

Reproductive biology of leaftail croaker (*Johnius trachycephalus* Bleeker, 1851) in Muara Angke waters of Jakarta Bay, Jakarta

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Abstract. The leaftail croaker (*Johnius trachycephalus*) is a demersal fish favored by the community and is commonly processed into salted fish. This fish no research has been conducted on the reproductive biology of the leaftail croaker in the Muara Angke Waters, this research is very important to carry out considering the lack of biological information. This study aims to analyze the reproductive biology of the fish in Muara Angke coastal waters as a basis for sustainable management, including sex ratio, spawning season, reproductive potential, and spawning pattern. This research was conducted in the Muara Angke coastal waters for 6 months (August 2024 – January 2025). The data collection was carried out using primary data, starting from fish sampling, dissection, and ending with gonad extraction. The results show that the sex ratio of the fish was 0.6:1, and it was dominated by females. The spawning season is estimated to occur in August and December. The size at first gonadal maturity of the fish was 260 mm (male) and 159 mm (female). The reproductive potential of the fish ranged from 15,486 to 82,830 with a partial spawner spawning pattern. According to oocyte diameter, the fish is categorized as a partial spawner. The implication of this study was the reduction of fishing intensity that was suspected to occur during the spawning season, as well as the reduction of the capture of small sized fish.

Keyword: croaker fish, reproduction biology, waters of Muara Angke

1 Introduction

Leaf tail croaker is a demersal fish belonging to the Sciaenidae family. Leaf tail croaker is caught by fishermen using gillnet fishing gear. Leaf tail croaker is a fish in demand for consumption because it has thick, soft meat quality and a savory taste [17]. One of the potential existences of leaf tail croaker resources is in Jakarta Bay, precisely in the Muara Angke Waters.

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The waters of Muara Angke are part of Indonesian waters where there are many activities, both social and economic. The location of Muara Angke is administratively in Kapuk Muara Village, Penjaringan District, North Jakarta Administrative City. The Muara Angke area has abundant natural resource potential. The abundance of fishermen and their catches illustrate that the Muara Angke Waters contain diverse biodiversity. Fishermen use various types of fishing gear with diverse catches. The majority of fishermen in the Muara Angke Waters use gillnets to catch target biota. Lefttail croakers are usually used as fresh fish consumed and salted fish at affordable prices [9]. The Muara Angke community utilizes leaftail croaker as salted fish. [22] The utilization of leaftail croakers and the increasing market demand continuously without any management efforts will trigger a decline in the leaftail croaker population in the Muara Angke Waters.

The sustainability of the leaftail croaker population can be predicted by studying reproductive biology as one of the important aspects studied as basic information that must be taken for sustainable management of the fish. Research on the reproduction of the leaftail croaker has been conducted by [19] at Lampu Satu Beach, Merauke Regency, [3] in the Muara Sembilang Waters, East Kalimantan, and [6] at the Tanjung Beringin TPI, North Sumatra. However, few research has been conducted on the reproductive biology of the leaftail croaker in the Muara Angke Waters. This research is very important to carry out considering the lack of biological information about the fish to analyze the reproductive biology parameters of the fish which include aspects of sex ratio, spawning season, reproductive potential, spawning patterns, and size of first gonad maturity. This information can be used as a basis for management so that the leaftail croaker can be managed effectively so that it can be utilized sustainably.

2 Methods

Sampling was carried out within six months (August 2024 - January 2025), in the Muara Angke Waters (Figure 1). The leaftail croaker obtained were the catches of fishermen in the Muara Angke Waters. Analysis of leaftail croaker samples was carried out at the Macro Biology I Laboratory, Division of Ecobiology and Aquatic Resources Conservation, Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, IPB University.

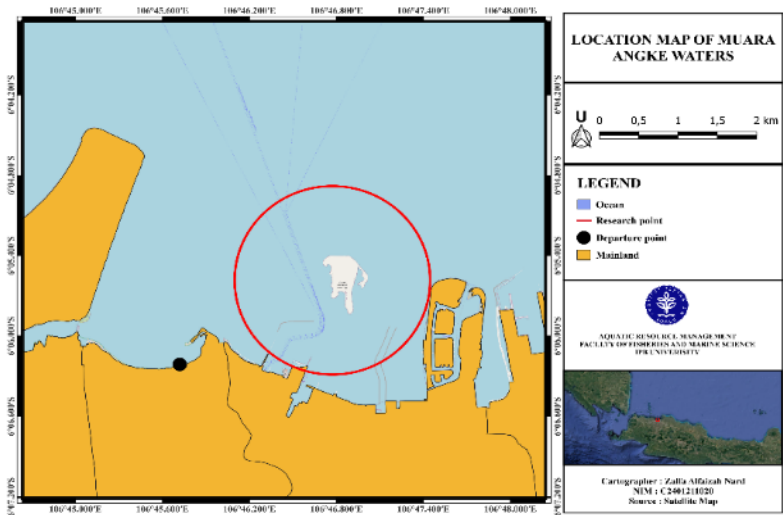


Fig. 1. Research location the reproduction of leaftail croaker in Muara Angke, Jakarta.

The data used in this study are primary data including length, weight, sex, gonad maturity level, fecundity, and egg diameter of the sample fish. The fish sample in this study were leaf-tail croaker obtained from the results of casting nets of fishermen in the waters in the waters of Muara Angke. The sample example was shown in the following image (Figure 2).



Fig. 2. The leaf-tail croaker was caught in the waters of Muara Angke.

The fish is collected directly from the fishermen's catch at night using gillnet with a mesh size of 1-3 inches. The number of leaf-tail croaker obtained ranges from 36-66 fish per month. The leaf-tail croaker is weighed and its length is measured. A ruler is used to measure the length of the fish (accuracy of 0.05 cm or 0.5 mm). The length measured is the total length. The weight of the fish is measured using a digital scale that has an accuracy of 0.005 g. The leaf-tail croaker was dissected to remove the gonads, then the gonads were separated and placed in small ziplock bags and given 5% formalin for analysis of fecundity and egg diameter.

The dissected leaf-tail croaker, separated gonads, determined sex, and gonad maturity level are seen through morphological characteristics and gonad maturity level classification referring to reference [8]. The gonads of croaker used in determining fecundity are gonads that are starting to mature and are mature, namely at GML III to IV. Fecundity calculations use a mixed or combined approach of gravimetric and volumetric methods.

Measurement of egg diameter from the three gonad sub-sections will be carried out using egg samples. The number of eggs measured for diameter is 50 eggs in each gonad sub-section. Measurement of egg diameter using a microscope equipped with an ocular micrometer with a magnification of 4 x 10 where the egg sample is placed on a glass slide to be observed.

2.1 Data analysis

2.1.1 Sex ratio

Sex ratio is used to determine the ratio of male and female fish. The ideal ratio proportion is not always 1:1, and each type of individual fish will have a different ratio. The following is an equation to find the sex ratio value of [8]:

$$X = \frac{J}{B} \quad (1)$$

X : sex ratio
 J : number of male fish (ind.)
 B : number of female fish (ind.)

2.1.2 Gonad maturity level

The spawning season can be estimated through the gonad maturity level (GML). The gonad maturity level is the classification of the maturity of the fish gonads in the changes experienced at each stage, these stages can be estimated through the distribution of gonad maturity which refers to its gender [10]. The level of gonad maturity can be determined through the classification of [8].

2.1.3 Size at first maturity

The size of the first gonad maturity is needed to support the sustainability and preservation of fish populations in the waters. Determining the estimated value of the size of the first gonad maturity using the Spearman-Kärber method [20] with the following logarithmic equation:

$$m = \left[X_k + \left(\frac{x}{2} \right) \right] - (x \Sigma p_i) \quad (2)$$

with a 95% confidence interval for L_m as follows:

$$L_m = \text{antilog} \left[X_k + \left(\frac{x}{2} \right) \right] - (x \Sigma p_i) \quad (3)$$

m : log length of fish at first gonad maturity
 L_m : average value of fish length at first gonad maturity (mm)
 X_k : log of the mean value of the last length class of fish that has mature gonads
 x : log of length increase at the middle value
 p_i : proportion of fish with mature gonads in length class i to the total number of fish in the interval length i
 q_i : $1 - p_i$

2.1.4 Gonad maturity index

Gonad maturity index or maturity is a value in percentage obtained from the ratio between gonad weight and body weight multiplied by 100%. The following is the equation to obtain the [8] gonad maturity index value:

$$IKG = \frac{BG}{Bt} \times 100\% \quad (4)$$

IKG : gonad maturity index
 Bg : gonad weight (g)
 Bt : body weight (g)

2.1.5 Reproductive potential

Reproductive potential can be estimated by the fecundity of individual fish. Fecundity is a way to estimate the number of fish offspring that will be produced. The ability of fish to produce eggs during the spawning period is a reproductive potential that can be used to

estimate recruitment [10]. According to [8] fecundity is observed and analyzed using a mixed (combined) approach, namely gravimetric and volumetric with the following equation:

$$F=\frac{G\times V\times X}{Q}$$

(5)

- F : Fecundity (number of oocyte)
- G : Total gonad weight (g)
- V : Volume of dilution contents (ml)
- X : Number of oocyte in 1 ml
- Q : Sample gonad weight (g)

3 Result and Discussion

3.2 Result

3.2.1 Sex ratio

The number of leaftail croaker during the study was 318 with a proportion of 201 females and 117 males. The sex ratio between males and females was obtained with a percentage of 37% males and 63% females. Based on the chi-square test with a significance level of 0.05, the results showed that the ratio of male and female leaftail croakers was 0,6: 1 (Figure 3). The sex ratio of leaftail croaker varies each month with the dominance of female fish. The highest sex ratio was in October with 23 males and 28 females. The smallest sex ratio was in January with 10 males and 50 females. The sex ratio based on the size of the long class interval showed various results. Male leaftail croaker were mostly found in the class intervals of 110-132 mm and 179-201 mm. Female leaftail croaker were mostly found in the class intervals of 156-178 mm.

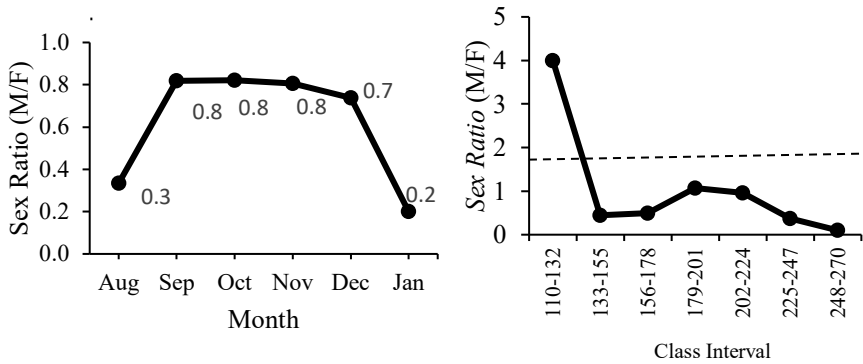


Fig. 3. Sex ratio graph of leaftail croaker (*J. trachycephalus*) in Muara Angke waters based on observation time and size.

3.2.2 Gonad maturity level

Determining the level of gonad maturity is done directly visually, namely by seeing the color, and changes in the contents of the gonad, and observing its shape [2]. Based on morphological observations, GML I to GML V were obtained. During the observation period, GML I was found, which means that every month there are immature leaftail croaker that have been caught. Both male and female leaftail croakers have the potential to spawn every

month because during the observation period, mature GML was obtained. This illustrates that the leaftail croaker spawned during the observation period. Figure 4 shows the percentage of the relative frequency of gonad maturity levels of male and female leaftail croaker in Muara Angke Waters.

Figure 4 showed in the class interval of 110-132 mm, the frequency of male fish that began to be dominated by mature GML was in the class interval of 248-270 mm. In the class interval of 110-132 mm, most female leaftail croakers began to mature their gonads but were still dominated by GML II. The frequency of female fish that began to be dominated by mature GML was in the class interval of 156-178 mm. Figure 5 showed the percentage of relative frequency of gonad maturity levels in male and female gulamah fish in the waters of Muara Angke based on the observation period. The graph indicated that the gulamah fish spawned gradually and not at a single time.

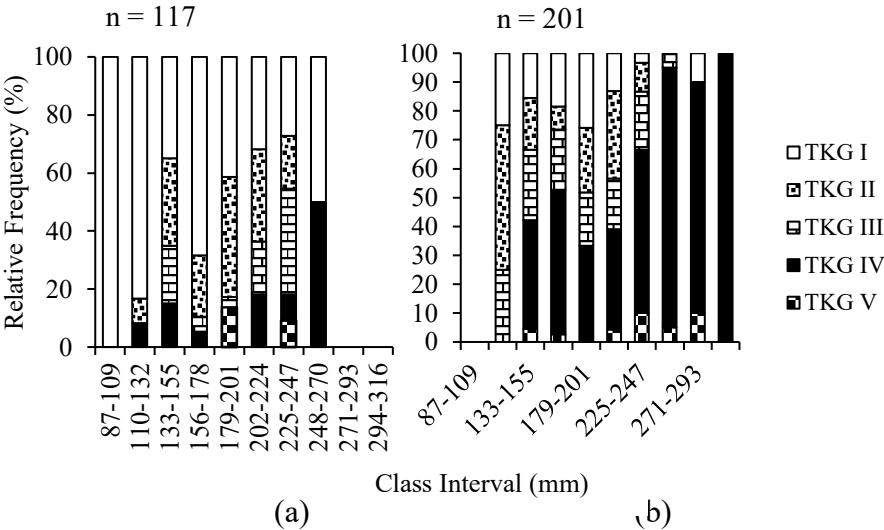


Fig. 4. Relative frequency graph of gonad maturity levels of the leaftail croaker (*J. trachycephalus*) in Muara Angke waters based on class size, (a) male, (b) female.

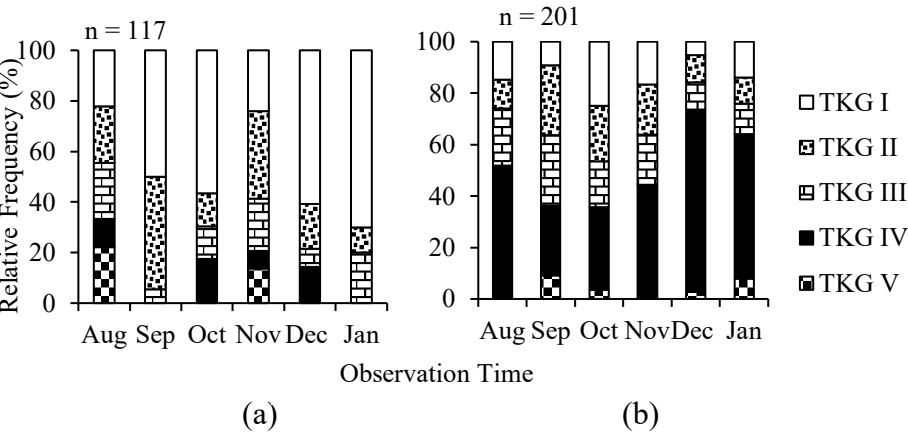


Fig. 5. Relative frequency graph of gonad maturity level of leaftail croaker (*J. trachycephalus*) in Muara Angke waters based on observation time, (a) male, (b) female.

3.2.3 Size at first maturity

The size of the first gonad maturity can vary, this is due to environmental factors, water quality, and differences in location. Figure 6 showed that the size at first maturity for male leaftail croaker was at a length of 260 mm, while females at a length of 159 mm. These were in line with the GML distribution which was dominated by matured fish at the class interval of 156-178 mm (for females) and 248-270 mm (for males).

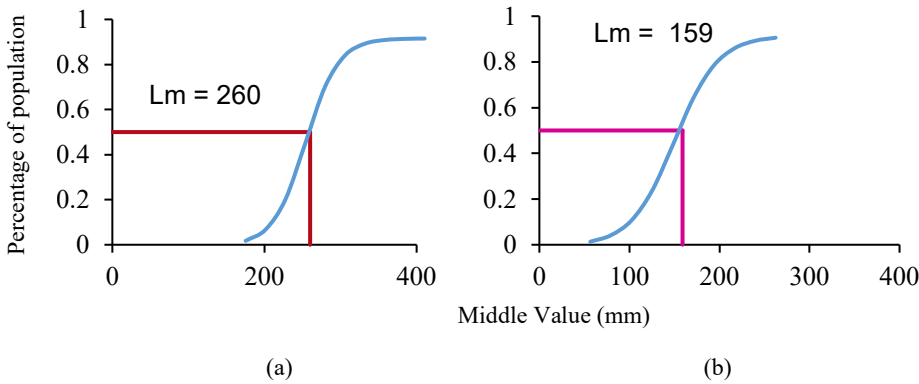


Fig. 6. Graph of the size at first (Lm) of the leaftail croaker (*J. trachycephalus*) (a) male and (b) female in the Muara Angke waters.

3.2.4 Gonad maturity index

The gonad maturity index values of male and female leaftail croaker fluctuated during the observation period. The highest average IKG values of male and female leaftail croaker were in August and December. This indicated that the spawning season occurred in those months (Figure 7).

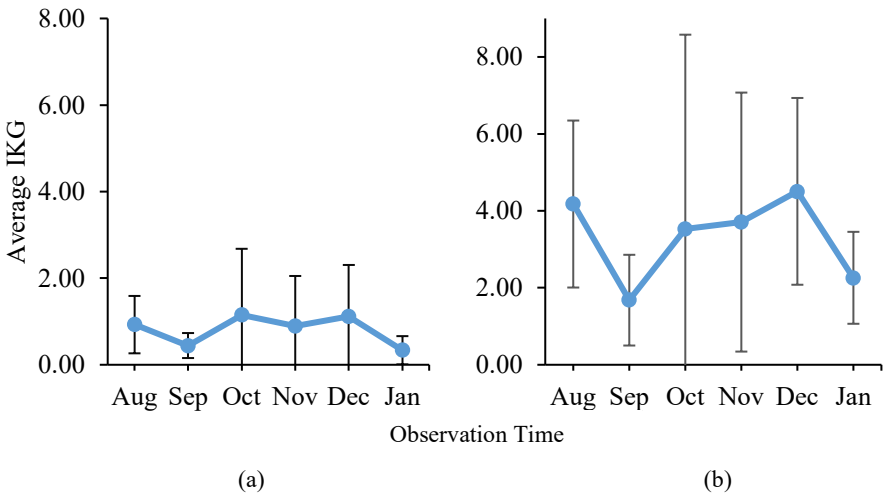


Fig. 7. Graph of gonad maturity index of leaftail croaker (*J. trachycephalus*) in Muara Angke Waters, (a) male, (b) female.

3.2.5 Reproductive potential

Calculation of fecundity in leaftail croaker using GML III and GML IV with a total of 137 gonads. Based on the observation results, the fecundity of the leaftail croaker ranged from 15,486–82,830 grains. The relationship between the length and fecundity of the leaftail croaker is $F = 161.06 + 3242.4$ ($R^2 = 0.2302$). This illustrating that there is no correlation between fecundity and length. The relationship between fecundity and weight is $F = 92.33 + 24373$ ($R^2 = 0.2196$) which means that there is no correlation between fecundity and weight of leaftail croaker.

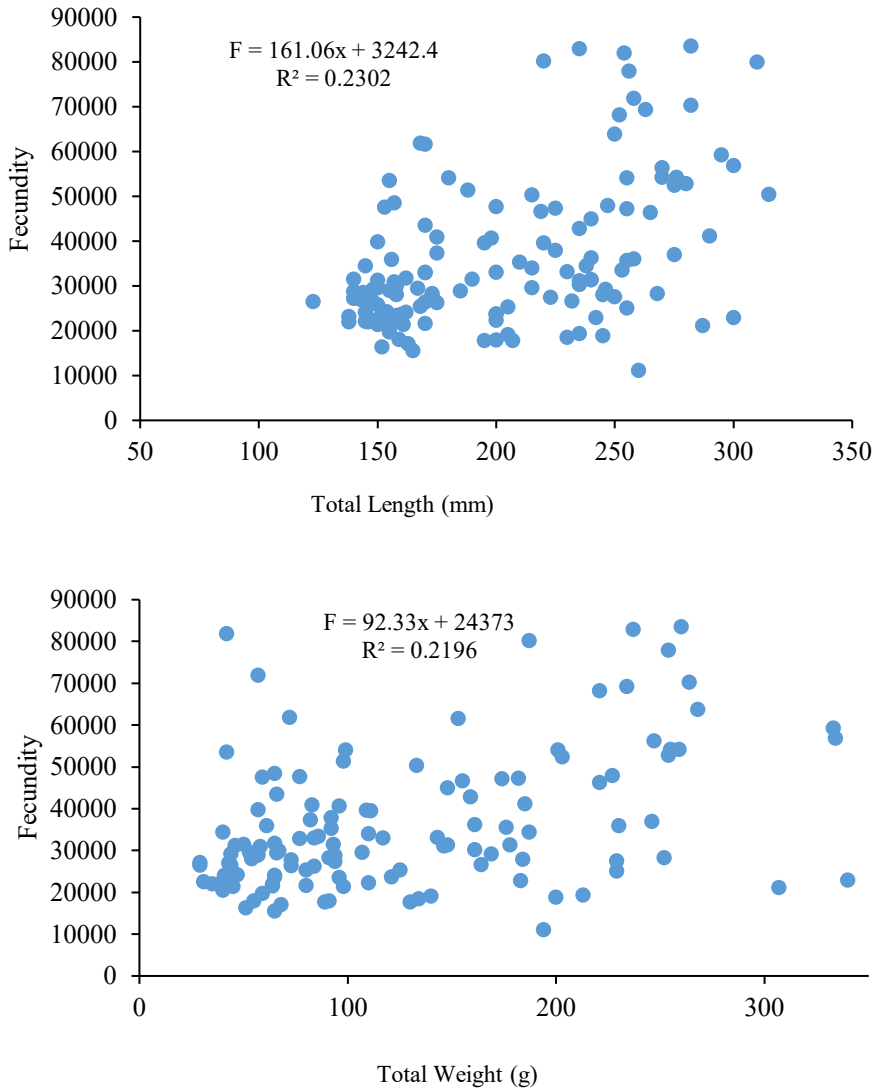


Fig. 8. Graph of the relationship between total length and total weight with the fecundity of the leaftail croaker (*J. trachycephalus*) in the Muara Angke Waters.

3.2.6 Spawning pattern

The diameter of leaftail croaker eggs is divided into 16 classes with varying sizes between 0.0025-0.076 and a class width of 0.045 mm (Figure 8). The distribution of the diameter of leaftail croaker eggs showed two peaks in the mature GML, suggesting that leaftail croakers have a partial spawner spawning pattern, where mature eggs are released gradually.

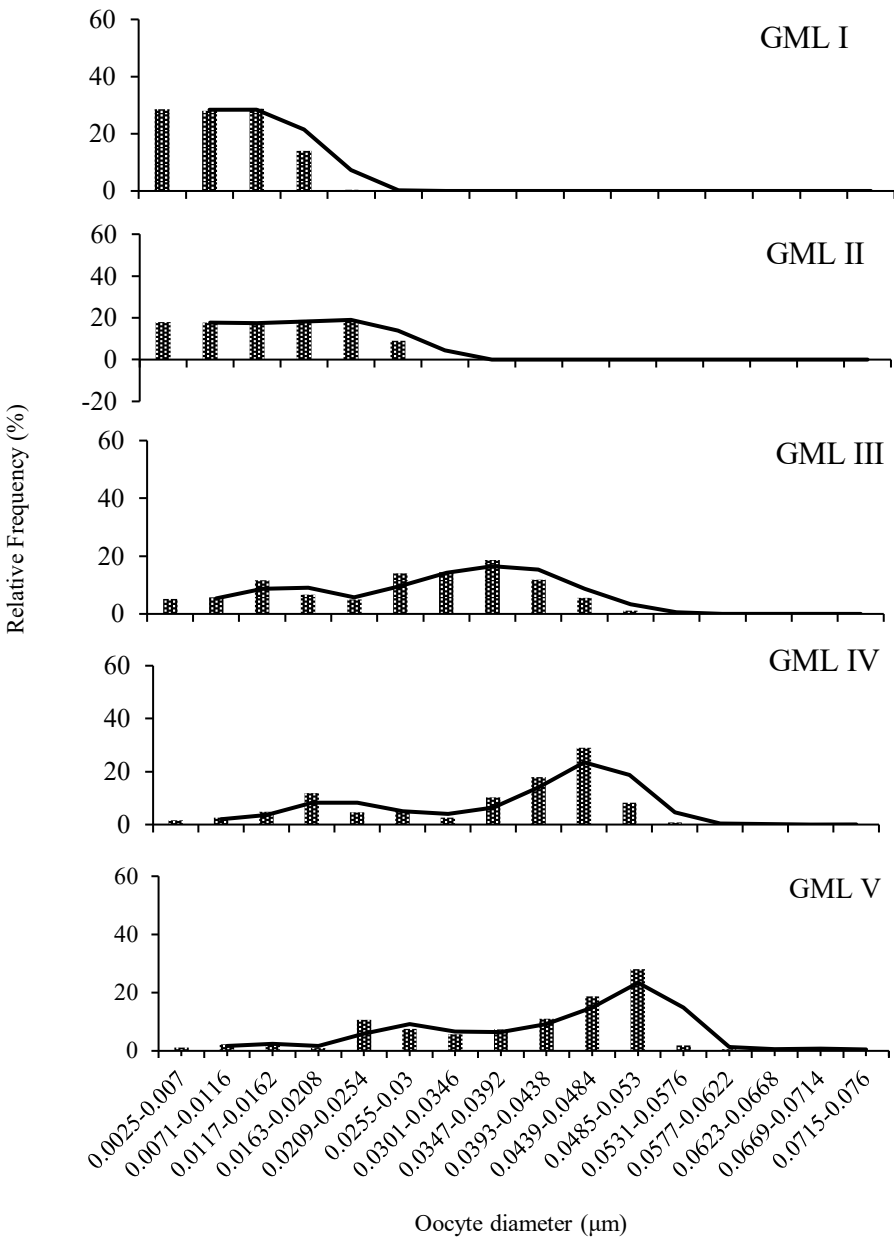


Fig. 9. Frequency distribution of egg diameter of leaftail croaker (*J. trachycephalus*)

3.3 Discussion

During observations from August 2024 to January 2025, a total of 318 leaftail croakers were obtained, consisting of 117 males and 201 females. The distribution of the length of male and female leaftail croakers varied. The highest male leaftail croaker was in the 179-201 mm class interval, while the lowest length distribution was in the 87-109 mm and 248-270 mm. Female leaftail croakers have the highest length distribution in the 133-155 mm class interval and the lowest length distribution in the 110-132 mm. Different from the research of [3] in the waters of Muara Sembilang, East Kalimantan, the highest distribution of length in male leaftail croakers is in the class range of 93-115 mm, and in female leaftail croakers 148-163 mm and the research of [12] regarding one of the demersal fish in Banten Bay which has a smaller distribution. The difference in size is caused by the length of observation time, the difference in the number of samples, and the difference in observation locations. Other factors are caused by aspects that support fish development, namely fishing intensity and water conditions [4]

The proportion of male and female fish in the waters is estimated by the sex ratio. According to [23] good conditions can be said to be balanced when the sex ratio is 1:1 or the number of female fish is greater than the number of male fish. Table 1 explains the differences in sex ratios of several studies of leaftail croaker in several waters.

Table 1. Comparison of sex ratios of leaftail croaker (*J. trachycephalus*) from several studies.

Location	Number of examples (n)		Sex Ratio	Domination	References
	Male	Female			
Muara Angke waters	117	318	Unbalanced	Female	Present study
Muara Sembilang Waters, East Kalimantan	32	184	Unbalanced	Female	[3]
Tanjung Beringin TPI, North Sumatra	65	72	Balanced	Female	[6]

Male and female leaftail croaker in various waters have differences but have the same dominance, namely females. Leaftail croaker in Muara Angke Waters is in an unbalanced condition. Based on the results of the analysis, it was found that the sex ratio of 0.6:1 which is dominated by female leaftail croaker, describes the population of leaftail croaker in Muara Angke Waters as being in good condition. This study also analyzed the sex ratio based on the length class interval and found that male leaftail croakers were mostly found in the 110-132 mm and 179-201 mm class intervals. Female leaftail croakers were mostly found in the 156-178 mm class interval. The ratio of male and female fish differs due to food availability and growth patterns [4].

The spawning season can be predicted through the distribution of gonad maturity levels which are also related to the gonad maturity index. Observations of female leaftail croakers indicated that the initial gonad maturity stage (TKG I) was most prevalent during a particular period. Conversely, more advanced gonad maturity stages (GML II and III) reached their highest occurrence during a distinct, later period. For male leaftail croakers, the highest proportion of individuals in the initial maturity stage (TKG I) was observed at an earlier point in the year. Intermediate maturity (TKG II) peaked during a subsequent period, and the most

mature stage (GML III) showed its highest presence towards the end of the yearThe percentage of GML IV is widely distributed each month. This indicates that leaftail croaker spawns gradually and not at one time. The spawning season can be predicted by the distribution of mature GML and the highest IKG values for both males and females, in this study, it was suspected that the spawning season occurred in August and December. This is different from the research of [3] who revealed that in October-December many mature GML was found, this was because the month of their research was included in the spawning months of leaftail croaker. According to [11] the Scianidae spawning period is in the pre-rainy season. This is in line with the months of August and December which are in the pre-rainy season period. Based on the length class interval, the frequency of male fish that began to be dominated by mature gonad was in the class interval of 248-270 mm and the frequency of female fish that began to be dominated by mature GML was in the class interval of 156-178 mm.

The first mature gonad size (Lm) of female leaftail croaker in Muara Angke Waters is smaller than that of male leaftail croaker. Table 2 shows a comparison of the mature gonad size of leaftail croaker in several studies.

Table 2. Comparison of the first mature gonad size of the leaftail croaker (*J.trachycephalus*) from several studies.

Location	Number of examples (n)	Size at first gonad maturity (Lm)		References
		Male	Female	
The Waters of Muara Angke	318	260 mm	159 mm	Present study
Tanjung Beringin TPI, North Sumatra.	137	127 mm	122 mm	[6]
Visakhapatnam Beach, India	3.406	177 mm	175 mm	[11]

The size of the first gonad maturity of the leaftail croaker in this study and compared to other studies showed quite significant differences. The size of the male leaftail croaker in this study was larger than in other studies. The female leaftail croaker in this study was in the middle range between the two studies where at the Visakhapatnam Beach location in India the Lm value of the female fish was greater. This study obtained a range of values for the size of the first gonad maturity of the male which was quite far from the female, this happened because there was a difference in the number of sample fish that were far apart. A comparison between the three locations showed that the female leaftail croaker matured faster than the male leaftail croaker. The size of the first gonad maturity varies greatly both in one species and different species [15]. The first catch of the gonad maturity of the leaftail croaker at the Tanjung Beringin Serdang Bedagai TPI was 127 mm (male) and 122 mm (female). According to [1], the difference in the size of the first gonad maturity is influenced by several things, namely fish growth, food availability and temperature. It was observed that female fish reached gonad maturity at an earlier size. This finding could be attributed to factors such as the relatively good food availability in Muara Angke waters, and the females preferential allocation of metabolic energy from food towards gonad development, while males seemingly focused more on somatic growth

Gonado somatic index is related to the level of gonad maturity. The gonad maturity index will be high as the level of gonad maturity increases. This indicates that changes in IKG values follow the stages of egg development where the gonads reach their maximum size when the fish are ready to spawn and will decrease when the spawning stage is in progress until it is finished [21]. High IKG values in male leaftail croaker occurred in August (0.9272 ± 0.6628) and December (1.1224 ± 1.1832), in female leaftail croaker in August ($4.1772 \pm$

2.1698) and December (4.5068 ± 2.4270). This indicates that the peak spawning season for leaftail croaker is in that month. The highest IKG for both male and female leaftail croaker in the study by [3] occurred in October. According to [1] differences in gonad maturity index are in line with the level of gonad maturity caused by several factors, namely observation time, fish body, food and temperature.

Reproductive potential can be predicted from the results of estimating the number of eggs obtained. Fecundity calculations were carried out on GML III and IV as many as 137 gonads. Table 3 shows a comparison of the reproductive potential of several studies of leaftail croakers in different waters.

Table 3. Comparison of the reproductive potential of the leaftail croaker (*J.trachycephalus*) from several study.

Location	Number of examples (n)	Fecundity	Coefficient of determination	References
The Waters of Muara Angke	318	15.486 – 82.830	0,2302 (length), 0,2196 (weight)	Present study
Tanjung Beringin TPI, North Sumatra.	137	19.726 -110.343	0,7018 (weight)	[6]
Visakhapatnam Beach, India	3.406	35.650 - 196.496	0,191 (length)	[11]

The potential for eggs released by leaftail croaker in this study was quite small compared to other waters. The correlation between length, weight, and fecundity in this study had a linear relationship and explained that there was no correlation between length, weight, and fecundity. Similar to the research of [11] which had a small correlation value. According to [14], the absence of correlation is caused by the diversity of fecundity at the same length or weight. Large length and weight will produce high fecundity values [5]. However, in the results of observations, there was a condition where a small length or weight had high fecundity. This is related to the size of the egg diameter where the fish experiences a small egg diameter condition so that it has high fecundity [16]. According to [13], the fecundity value is influenced by body size, habitat, and food availability in the waters.

Spawning patterns can be predicted through the distribution of egg diameters. This observation uses the entire GML to see the distribution of egg diameter sizes. Spawning patterns are determined through the distribution of egg diameters in GML III and IV. Figure 8 shows that the graph of the distribution of egg diameters in GML III and IV has two peaks. The peak in GML III is at the class interval of 0.0071- 0.0116 mm and 0.0347-0.0392 mm while the peak in GML IV is at the class interval of 0.0163-0.0208 mm and 0.0439-0.0484 mm. The spawning pattern of leaftail croaker can be said to be a partial spawner, which means that leaftail croaker spawns gradually and little by little. Similar to the research of [6] also explained that the spawning pattern of leaftail croaker is partial spawner and research by [18] showed partial spawner in one of the demersal fish in Majakerta Waters, Indramayu. The size of the egg diameter is influenced by various factors, namely the size of the fish, age, and also the GML of the fish [7].

The Muara Angke environment was potentially subjected to fishing pressure, as evidenced by the high proportion of small sized fish caught. [3] High exploitation could lead to a decline in the gulamah fish population stock. This decline consequently impacted the reproduction of the fish. Additionally, pollution also had the potential to occur in Muara Angke, given its numerous ongoing activitie. His study yielded results indicating that fish could adapt to their environmental conditions. This was suggested because the fish population, regarding both males and females, was still considered healthy, with the female

population being larger than the male. [23] A healthy condition was characterized by a greater number of female fish compared to male fish.

Based on the observations, efforts that could have been implemented included controlling fishing activities during the suspected spawning season of fish, specifically in August and December. This involved reducing the capture of small sized of fish, particularly those below their size at first gonad maturity. The proposed approach was to adjust the mesh size of fishing gear used by fishermen recommended mesh size for fish capture was 2 inches. This measure was intended to allow of fish that had not yet reached gonad maturity to escape capture and continue their reproductive process in nature. The aforementioned efforts aimed to ensure the preservation and sustainability of the fish population in Muara Angke Waters.

4 Conclusion

The sex ratio of leaftail croakers in Muara Angke Waters is dominated by female fish. The spawning season of leaftail croaker in Muara Angke Waters is predicted to occur during the month of observation. The peak spawning season of leaftail croaker is in August and December. Male leaftail croaker reaches their first mature gonad size (Lm) at 260 mm and females at 159 mm. The reproductive potential of leaftail croaker ranges from 15,486–82,830 eggs. The spawning pattern of leaftail croaker is included in the partial spawner type.

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