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INDONESIAN FISHERIES RESEARCH JOURNAL
Volume 31 Number 2 Dec 2025
p-ISSN: 0853-8980
e-ISSN: 2502-6569
Accreditation Number RISTEK-BRIN: 85/M/KPT/2020

REPRODUCTIVE BIOLOGY OF YELLOW-FINNED BARB (*Mystacoleucus marginatus*, VALENCIENNES 1842) IN THE LAU BELAWAN RIVER, NORTH SUMATRA PROVINCE

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Recieved: June 24 2025, Received in revised November 9 2025, Accepted: December 12 2025

ABSTRACT

Lau Belawan River has a fish potential, including yellow-finned barb (*Mystacoleucus marginatus*. The objective of this study was to investigate the reproductive biology of the yellow-finned barb (*Mystacoleucus marginatus*, Valenciennes 1842) in the Lau Belawan River, North Sumatra Province. The research location consists of 3 stations. Fish samples were collected by capturing fish using a low-voltage backpack electrofishing unit. Sex ratio was determined through gonadal observation after dissection, then the results are tested using chi-square statistics, gonad maturity index obtained by comparing body weight with gonad weight, and estimation of the size of the first mature

INTRODUCTION

The Cyprinidae family is the most dominant fish in tropical regions such as Indonesia, especially in freshwater. The same result was also found in the study (Jusmaldi *et al.* 2019) in the Mahakam upstream tributary (Desrita *et al*. 2018) in the Wampu watershed (Desrita *et al*. 2019) in Batangtoru watershed and its tributaries, and (Desrita *et al*. 2022) in Barumun watershed. The yellow-finned barb fish is one of the fish of the Cyprinidae family in the Lau Belawan River. Yellow-finned barb fish belong to the Order: Cyriniformes, Family: Cyprinidae, subfamily: Cyprininae genus: Mystacoleucus, and species: *Mystacoleucus marginatus* by (Valen *et al*. 2020) The distribution of *M. marginatus* includes Asia: Mekong River, Chao Phraya River, and downstream Mekong River, Malaysia Peninsula, Borneo, Sumatra, and Java (Indonesia) (Kottelat *et al*. 1993). Yellow-finned barb fish are found in water on the bottom of rivers and tributaries with sand or gravel substrates (Kottelat *et al*. 1993). Research on yellow-finned barb fish studies that have been carried out on the biological aspects of yellow-finned barb fish, “ on feeding habits by (Hardjasmita *et al*. 1976), growth by (Hardjasasmita *et al*. 1976; Kamiswara *et al*. 2021) “ and reproduction (Kaban and Wibowo 2018 :Hardjasasmita *et al*. 1976; Baihaqi *et al*. 2022), diversity and genetics research (Pujiastuti 2004; Kaban and Wibowo, 2018; Kasmawati *et al*. 2018; Valen *et al*. 2019; Valen *et al*. 2020; Liu *et al*. 2015).

This study focuses on the characteristics of reproductive biological aspects of yellow-finned barb fish (*M. marginatus*) in the Lau Belawan River, North Sumatra Province, consisting of sex ratio, gonad maturity index, gonad maturity level, fecundity, and oocyte diameter. The research provides good management recommendations for the sustainability of yellow-finned barb fish in the Lau Belawan River.

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DOI: http://dx.doi.org/10.15578/ifrj.31.2.2025.25-33

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MATERIALS AND METHODS

Area Study and Sample Collection

The research was conducted for 6 months, from October 2023 to March 2024, in Lau Belawan River, North Sumatra province. The research location consists of 3 stations, namely station 1 Namorih Village, station 2 Kampung Tengah Village, and station 3 Ladang Bambu Village, Deli Serdang, North Sumatra Province. Fish samples were analyzed in the Laboratory of Biology and Aquaculture, Department of Aquatic Resources Management, Faculty of Agriculture, and gonad samples in histology at the Anatomic Pathology laboratory, Faculty of Medicine, Universitas Sumatera Utara.

Fish samples were collected by capturing fish using a low-voltage backpack electrofishing unit. Backpack electrofishing was operated by 2 operators who walked along the river bank in a zigzag manner and against the current direction. All captured fish were census-collected from small to large size, measured for total length, and weighed. The fish were then dissected to extract the gonads of both male and female fish, and the gonads were weighed. The fresh gonads were examined morphologically, and then the Gonado Maturity Level (GML) was determined by referring to the modification (Schrek and Moyle 2002). Afterwards, fresh gonads still intact were put into a container containing 10% PA formalin and then histologized in the laboratory. Environmental parameters measured during the study were physical parameters: temperature, brightness, and current velocity, while for chemistry: pH (acidity), dissolved oxygen (DO), and alkalinity (Table 1).

Data analysis

The sex ratio is the ratio between male fish and female fish. However, the sex of the fish must first be known. The sex ratio is known using the formula (Matjik and Sumertajaya, 2013) :

$$X = \sum \frac{J}{B}$$

where:
X = sex ratio
J = number of fish male (individual)
B = number of fish female (individual)

Fecundity is the number of eggs released when spawning. The fecundity of yellow-finned barb fish is calculated at GML III and IV using the gravimetric method (Schrek and Moyle, 2002) :

F : t = B : b
where:
F = fecundity
t = number of oosit from gonado sample (eggs)
B = total gonado weight (g)
b = gonado sample weight (g)

The gonad maturity index was measured for all captured, yellow-finned barb fish by measuring the gonad weight and the weight of the male/female fish. GMI was determined using the formula (Schrek and Moyle, 2002) :

$$GMI = \frac{gw}{fw} \times 100$$

where:
GMI = Gonado Maturity Index
gw = gonad weight (g)
fw = fish weight (g)

Estimating the size of the first mature gonads used (Udupa 1986). The criteria for mature gonads are at GML III and I\ $\text{Log } M = Xk + (\frac{x}{2} - x \sum pi)$ ollows:

where:
Xk = Logarithm of the mean value at gonad maturity 100%
Xn = Difference of class mean logarithm
Xi = Logarithm of class mean
pi = ri/ni
ri = number of gonad mature fish in class i
ni = number of fish in class i
qi = 1 – pi

$$\text{Variety} = X^2 \sum [\frac{pi\ x\ qi}{N-1}]$$

At the 95% confidence interval, that is

$= m \pm Z_{a/2} \sqrt{\ }$ variety

RESULTS AND DISCUSSION

Biology reproductive

The sex ratio is the ratio of male and female fish caught during the study. The research in the Lau Belawan River produced different sex ratios each month. The highest ratio occurred in October, with a ratio of 5.9 during the study, and the lowest in February, with a ratio of 0.8. Based on the station, the highest sex ratio occurred at station 1, 2.1, and the lowest at station 3, with a ratio of 0.1. (Fig. 1(a-b)).

The sex ratio of male to female yellow-finned barb fish (sex ratio) varies by month and station. The sex ratio each month ranges from 0.8 - 5.9, while when viewed at each station, station 1 has the largest sex ratio, followed by stations 2 and 3 with a range of 0.1

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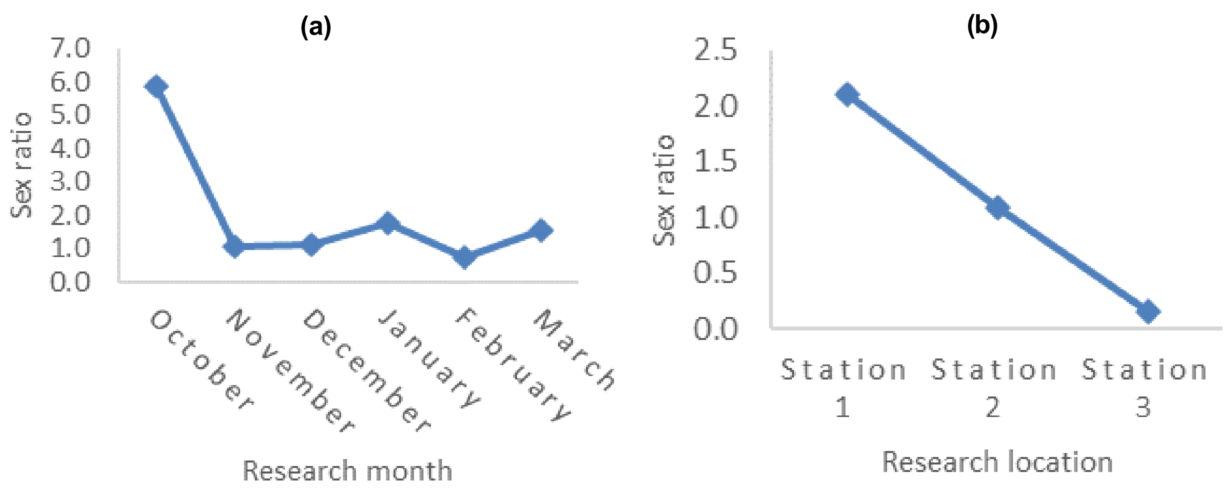

Figure 1. Sex ratio of yellow finned barb (*M. marginatus*) by month (a) and research location (b)

- 2.1. Differences in sex ratio occur due to the number of yellow-finned barb fish populations, the movement of fish groups, and activities about to spawn (Bond, 1979). The normal sex ratio is 1:1 between male and female fish. If there is more than this ratio, then it is due to differences in the number of male and female fish and the availability of natural food in the waters. Yellow-finned barb fish in November and December have a sex ratio 1:1, except in October, January, February, and March. Based on the station, the normal ratio occurs at station 2, while stations 1 and 3 do not. If natural food is abundant, female fish are more dominant, and vice versa. If food availability is reduced, the presence of male fish is dominant (Nikolsky, 1963).

The gonad maturity level during the study varied from October to March for both male and female fish (Fig 2(a-b)). Male yellow-finned barb fish in October, November, December, and February are dominated by GML I, while GML II dominates January and March. Furthermore, female yellow-finned barb fish for GML I dominate in October, November, January, February, and March, while GML II is only in December. Female yellow-finned barb fish in November for the number of fish in GML III and IV phases are 7 and 1 fish. This is the same as in December, namely, 7 fish and 1 fish for GML III and IV. When viewed by the station, GML III dominates at station 1, and GML I dominates at stations 2 and 3 for male yellow-finned barb fish. In contrast to female yellow-finned barb fish, GML I dominates at all research stations (Fig 3(a-b). Fish that begin to enter the maturity stage will focus more on gonad development rather than body growth (Bond, 1979), as well as yellow-finned barb fish.

Gonad matures, male and female, were also analyzed, providing information on the dominance of gonadally mature males in January and female yellow-finned barb in March (Fig 4(a-b)). Looking at each

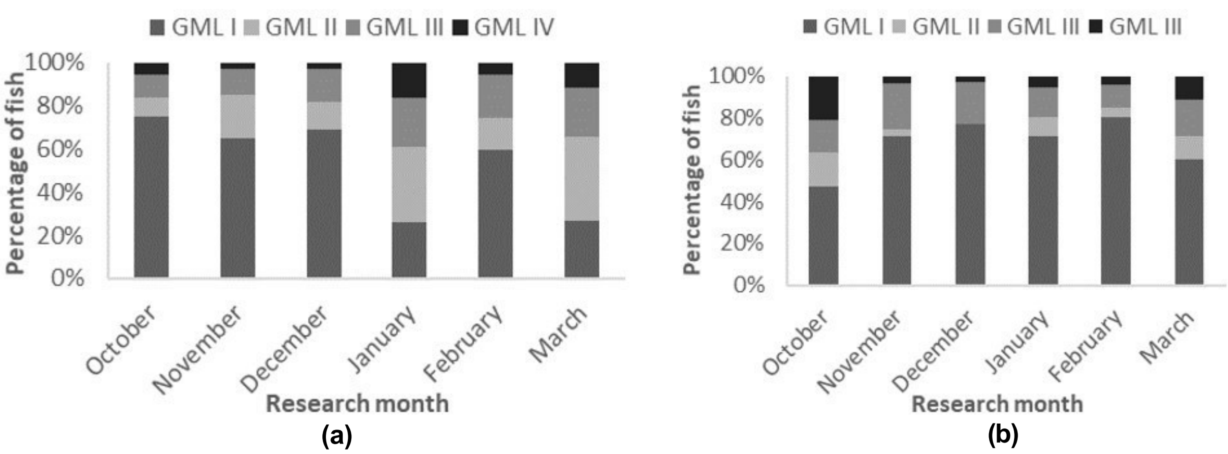

Figure 2. Percentage of Gonad maturity level of male (a) and female (b) yellow-finned barb fish (*M. marginatus*)

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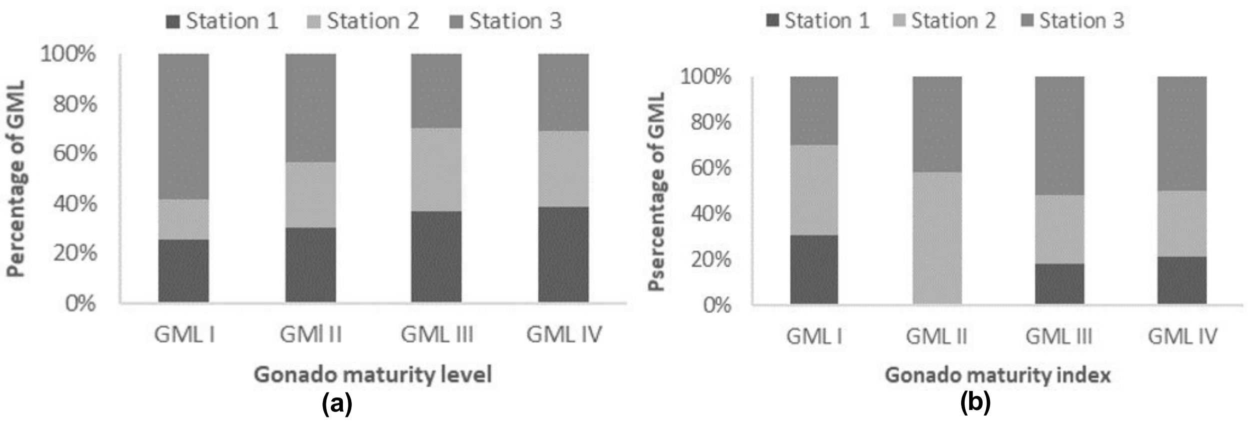

Figure 3. Percentage of Gonad maturity level of male (a) and female (b) yellow-finned barb fish (*M. marginatus*) at the study site

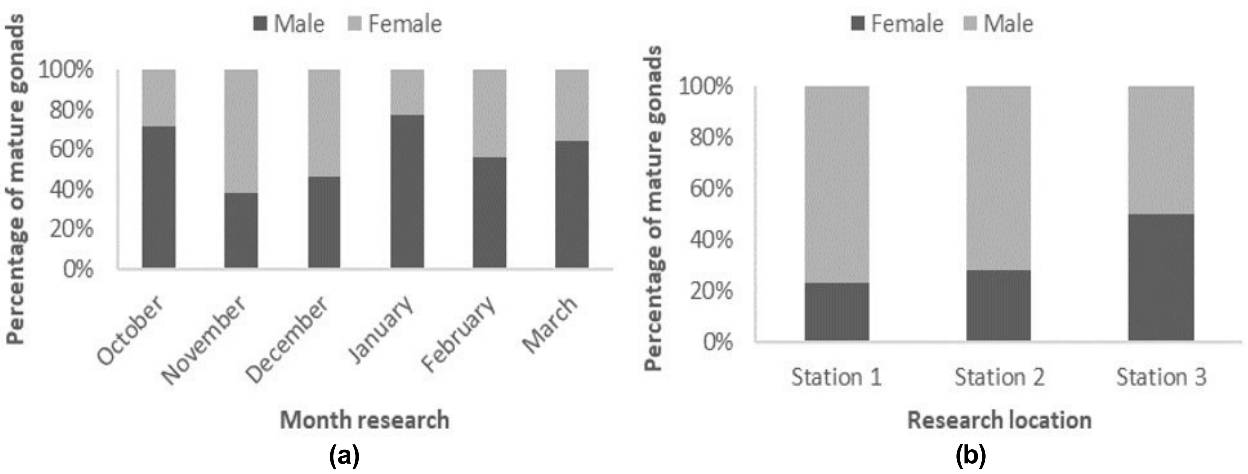

Figure 4. Number of gonad mature males (a) and females (b) of yellow finned barb (*M. marginatus*) in the month and location of the study

station, gonadally mature male-finned barbs dominate station 1, station 2 is also dominated by male yellow-finned barbs, and station 3 is not dominated.

Based on the results, the size of the male yellow-finned barb at first maturity is 73.68 mm, while the size of the female yellow-finned barb is 76.18 mm. Contrary to the research results (Hardjasasmita *et al*. 1976), GML IV gonad maturity was achieved by female fish measuring 153 mm and males 100 mm.

The gonad maturity level (GML) of male and female yellow-finned barb fish morphologically obtained yellow-finned barb fish with GML I, II, III, and IV (Table 3). Likewise, the results of histology of male and female yellow-finned barb fish gonads show that the GML of yellow-finned barb fish is well developed starting from previtellogenic oocytes, oogonium, oocytes, and ootids for female yellow-finned barb fish. The structure has also developed for male fish testes, starting with spermatogonium, spermatocytes, spermatids, and spermatozoa (Figure 5).

The yellow-finned barb fish in the Lau Belawan river consisted of GML I-IV for both male and female yellow-finned barb fish. The description of the GML can be seen in Table 3. Not only morphologically, but the

Table 2. Size of first mature gonad yellow-finned barb fish (*M. marginatus*)

Sex	Total length (mm)	Lower limit (mm)	Upper limit (mm)
Male	73.68	61.22	88.69
Female	76.18	70.97	84.02

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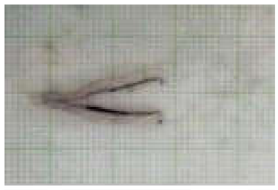
Table 3. Description of gonad morphology of female and male yellow-finned barb fish in Lau Belawan River

GML	Description of Gonad Female Fish	Figure	Description of Gonad Male Fish	Figure
I	Small filamentous ovary, ovules not visible, clear		The testicles are small and thin, thread-like, and have a transparent white.	
II	Ovaries are grayish-white; ovules are visible; ovaries are not dense and fill 25% of the body cavity		The testes are white and begin to compact, filling 20% of the body cavity	
III	Ovaries are dense grayish white; ovules are visible; ovaries begin to be dense and fill 60% of the body cavity		The testicles are milky white and fill half of the abdominal cavity or 50% of the abdominal cavity	
IV	Ovaries are gray to reddish yellow; egg grains are very clearly visible; eggs on the ovaries are yellow; ovaries are dense and fill 90% of the body cavity		The testes are dense, milky white, and solid; the testes fill most of the abdominal cavity or 85% of the abdominal cavity	

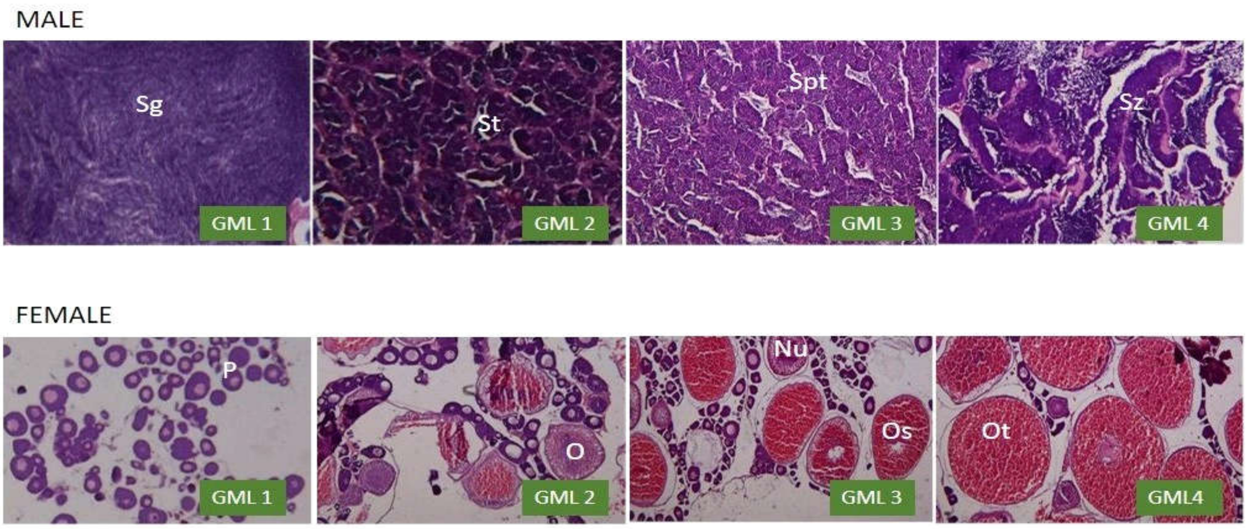


Figure 5. Histology of gonads of yellow finned barb fish (*M. marginatus*) male and female in the Lau Belawan river, North Sumatra. Testes of male fish, Sg=spermatogonium (GML 1) St=spermatosit (GML 2), Spt=spermatid (GML 3) and Sz=spermatozoa (GML 4). Histological structure of female fish gonads P=previtolegenik oosit (GML 1), O=oogonium (GML 2), Os=oosit, Nu=nukleus (GML 3) and Ot=ootid (GML 4)

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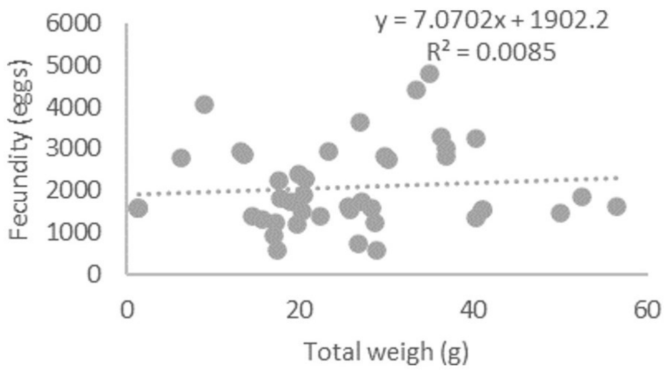

Figure 6. Relation of fecundity with weight body fish (*M. marginatus*)

description of the level of gonads maturity is also shown in the histology of the ovaries and testes of yellow-finned barb fish. At GML I, the ovary is seen with previtellogenic oocytes. At GML II, oogonium was seen, oogonium developed into oocytes, and cell nuclei (nucleus) were seen at GML III. Ootids that female fish will release during spawning are visible at GML IV. Ootid development in GML IV consists of several stadia, namely I-IV. These stadia result in heterogeneous female fish gonads. It is also seen in the size of the diameter of the oocyte, which is different for each grain. Stated that the spawning season's frequency and length cause eggs to become homogeneous at the mature stage (Bond, 1979). There is a heterogeneous composition of oocytes in GML IV, including the non-synchronized type (Desrita, 2011).

Furthermore, oocytes in stage IV (mature) will be released at spawning; oocytes in stage III continue to develop until they reach the mature level. When they are mature, they will be released immediately. The development of the testes histologically does not show striking changes because the GML I - IV sperm shape is the same. Sperm development is only seen in sperm density on the sperm-wrapping membrane. In GML I for testes, sperm are called spermatogonia, GML II are called spermatocytes, GML III are called spermatids, and GML IV are spermatozoa.

Furthermore, the relationship between fecundity and the weight of yellow-finned barb fish (*M. marginatus*) is not so strong, characterized by the value of R^2(determination) 0.0085 (Figure 6). The diameter of yellow-finned barb fish's eggs (oocytes) measured directly from the ovary in the Lau Belawan River varies. The 0.5 - 0.6 mm class interval dominates for GML III and 0.7 – 0. 8 mm in GML IV.

Gonads of yellow-finned barb fish that mature gonads are calculated to determine fecundity, especially fish with GML III and IV. The fecundity of yellow-finned barb fish totaled 44 fish, consisting of 32 with GML III and 12 with GML IV. Yellow-finned barb fish fecundity ranged from 561 to 4.792 eggs, averaging 2.079,8. The fecundity of yellow-finned barb fish (*M. marginatus*) ranged from 4.432 – 9.887 eggs with a total length of 87 - 136 mm and egg diameter ranging from 0.08 - 0.012 mm (Figure 7(a-b) 9) (Kaban and Wibowo, 2018). Much different from Bilih (*M. padangensis*) in Lake Toba, the fecundity ranged from 8.683 to 17.824 eggs (Suryanti *et al*. 2017) Fish fecundity varies depending on size, food in the water, and environment (Rahardjo *et al*. 2024).

Morphological calculation of egg diameter (oocyte) has 7 class intervals ranging from 0.06 - 1 mm. Egg diameter for female yellow-finned barb fish in GML III is dominated by the size interval 0.50 - 0.6 mm, while

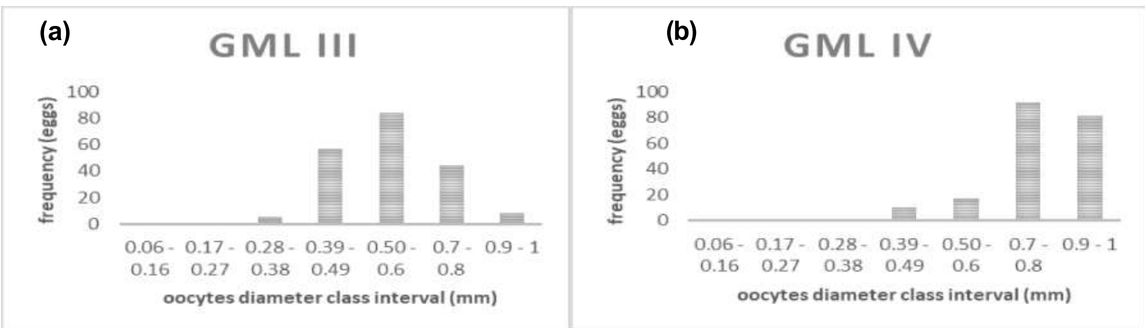

Figure 7. Diameter distribution of oocytes measured directly from fish ovaries of GML III (a) and GML IV (b) in Lau Belawan river, North Sumatra

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GML IV is dominated by the size interval 0.7 - 0.8 mm. Only one class interval exists when viewed from the size that dominates in GML III and GML IV. Also, the frequency analysis of the distribution of oocyte diameter size forms one mode in the gonads of female yellow-finned barb fish in GML III and IV. It can be assumed that yellow-finned barb fish are total spawners. A total spawner is a fish that spawns at one time during the spawning season by releasing mature eggs and spawning again during the next spawning season. In contrast, the Bilih fish (*Mystacoleucus padangensis*), which is in the cyprinidae family, has a partial spawner type because the results of measuring oocyte diameter have 1-3 modes of distribution (Suryanti *et al*. 2017).

Recommendations that can be applied in the waters of the Lau Belawan river are that young fish caught will impact the recruitment of yellow-finned barb fish in the waters. To overcome this problem, catching certain sizes, such as the size that can be caught, should be prohibited. The size of the first mature gonad of male yellow-finned barb fish is 73.68 mm with an upper limit of 88.69 mm, while female yellow-finned barb fish is 76.18 mm with an upper limit of 84.02 mm. For this reason, the minimum size setting that can be caught must be greater than 88.69 mm, taken from the upper limit of the first-time gonad ripe fish.

Environmental parameters

During the research conducted in the Lau Belawan River for environmental factors, both physical and chemical factors produced during the study such as temperature range from 27.03 - 28.22^{0}C, brightness 57.25 - 68.58 cm, while the current speed is 0.11 m/s, then the chemical factors are pH 6.9 - 7.68, dissolved oxygen (DO) 6.12 - 6.35 mg/L and alkalinity 27.54 - 35.87 mg/L shown in Table 1.

Environmental parameters are one of the supporting factors for the existence and sustainability of yellow-finned barb fish in the waters of the Lau Belawan River. The temperature in the waters of the Lau Belawan River is still in a state that supports the existence of yellow-finned barb fish with a range of 27.08 - 28.22^{0}C. Not much different from the temperature in with a temperature range of 25-30^{0}C[19] (Desrita *et al*. 2018) with a temperature range of 24.60 - 27.5^{0}C (Pasisingi *et al*. 2014) 24-29^{0}C (Muhtadi *et al*. 2017) with a water temperature range of 23-29^{0}C. The optimal temperature for plankton and plankton life. The optimal temperature for plankton and yellow-finned barb fish life is 20-30^{0}C (Effendi, 2024). The temperature in the waters is closely related to the intensity of sunlight entering the waters, altitude from sea level, air circulation, cloud cover, flow, and depth of water bodies (Effendi, 2024). Sunlight entering the waters will have a stable temperature impact and affect the water's brightness.

Brightness in the waters of the Lau Belawan River ranges from 57.25 to 68.58 cm, and the brightness of the waters depends on color and turbidity. Brightness is a measure of water transparency determined visually using a secchi disk. Brightness is influenced by dissolved organic and inorganic materials, such as mud and fine sand, and organic matter in the form of plankton and other microorganisms (Effendi, 2024). Brightness also affects photosynthesis events by phytoplankton in the waters. The entry of sunlight into the waters will be blocked by dissolved organic matter, so that it influences brightness.

The average current speed of the Lau Belawan River is 0.11 m/s. Current speed is influenced by depth, water substrate, and habitat topography. The current in the waters of the Lau Belawan River is not too high

Table 1. Environmental parameters in L

Parameters	Unit	Quality standard	Station 1	Station 2	Station 3
Physics					
Temperature	℃	Deviation 3	27.13	27.08	28.22
Brightness	cm	-	68.58	57.25	59.00
Current speed	m/s	-	0.11	0.11	0.11
Chemical					
pH	-	6-9**	7.70	7.68	6.97
DO	mg/l	3**	6.35	6.12	6.23
Alkalinity	mg/l	5 - hundreds*	35.87	35.67	27.54

Note : ** Quality standard (Government regulation of Indonesia Republic no 22 of 2021)
* Quality standar (Effendi 2024)

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and tends to be slow. It is favored by aquatic biota, especially yellow-finned barb fish. pH (acidity) in waters is influenced by organic and inorganic materials dissolved in waters that come from the waters themselves and from outside the waters. The higher the organic content of a body of water, the more likely it is to impact changes in pH. The pH of the Lau Belawan River ranges from 6.97 - 7.70, with the highest pH at station 1 and the lowest at station 3. Around station 3, many rivarian trees are thought to be a source of organic matter at that location. The optimal pH range for aquatic biota life is 7 - 8.5 (Effendi 2024), while according to (Bond, 1979) the pH quality standard is 6 - 9. Acidic conditions will interfere with the life of aquatic organisms, especially in the process of metabolism and respiration. Dissolved oxygen (DO) in Lau Belawan River waters ranges from 6.12 - 6.35 mg/L, not much different from dissolved oxygen in research conducted by (Haryono, 2004), which is > 6 ppm, while (Desrita *et al*. 2018) 7.1 - 8.5 mg/L in the Wampu watershed. The three locations have different dissolved oxygen levels but are still in conditions that support fish life in the waters. According to (Government regulation of Indonesia Republic no 22 of 2021), the minimum limit of dissolved oxygen intended for fish life in waters is 3 mg/L. Dissolved oxygen in water comes from diffusion in the air and results from photosynthesis. They are then utilized by fish biota in respiration and other processes

CONCLUSION

In conclusion, the eggs of male yellow-finned barb fish were highest in January, while the eggs of female yellow-finned barb fish in March. The size of the first maturing gonads of female yellow-finned barb fish is faster than that of male yellow-finned barb fish. The size of the oocytes that dominate only one class interval means that yellow-finned barb fish are classified as total spawners when spawning.

ACKNOWLEDGMENT

We would thanks to Universitas Sumatera Utara for funding the research through the Talenta grant.

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