

class midpoints, ri is the total number of fish reaching gonadal maturity in class i, ni is the total number of fish in class i, and pi = ri/ni. m is the log of the fish length at first gonadal maturity. The determination of the size of fish at first capture (Lc) was carried out using the analysis by Sparre and Venema (1999):

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

$$\ln\left[\frac{1}{SL_c} - 1\right] = (S_1 - S_2)\, L$$

$$L_c = \frac{S_1}{S_2}$$

S_L is the estimated value, L is the midpoint length of the class (mm), SL_C is the cumulative relative frequency, Lc is the length at first capture, and S_1 and S_2 are constants in the logistic curve formula.

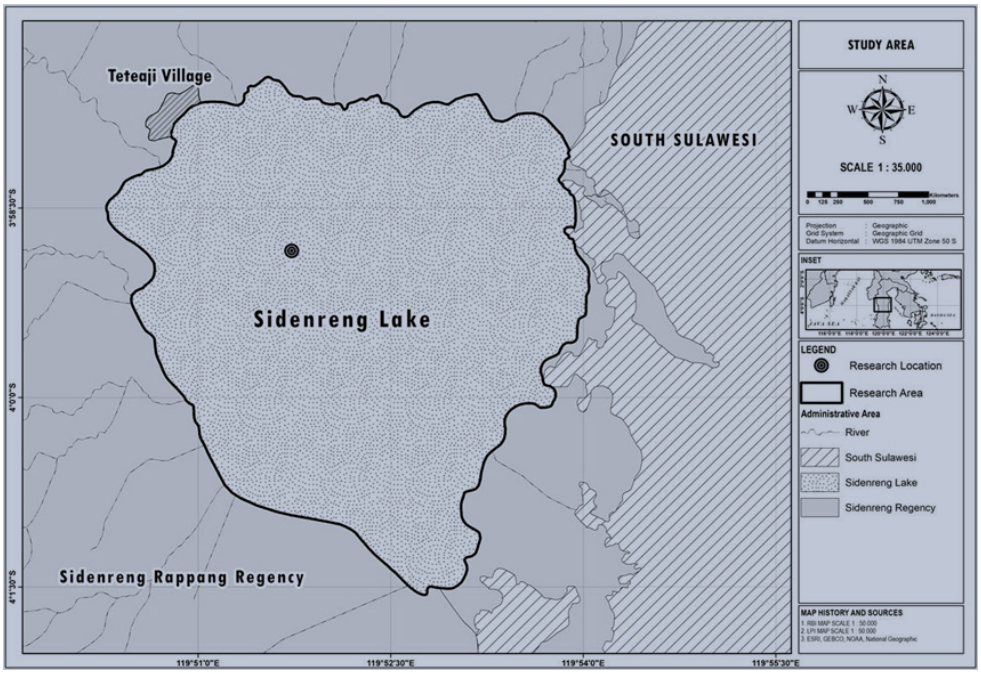


Figure 1. Research location map in Sidenreng Lake, South Sulawesi.

Table 1. Visual classification of gonad maturity levels (GML) for female and male fish (Effendie 2002).

GML	Fish length average (mm)	Location
I	Testes resemble clear threads and are shorter in size compared to ovaries.	Ovaries resemble clear threads with a smooth surface, elongated in shape, located in the upper abdominal cavity beneath the backbone.
II	Testes are larger than those in GML I and have a milky white color.	Ovaries are larger than those in GML I, pale white, with visible egg granules. Their size is estimated to fill 10-20% of the abdominal cavity.
III	Testes are larger than those in GML II, with the surface starting to become serrated and still milky white in color.	Ovaries start to enlarge and are white, with clearly visible egg granules, though the granules are still difficult to separate. Their size fills approximately 20-50% of the abdominal cavity.
IV	Testes are larger than those in GML III and clearly visible. Their surface is grooved and milky white.	Ovaries are larger and white, with visible egg granules that are easily separated. Their size fills 50-70% of the abdominal cavity.
V	Testes are wrinkled and resemble those in GML I.	Ovaries are wrinkled, white in color, and contain residual eggs that were not released.

RESULTS AND DISCUSSION

Gonad maturity levels

The silver barb caught by gill nets was grouped into four gonad maturity levels (GML). These consisted of GML I with 6 individuals (3% of the total catch), GML II with 14 individuals (14%), GML III with 76 individuals (38%), and GML IV with 93 individuals (47%). The category of fish ready to spawn totaled 169 individuals (GML III and IV), representing 84.5% of the total sample. The data indicate that fishing operations were conducted just before the spawning season, as nearly all fish caught were in a spawning-ready condition. Sumsanto *et al.* (2023) stated that silver barb spawn naturally during the rainy season, which occurs in May. Meanwhile, fishing activities were conducted in April, one month before the rainy season. Consequently, the majority of the gill net catches consisted of silver barb entering the spawning phase.

Adjusting the timing of fishing activities to align with the spawning season is an important consideration in fish conservation and fisheries management. Catching fish after the spawning season can help mitigate issues related to reproductive biology and the sustainability of fish resources. Understanding the gonadal maturity levels of both male and female fish is crucial for various reasons, including effective fisheries management, breeding programs, and conservation efforts. Matsuda (2021) recommended that fishing should ideally be conducted post-spawning to maintain fish populations.

The number of male and female silver barbs in GML III and IV phases at the same time showed differences (Figure 2). Male fish were predominantly in the GML III phase, while female fish were in the GML IV phase, with 45 and 74 individuals, respectively. Females of the fish tend to reach gonadal maturity faster than males. Tamsil (2024) reported a similar condition in the silver barb inhabiting Tempe Lake. Based on the sex ratio between females and males, the number of mature male silver barbs was fewer than mature females. The differences in gonadal maturity levels in fish are influenced by numerous factors. These include fish size and age (Udapa 1986), species differences, competition for food, population density, and water quality factors such as salinity, transparency, temperature, and other environmental factors that may affect fish growth (Wu *et al.* 2008).

The relationship between growth and gonadal maturity in male and female fish is highly complex and varies among species. The growth rate is strongly linked to earlier gonadal maturity. Engdaw dan Geremew (2024) explained that a high-protein diet in Nile tilapia resulted in better growth and earlier gonad maturity compared to a low-protein diet. Therefore, faster growth rates generally lead to earlier gonad maturity in female fish, although specific dynamics may vary depending on diet and genetic factors. Tamsil (2024) added that if the number of mature male silver barbs is fewer than mature females, the species can be categorized as polygamous. During a single spawning season, male fish can have more than one mate.

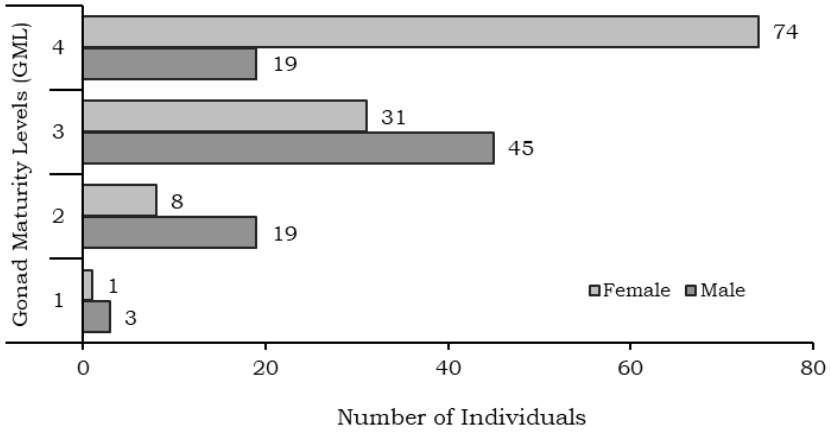


Figure 2. Gonad maturity levels (GML) of male and female silver barb found in Sidenreng Lake.

Length and weight relationship

The relationship between length and weight in silver barb can explain important aspects related to the fish's growth patterns. Based on the analysis of the length-weight relationship, the growth of male silver barb is classified as negative allometric. The constant value obtained, as shown in Figure 3, is b = 2.92, indicating that the increase in length is greater than the increase in weight, as b < 3. Similarly, the analysis of the length-weight relationship in female silver barb shows results that are not significantly different from those of the males. The b value for females is 2.90, also falling under b < 3, which categorizes their growth pattern as negative allometric. Muchlisin *et al.* (2010) explained that the b value is highly influenced by the fish's behavior in energy utilization. Fish that exhibit more active movement tend to have lower b values compared to more passive fish. The amount of energy used by fish for body maintenance and voluntary activities directly impacts the remaining energy available for growth (Rahmi *et al.* 2016).

The relationship between the length and weight of silver barb is one of the essential parameters for understanding its growth, health, and ecological status, which are influenced by the environmental conditions in Sidenreng Lake. Kresnasari (2020) explained that knowledge of the length-weight relationship of silver barb is aimed at supporting the sustainable management and conservation of fish resources, ensuring their long-term survival and health. Based on Figure 4, the relationship between length and weight shows a correlation coefficient (r) value of 0.973 for males and 0.949 for females. Both values are close to 1, indicating a strong relationship between the length and weight of the silver barb. Effendie (1997) stated that the length-weight relationship reflects relative growth, which can vary over time due to environmental conditions and food availability. The coefficient of determination (R^2) for the length-weight relationship explains that 97.3% of the weight increase in female silver barb and 94.9% of the weight increase in males is attributed to body length growth. This highlights the significant impact of length growth on the overall weight of silver barb in the lake.

Determination of gill net mesh size

The relationship between fork length (FL) and body girth is an important aspect of fisheries biology that influences gear selectivity and ecological studies. According to Cengiz (2022), several studies show that the maximum body girth of various fish species increases linearly with the total length (TL) or fork length (FL). The analysis of the relationship between fork length and body girth in female silver barb revealed a linear relationship with a correlation coefficient (r) of 0.986 and a coefficient of determination (R^2) of 0.9724. For male silver barb, the values were r = 0.99 and R^2 = 0.99. The correlation coefficients for both genders are close to 1, indicating a very strong relationship between fork length and body girth. The coefficients of determination, 97.24% for females and 99% for males, indicate that the body girth of silver barb is influenced by the increase in its length. Figure 4 illustrates the relationship between fork length and body girth for males and females of silver barb.

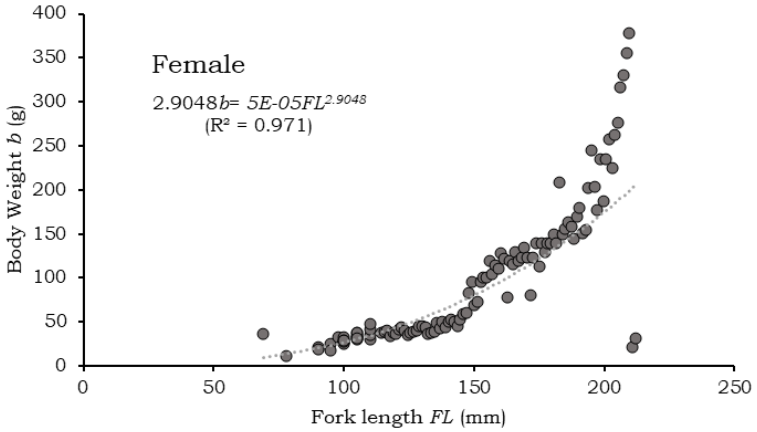


Figure 3. Relationship between fork length (FL) and body weight (b) of male and female silver barb, found in Sidenreng Lake.

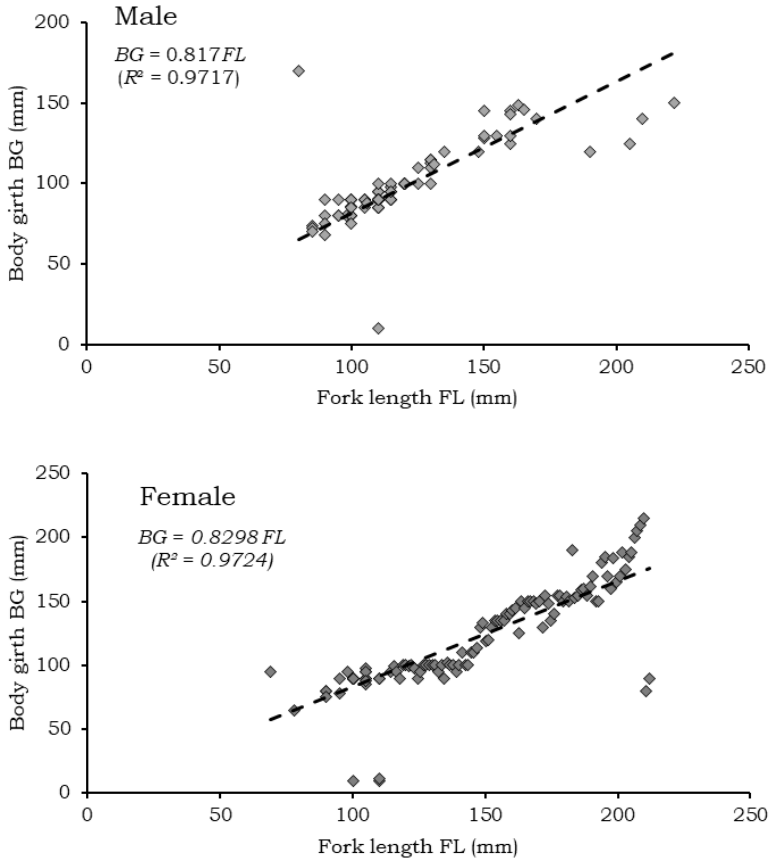
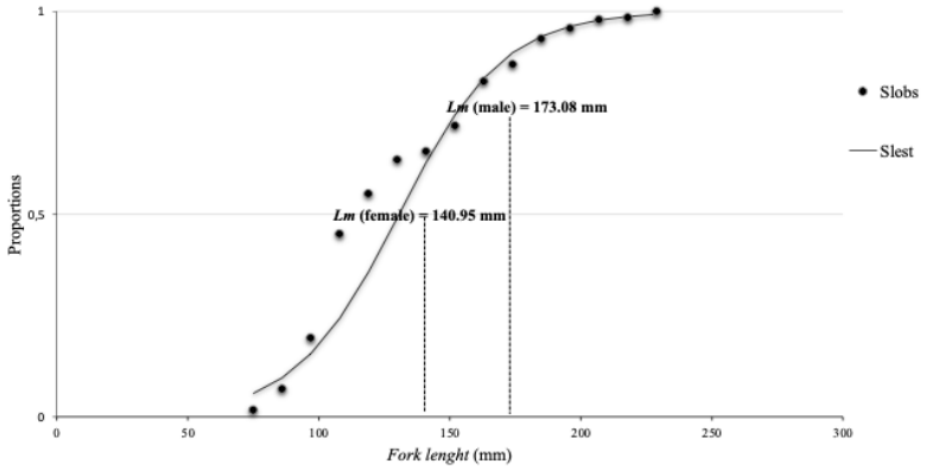


Figure 4. The relationship between fork length and body girth of silver barb found in Sidenreng Lake.

Figure 5 explains the size of the silver barb at first capture (Lc) and at first gonad maturity (Lm) using gill nets. Several factors influence this, including growth patterns, habitat, gear selectivity, and fishing methods. The size of silver barb first captured using gill nets with mesh sizes of 1.5", 2", 2.5", and 3" is Lc = 132.66 mm, while the Lm values for females and males are 140.95 mm and 173.08 mm, respectively. Based on Figure 6, female and male silver barbs caught were predominantly in the fork length ranges of 100-121 mm and 91-112 mm, respectively. The average fork length of male fish first captured by gill nets was smaller than the length at first gonad maturity (Lc < Lm), as was the case for females. The Lc < Lm values indicate that silver barbs in Sidenreng Lake were caught before reaching their first gonadal maturity phase.



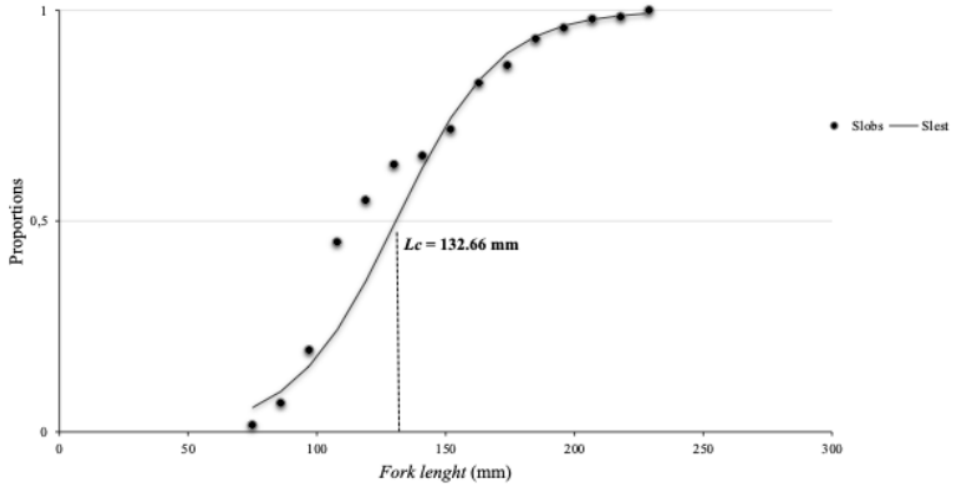


Figure 5. Size at first capture (Lc) and size at first gonadal maturity (Lm) of silver barb, found in Sidenreng Lake.

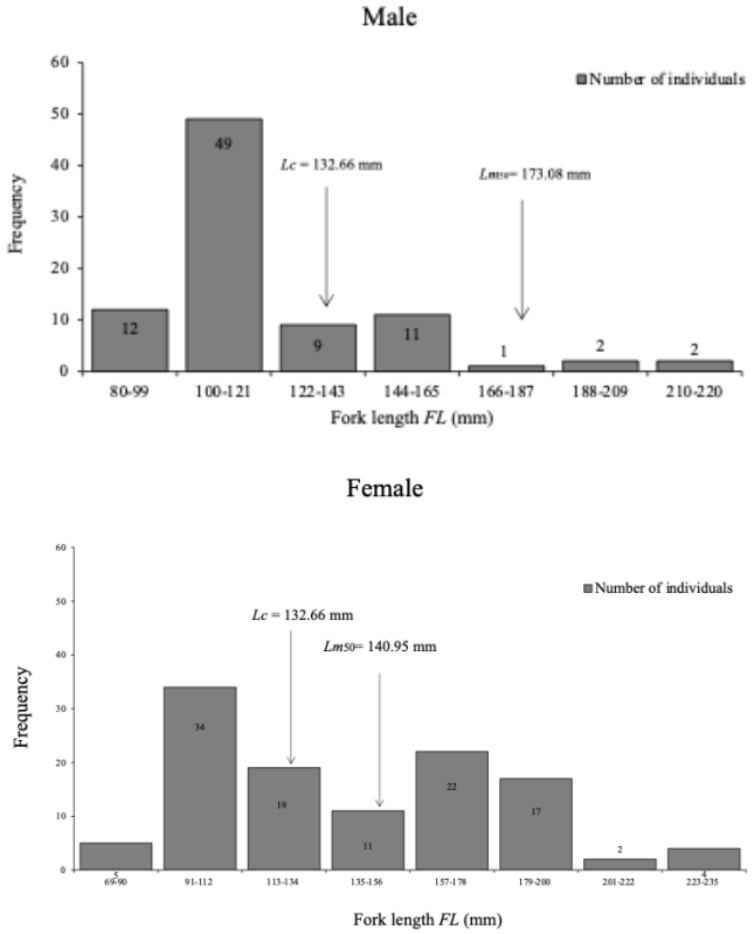


Figure 6. Frequency distribution of silver barb at first capture (Lc) and first gonadal maturity (Lm).

The size of the silver barb at first capture should be larger than the size at first gonadal maturity to ensure sustainable fishing practices and species conservation. The principle of fishing with an emphasis on Lc > Lm is supported by various studies on different fish species, which highlight the importance of allowing fish to reach sexual maturity before being caught (Guerrero and Arana 2009; Abdullah *et al.* 2015; Putera *et al.* 2020). The sustainability of fish resources is closely related to the size of fish at first capture and the size at sexual maturity, as both influence the reproductive capacity

and population dynamics of fish species. Restrictions on the size of fish that can be caught are essential to protect juvenile and adult fish from extinction.

The determination of the appropriate gill net mesh size based on the gonadal maturity level of the fish caught is crucial for sustainable fisheries management. The majority of the fish population targeted for capture should ideally have reached sexual maturity and undergone reproduction. The research findings show that the average fork length (FL) of fish caught by each gill net varies significantly. Gill nets with a mesh size of 1.5" caught fish with an average FL of 103 mm, 2" (130 mm), 2.5" (169 mm), and 3" (206 mm). Based on Figure 6, the recommended mesh size for capturing harvestable silver barb is 3", as the FL exceeds the Lm value of 173.08 mm for males and 140.95 mm for females.

CONCLUSION

The study concluded that:

1. The average size of silver barb first captured by gill nets in Sidenreng Lake is Lc = 132.66 mm.
2. Males of silver barb in Sidenreng Lake reach first gonadal maturity at a fork length (FL) of 173.08 mm, while females mature at 140.95 mm.
3. The recommended gill net mesh size for capturing silver barb of sustainable size in Sidenreng Lake is 3" (206 mm), as the average FL of fish caught is larger than the Lm value of 173.08 mm for males and 140.95 mm for females.

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