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Length-weight relationship and condition factors of *Lepturacanthus savala* in Lampung Bay, Indonesia

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Abstract. *Julian D, Reza M, Putra MGA. 2024. Length-weight relationship and condition factors of* Lepturacanthus savala *in Lampung Bay, Indonesia. Biodiversitas 25: 510-515.* Scarce information exists regarding the growth aspects of ribbon fish (*Lepturacanthus savala* Cuvier, 1829) in Lampung Bay waters. Thus, this study aimed to analyze the growth characteristics as fundamental information for managing *L. savala* fishery resources in the waters of Lampung Bay. The method of this quantitative and descriptive study was to analyze the growth of *L. savala*. Length, weight, and sex ratio data were acquired through a purposive sampling method based on the catch results from gillnet landings at Lempasing Fishing Port, Bandar Lampung. A total of 347 specimens were collected during data collection from May to August 2023, with a length range between 21.6-59.8 cm of total length (TL) and the highest frequency observed in the length interval class of 33-36 cm, consisting of 105 specimens. The results showed that the growth pattern of *L. savala* is positively allometric, with a value of b equal to 3.0915. The sex ratio between males and females is 1:2.4. The condition factor values ranged from 0.0442 to 2.9281, with the highest average value observed in June for males and females, reaching 1.03.

Keywords: Allometric, growth pattern, sex ratio, sustainable fisheries

INTRODUCTION

Ribbon fish *Lepturacanthus savala* Cuvier, 1829, locally known as *layur*, is a common species caught in gillnet and seiner fisheries in Lampung Bay (Hidayat et al. 2021). In some areas, trawl also catches it (Agustina et al. 2015; Kharatmol et al. 2020). This species, characterized as benthopelagic and amphidromous, inhabits tropical waters within the coastal regions of the Indo-West Pacific and the Indian Ocean (Nakamura and Parin 1993; Indarjo et al. 2020). The reproductive system of *L. savala* includes a pair of ovaries, oviducts, and common ovarian ducts in females. At the same time, males have a pair of elongated testes, vas deferens, and a common sperm duct (Kudale et al. 2023a). *Lepturacanthus savala* primarily consume other fishes, with their diet supplemented by crustaceans and mollusks, indicating their carnivorous nature. Additionally, instances of cannibalism emerged, wherein *L. savala* fed on individuals of its species (Kudale et al. 2023b). In addition to *Stolephorus* spp., *Sardinella* spp., and *Dussumieria* spp., the juvenile *L. savala* exhibited a feeding behavior involving larval stages and small juveniles of anchovies and clupeoides (Kudale et al. 2023b). Ribbon fish have elevated levels of n-3 polyunsaturated fatty acids (PUFA), particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which are recognized for their positive effects on human health (Ramesh et al. 2015). Hence, based on these considerations, it is evident that despite the current affordability of this fish, its utilization has increased over time in response to developmental trends.

Numerous reports indicate a decline in the natural populations of *L. savala*, primarily attributed to overfishing and inherent environmental changes, influencing resource availability, such as appeared in Pakistan (Memon et al. 2016), Taiwan (Wang et al. 2017) and Bangladesh (Al-Mamun et al. 2021). According to recent data in Indonesia, there has been biological overfishing of *L. savala* in the waters of the Sunda Strait (Agustina et al. 2015). It is demonstrated by a growth overfishing condition, wherein females were exploited at a rate of 72% and males at a rate of 83%. This is reflected in the smaller length at first capture than at first gonad maturity (Agustina et al. 2015).

Furthermore, the fish demonstrates a low migratory behavior, resulting in low resilience to fishing pressure. This condition makes the fish more susceptible to exploitation (Agustina et al. 2015). On the other hand, the management of *L. savala* resources in the waters of Lampung Bay is not optimally implemented due to insufficient data and information concerning its growth characteristics. Therefore, research is essential to comprehend the growth aspects of *L. savala*. This knowledge is vital to provide valuable input for determining sustainable *L. savala* fishery management policies.

Recently, in Indonesia, several studies have been conducted on the aspects of the growth of *L. savala*, including those by Agustina et al. (2015) in Sunda Strait, Rachmawati and Hartati (2017) in Pangandaran Waters, and Indarjo et al. (2020) in Juwata Waters. However, no published work is available for estimating growth parameters using length-weight data of the species from the

Lampung Bay Waters. This study aimed to provide baseline information on the life-history parameters of this species, such as the length-weight relationship, sex ratios, and condition factor. For sustainable management, more studies on fish growth are necessary (Vieira 2023). Therefore, this study serves as fundamental information for understanding the growth characteristics of *L. savala* in Lampung Bay. This study also represents the first investigation to examine growth-related aspects of *L. savala* in Lampung Bay.

MATERIALS AND METHODS

Data collecting

The data collected in this study were derived from research conducted in the Lampung Bay Waters from May to August 2023. Observations were made on a regular monthly basis from the catches of gillnet fishermen who landed their catches at the Lempasing Fishing Port (Figure 1). A total of 347 ribbon fish were measured for their length distribution and examined for sex determination and assessment of their maturity stages. The length measurements were taken using a measuring board, spanning from the tip of the mouth to the end of the caudal fin, referred to as total length (TL).

Data analysis

The length distribution was obtained by determining the class intervals, class mean values, and frequencies within each length group. Subsequently, this ascertained length distribution was graphically represented for visual clarity and analysis. Length frequency distributions were measured within 4 cm intervals. These intervals were arranged following the equation below.

$$Fi = \frac{n_i}{N} \times 100$$

Where:
Fi : frequency for a given interval of 0.5 cm
ni : number of specimens within intervals
N : total number of measured specimens.

In this study, the relationship between weight and length is defined by two constants: "a" (the coefficient for weight about fish length) and "b" (a parameter describing fish body shape) that follows the general equation (King 2007) as follows:

$$W = aTL^b$$

Where:
W : body weight (g)
TL : total length (cm)

In the equation above, the parameters "a" and "b" are constants based on the measured length-weight relationship; the measurement of model fit is evaluated by coefficient determination (r^2). The Student's t-test was used to examine the difference value of b. The growth would be isometric (b=3), positive allometric (b>3), or negative (b<3). It is also applied to test the significant differences between males and females. If the fish growth pattern is isometric, the fish condition factor is calculated by the formula (Effendie 2002):

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

Meanwhile, if the growth pattern is allometric, the condition factor can be calculated using the formula (Effendie 2002):

$$K = \frac{W}{aL^b}$$

Where:
K : condition factor
W : body weight (g);
L : total length (cm)

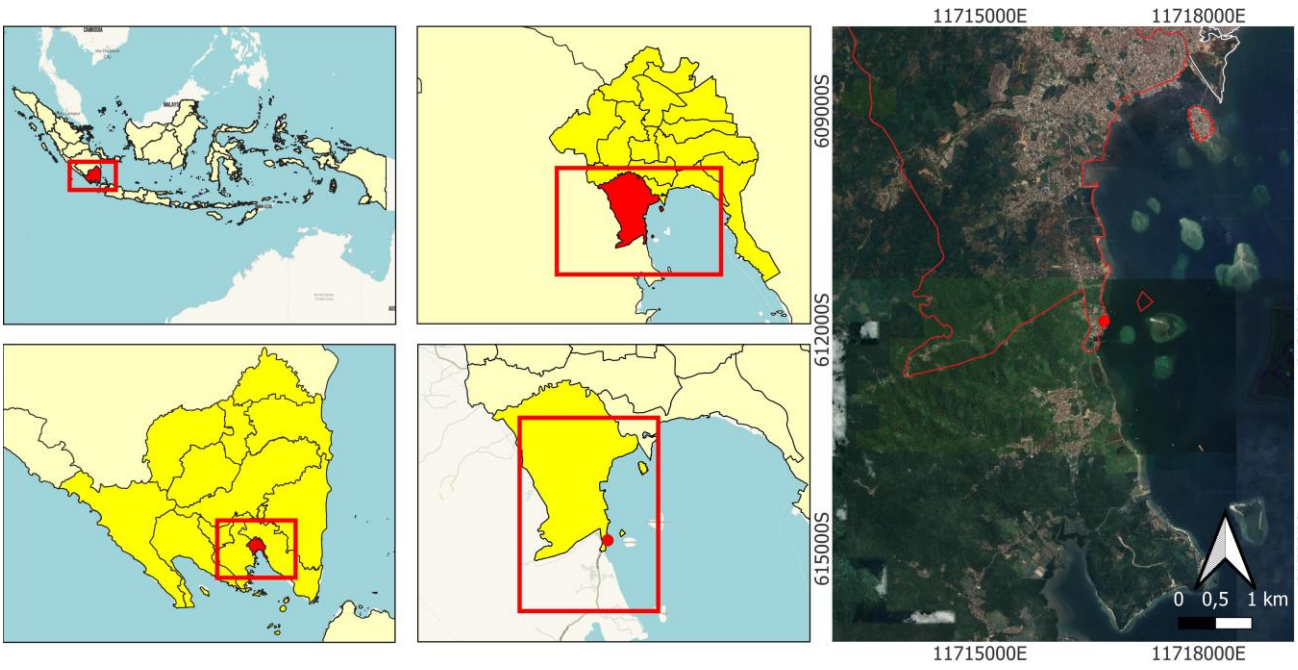

Figure 1. Research locations map in Lempasing Fishing Port, Telukbetung Barat Sub-district, Bandar Lampung, Lampung, Indonesia

RESULTS AND DISCUSSION

Length frequency distribution

The length frequency distribution of *L. savala* landed at Lempasing Fishing Port shows that the fish caught had a size range of 21 to 60 cm (Figure 2). The highest frequency in the interval class 33-36 cm was 105 fish, while the lowest in size range 57-60 cm was only 1 fish. *Lepturacanthus savala* caught in this study had a maximum length of 59.8 cm. This size is smaller than the maximum length in Pangandaran, which is 100 cm TL (Rachmawati and Hartati 2017). Based on the length at first maturity of *L. savala*, which is 38 cm (Pakhmode et al. 2013), it can be observed that the majority of the small-sized fish group in the present study dominates the structure of the conger distribution. It serves as an indication of the pressure on the population in those waters. The size structure of a fish population is crucial for preserving reproductive potential and stability; notably, larger individuals tend to produce a greater quantity of higher-quality eggs (Hixon et al. 2014). Hence, examining the changes in size structure can provide beneficial information regarding the resilience of a fish population. Several external influences, like fishing and temperature, have the potential to alter the size structure of a fish population. Fishing operations, in particular, are size-selective, targeting larger individuals and thereby impacting the general size distribution of the fish population. (Ginter et al. 2015).

The length range in this study is almost similar to the research conducted in Tarakan Waters (Indarjo et al. 2020), which is around 20.4-54 cm TL for males and 20.5-68 cm TL for females, in Sunda Strait Waters (Agustina et al. 2015) ranged from 23.2 to 64.3 cm TL for males and 24.5 to 64.2 cm TL for females, and in the eastern region of Java Sea (Saleh and Soegianto 2017) ranged from 26.1 to 46.9 cm TL. Another study, which was carried out in another country, regarding the length distribution is shown in Table 1.

Sex ratio

The sex ratio of male and female *L. savala* during the study is 1:2.4. Based on the results of the Chi-Square test in each month of sampling and overall with a 95% confidence interval ($\alpha = 0.05$) showed that the sex ratio of *L. savala* was in an unbalanced condition where it was dominated by female where the X_{count} value was less than the X_{table} value. (Table 2, Table 3). The chi-square test conducted in May indicated a failure to reject the null hypothesis (H0), where H0 represents the balanced sex ratio of *L. savala*. Consequently, H0 was accepted, implying that the sex ratio of *L. savala* in May was balanced. Conversely, chi-square tests conducted in the subsequent months (June to August) led to the rejection of H0, indicating an imbalance in the sex ratio of *L. savala* during those months.

Variation in sex ratios has long been discussed in evolutionary biology. The principle of natural selection requires that a 1:1 sex ratio be maintained by constantly preferring the less prevalent sex, thus restoring skewed ratios to equilibrium. In nature, mismatched sex ratios are common in many species, and explanations typically entail disparities in mortality rates between males and females (Arendt et al. 2014). In the present study, the sex ratio of male and female *L. savala* is 1:2.4. This shows that the sex ratio of *L. savala* in Lampung Bay is dominated by females. Differences in patterns of group behavior between male and female fish, differences in mortality rates, and differences in growth can cause deviations from this ideal condition. According to Pavlov et al. (2014), differences in fish sex ratio can be associated with certain environmental conditions or fishing intensity. A decrease in the abundance of fish in the population leads to better food availability, increasing the number of female fish.

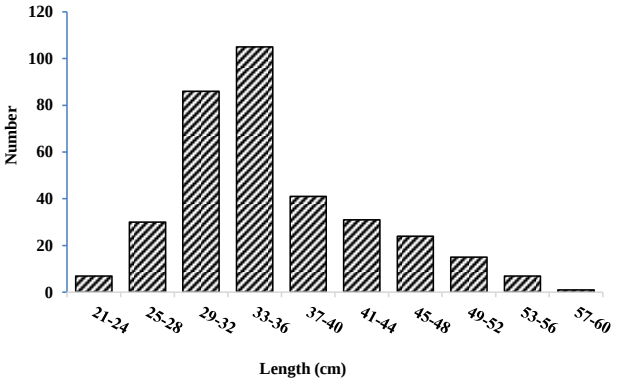

Figure 2. Length-frequency distribution of *Lepturacanthus savala*

Table 2. Monthly sex ratio of *Lepturacanthus savala* (May-August 2023) in Lampung Bay Waters, Indonesia

Month	Number of fish		Sex ratio
	Male	Female	(Male:Female)
May	9	14	1:1.56
June	52	106	1:2.04
July	17	66	1:3.88
August	24	59	1:2.46
Total	102	245	1:2.40

Table 1. Length range of *Lepturacanthus savala* from different countries

Location	Length range (min. -max.) in cm	Source
Karachi Waters, Pakistan	13-107 TL	Raza et al. (2022)
Bohai and Yellow Seas, East China Sea, South China Sea	7.9-23.9 PEL*	He et al. (2022)
Pakistan Waters	5-127 TL	Memon et al. (2016)
Karwar Waters, Karnataka State, India	10-63 TL	Kudale and Rathod (2014a,b)
Ratnagiri Coast, Maharashtra, India	10-70 TL	Pakhmode et al. (2013)

Note: *) PEL: Preanal length

Growth pattern

The growth pattern is obtained based on the length-weight relationship (LWR) of *L. savala* (Figure 3). The LWR in the present study indicates the positive allometric growth of males ($W = 0.0002\ L^{3.307608}$), females ($W= 0.0002914\ L^{3.2386977}$) and combined sex ($W = 0.0004328\ L^{3.0915094}$) with b>3 (Figure 3). The presently reported study is the first to provide LWRs of *L. Savala*, at least from Lampung Bay Waters.

A comparison with data from other literature showed that b values of fish do not vary widely among locations (Table 4). The observed values of b value for *L. savala* from the other parts of the world were about the same as the estimated values of *L. savala* in this study. Most of the studies indicated the growth pattern as positive allometric. In addition, the estimated b value in the present study exceeded 3, which shows the fish's ideal condition in the Lampung Bay Waters.

Another similar study in Indonesia, Pakistan, and India Waters indicated that LWR showed a negative allometric growth pattern (Chakravarty et al. 2012; Tabassum et al. 2013; Indarjo et al. 2020). Differences in b values arise from habitat, season, stomach fullness, gonad maturity, sex, health, preservation techniques, and observed length ranges (Li et al. 2013; Hossain et al. 2015; Tobes et al. 2016).

Condition factor

The average condition factor values of *L. savala* in Lampung Bay from May to August are presented in Fig. 4. Male and female condition factors were almost the same during the observation period. The values of the condition factor calculated for each fish ranged from 0.0442 to 2.9281. The average condition factor of the male ranged from 1.0024 to 1.0310, while the female ranged from 1.0050 to 1.0312. The highest condition factor for males and females was found in June. It is postulated that during this period, the fish capitalizes on the abundance of food resources, thereby augmenting its condition factor (Figure 4).

The condition factor reflects the range and specifics of the fish's physiological state, connecting with maturity and indicating body fat increase and gonadal development (Levêque 2018). Based on the result, the condition factor value of female is greater than that of male fish. This indicates that the females have better conditions for survival and reproduction than the males *L. savala*. This is following Effendie (2002) that female fish have better conditions by filling sex cells for the reproduction process compared to male fish.

The evaluation of condition factors aims to identify abrupt changes in water conditions that impact fish health. A poor condition factor may indicate an abnormally dense fish population, while a good condition factor may indicate the reverse. This assessment aids in population control, potentially resulting from decreased food availability. The condition factor for fish includes all changes related to food supply, sexual maturity, and overall environmental conditions (Gomez 2020). Furthermore, the condition factors of *L. savala* caught in Lampung Bay have the same values as those of *L. savala* obtained in other waters, as shown in Table 5.

Table 3. The chi-square test result of the sex ratio of *Lepturacanthus savala* from May to August 2023

	May	**June**	**July**	**August**	**Total**
X_{count}	1.09	18.46	28.93	14.76	58.93
X_{table}	3.84	3.84	3.84	3.84	3.84
Decision	Failed to reject H0	Reject H0	Reject H0	Reject H0	Reject H0
Conclusion	Balance	Unbalance	Unbalance	Unbalance	Unbalance

Table 4. Length-weight relationship of *Lepturacanthus savala* from different studies

Location	**Sex**	**Length type**	**a**	**b**	**R2**	**Source**
Lampung Bay, Indonesia	M	TL	0.0002	3.307608	0.798	*Present study*
	F		0.0002914	3.2386977	0.914	
	C		0.0004328	3.0915094	0.819	
Bohai and Yellow Seas, East China Sea, South China Sea	C	PEL	0.000174	2.54	0.85	He et al. (2022)
Juata Waters, Tarakan, Indonesia	M	TL	0.5824	1.237	0.5821	Indarjo et al. (2020)
	F		0.7668	1.3557	0.6324	
Eastern region of Java Sea, Indonesia	C	TL	0.000	3.510	0.930	Saleh and Soegianto (2017)
Pangandaran Waters, West Java, Indonesia	M	TL	0.0014	2.8484	0.7419	Rachmawati and Hartati (2017)
	F		0.0006	3.0545	0.9464	
	C		0.0013	2.9176	0.7624	
Pakistan Waters	C	TL	0.0001	3.191	0.960	Memon et al. (2016)
Karwar Waters, Karnataka State, India	M	TL	0.00000063	3.963	0.686	Kudale and Rathod (2014a,b)
	F		0.00000046	3.578	0.969	
Karachi Coast, Pakistan	C	TL	0.087	2.821	-	Tabassum et al. (2013)
Ratnagiri Coast, Maharashtra, India	C	TL	0.0006049	3.2285	0.92	Pakhmode et al. (2013)
Visakhapatnam, India	M	TL	0.00001	2.894	0.857	Chakravarty et al. (2012)
	F		0.000014	2.517	0.825	

Note: M: male; F: female; C: combine; TL: total length; PEL: preanal length

Table 5. Condition factor of *Lepturacanthus savala* from different areas

Location	Sex	Average condition factor	Source
Lampung Bay, Indonesia	M	1.0024-1.0310	*Present study*
	F	1.0050-1.0312	
Pangandaran Waters, West Java, Indonesia	M	1.9300-2.4100	Rachmawati and Hartati (2017)
	F	0.9300-1.1900	
Karwar Waters, Karnataka State, India	M	0.9300-1.1800	Kudale and Rathod (2014a)
	F	0.8000-1.2000	

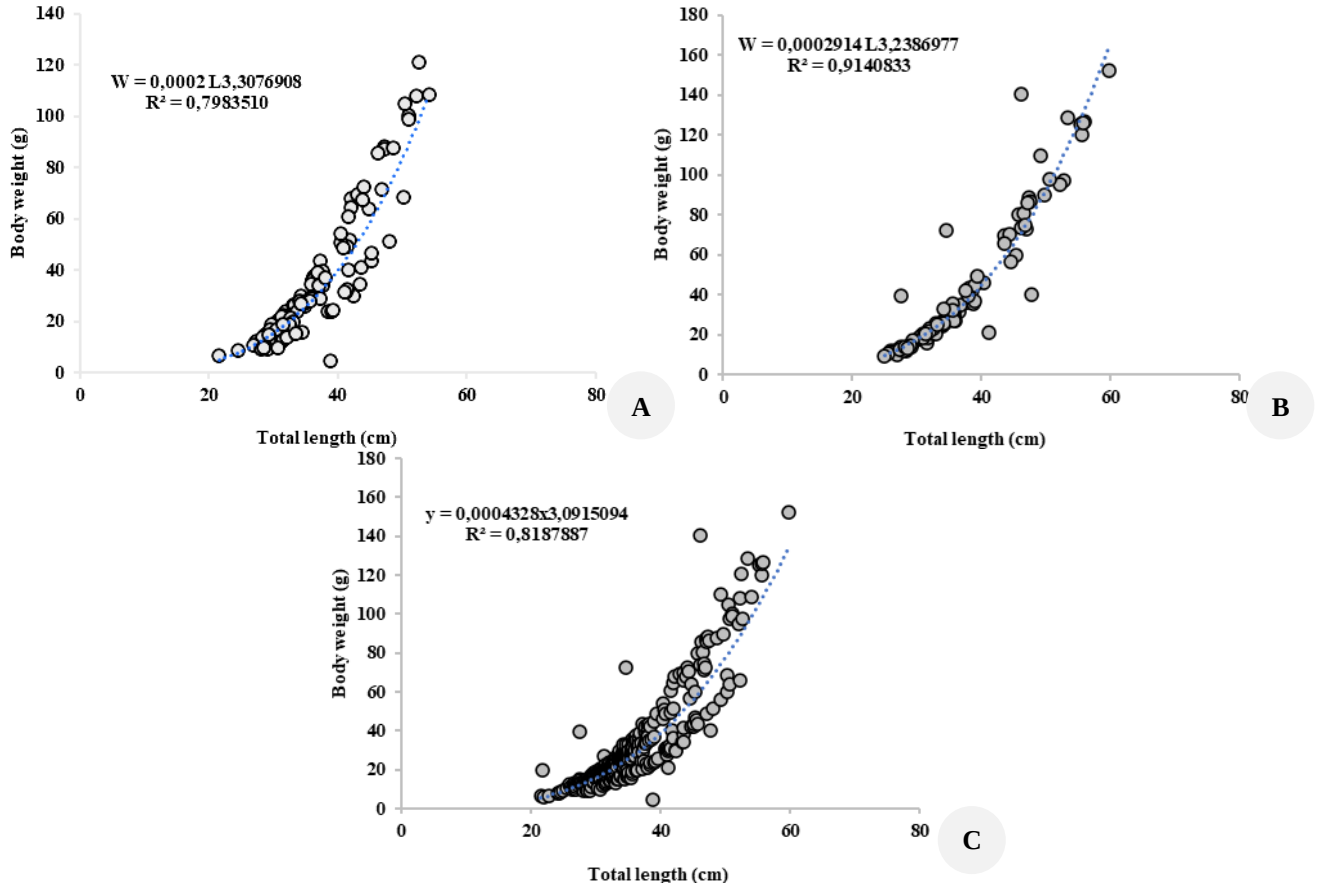

Figure 3. Length-weight relationship of *Lepturacanthus savala*: A. Male; B. Female; C. Combine

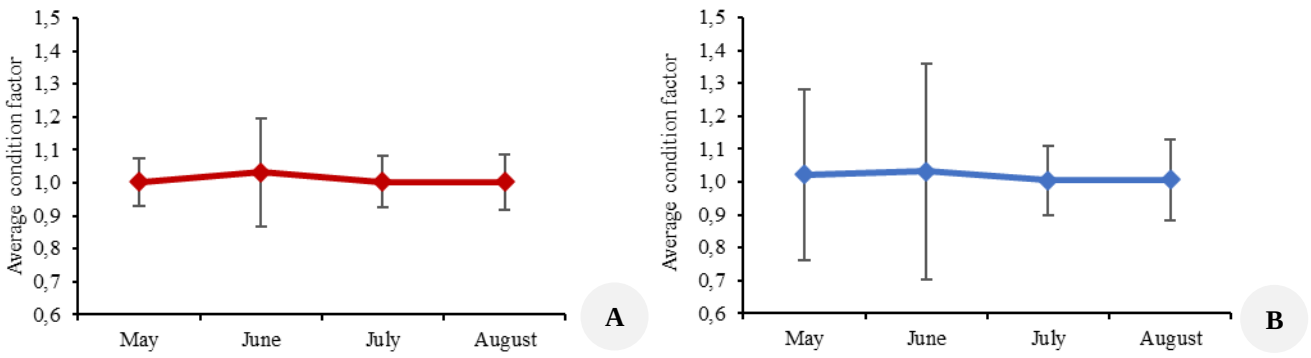

Figure 4. The average condition factor of *Lepturacanthus savala* each month: A. Male; B. Female

In conclusion, the results obtained showed that the average size of caught *Lepturacanthus savala* was 35.8 cm with a length range between 21.6-59.8 cm of total length (TL), and the highest frequency observed in the length interval class of 33-36 cm, consisting of 105 specimens. The overall length-weight relationship of *L. savala* landed at Lempasing Fishing Port was positive allometric. The male-to-female sex ratio was 1:2.40 with unbalanced conditions and dominated by females. The average condition factor of the male ranged from 1.0024 to 1.0310, while the female ranged from 1.0050 to 1.0312. This species was examined to address gaps in our existing knowledge base, which will contribute to the development of appropriate management policies. Furthermore, establishing a routine monitoring system for the *L. savala* fishery is imperative.

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