Asia-Pacific Journal of Science and Technology :Volume :27. Issue 01. Article ID.: APST-27-01-20. Research Article

APST

Asia-Pacific Journal of Science and Technology

https//:www.tci-thaijo.org/index.php/APST/index

Published by the Research and Technology Transfer Affairs Division,
Khon Kaen University, Thailand

# The pattern of growth, condition factor and gillnet selectivity of a commercially important sheatfishes (*Kryptopterus lais*) from waters of Sungai Batang, Indonesia towards sustainable management

Ahmadi A[1,*]

[1]Faculty of Marine and Fisheries, Lambung Mangkurat University, South Kalimantan, Indonesia
[*]Corresponding author: ahmadi@ulm.ac.id

Received 17 September 2020
Revised 15 April 2021
Accepted 28 May 2021

## Abstract

The present study describes the growth pattern, the condition factor, and the gillnet selectivity of Sheatfishes (*Kryptopterus lais*) from Waters of Sungai Batang, Indonesia. This species is commercially exploited and highly vulnerable to overfishing. Meanwhile, the exploitation rate is greater than the growth rate of the fish. The fish samples were purchased directly at the fishing village once every 2-week during the sampling period. A total of 170 specimens of *K. lais* comprising 78 males and 92 females (total length of 88-215 mm and weigh of 7-89 g) were empirically evaluated. Both males and females grew negatively allometric ($b$ = 2.34 - 2.76). No significant difference was observed in total length and body weight between males and females. However, females had body depth and the condition factor (Kn) value greater than males. The highest percentage of catches fell between 140 and 149 mm in total length (TL) (17.39 - 20.51%) and weighed between 15 and 19 g (20.65 - 21.79%). The mean Kn values ranged from 0.77 ± 0.18 to 0.93 ± 0.14, indicating that fish were still in good condition. The size at first maturity of males and females was predicted as 149 and 147 mm TL. The length at first capture and selection factor obtained were 150 mm TL and 2.36, implying gear selectivity should be improved. The present gillnet was considered female-biased gear with male to female ratio of 1: 1.2. This study provides the baseline scenario for formulating a sustainable fisheries management strategy since many aspects of the *K. lais* fishery are not disclosed.

**Keywords**: Allometric growth pattern, *Kryptopterus lais*, Gillnet selectivity, Waters of Sungai Batang

## 1. Introduction

Kryptopterus is a genus of catfishes belonging to the family Siluridae. It is widely distributed in freshwater bodies throughout Southeast Asia. A total of 24 species of genus *Kryptopterus* have been identified and well-documented [1]. *Kryptopterus lais* are beneficial for culinary business, such as being the smoked fish household industry, and the ornamental fish trade. The selling prices of fresh fish at local fishermen and fish markets are 3 and 5 USD per kg, respectively, while the smoked fish is sold at 14 USD per kg. In nature, *Kryptopterus* or *Ompok* species inhabits natural lakes, rivers, and swamp forests [2,3]. They were categorized as carnivore species that consume insects, fry, and shrimps. Species *K. palembangensis* and *K. bicirrhis* were abundantly found during the rainy season, closely related to the availability of food resources, migration, and flooding cycles [2,4]. These can be cultured in floating cages, rain reservoir ponds, or aquaponic recirculation systems and responsive to artificial feeds [5,6]. Some species like *Ompok hypothalamus, K. Apogon,* and *K. bicirrhis* were considered total spawner fish [2]. An effort to domesticate *O. hypothalamus* in the fishpond was also performed as part of protection and conservation measures [7]. At the same time, breeding technologies were also being developed for those species [8].

Each fish species of the family Siluridae has its own morphometric and meristic characteristics and may behave differently to its surrounding environment. To bring about the *Kryptopterus* fishery resource practically, it is necessary to comprehensively study its biological, ecological, and socio-economic aspects [9-11]. The most common scientific method to determine the growth pattern of fish species is the length-weight relationship [12] and for understanding the survival rate, gonad maturity, and biology reproduction system [2,13] of various species and populations from different geographical areas. The length-weight relationship study is needed to be done to protect and manage fishery resources appropriately [13,14].

In the investigated area, the demand and supply of *K. lais* for fishery business are completely dependent on the catch from Waters of Sungai Batang. No commercial aquaculture supports this business so far. The relatively high selling price of *K. lais* is the main factor that drives overfishing. Moreover, water pollution, seasonal change, habitat degradation, and growing human interventions on wetlands may also pose a potential threat to this species [2,9,10], and finally, those affect the socio-economic as a whole [11]. The changes in fish population structure linked with the fish's life history (e.g., growth, age, and size structures) are significantly affected by size-selective fishing gears [15]. There are no conservation actions for *K. lais*, while CITES legislation has not been implemented for this species. It is categorized as Least Concern (LC) on the IUCN Red List [16]. We started investigating the length-weight relationship, relative condition factors, sexual maturity, size at first capture, and gill net selectivity for *K. lais* to get a clear picture of *K. lais* fishery in this area of study as an effort to encourage sustainable fisheries management.

## 2. Materials and methods

### *2.1 Research site*

The research was conducted in Sungai Batang Waters-Martapura in South Kalimantan Province, located on latitude 3°28'34" S and longitude 114°45'23" E (Figure 1).

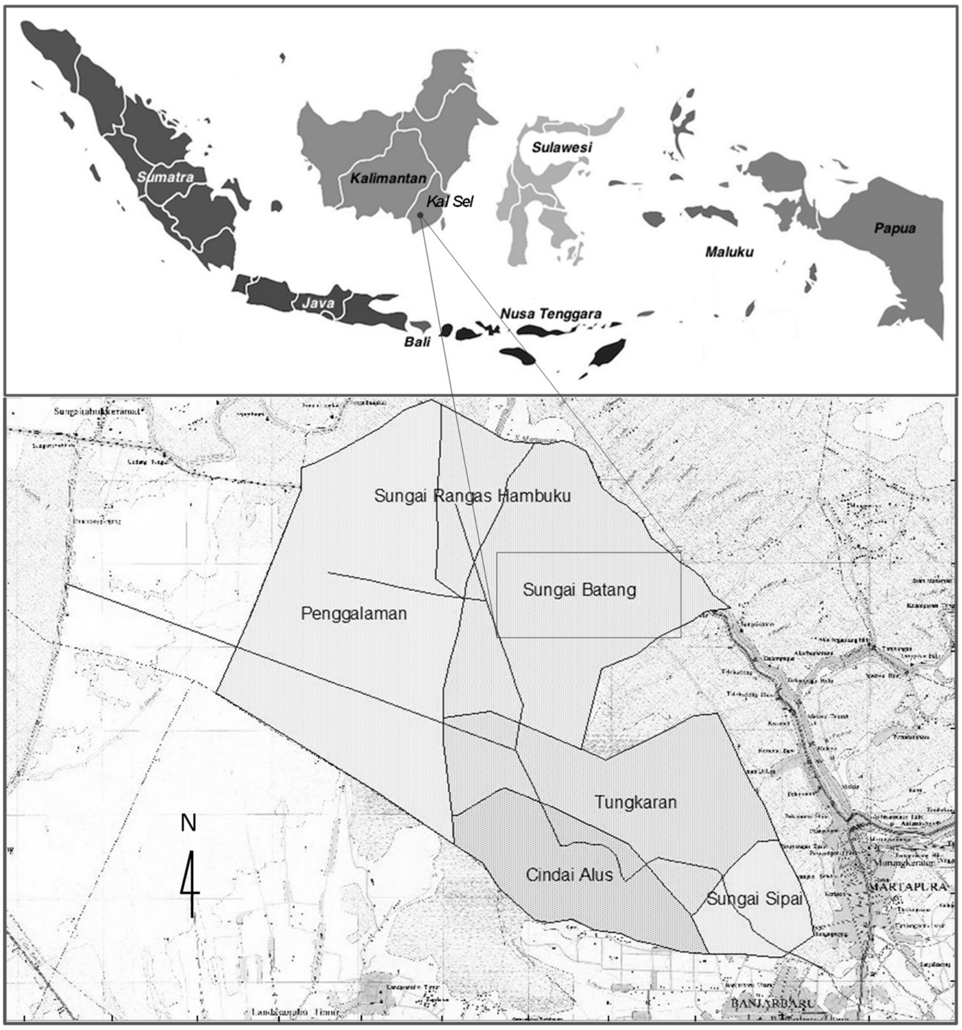


**Figure 1** The map showing the location of Waters of Sungai Batang, Indonesia.

Martapura River was connected to Barito River and Riam Kanan Lake, which provides socio-economic benefits for the local community such as fish farming (i.e., Nile tilapia, carp), capture fisheries, agriculture, and irrigation. In addition, the dried fish processing business driven by fishermen's women was also available. The wetland's water level fluctuates between 0.5 and 2 m. The dry season was started from June to November, while the rainy season was from December to May, and our study coincided perfectly with the rain season with rainfall of 268-326 mm. The *K. lais*, locally called "Lais" (Figure 2), were mostly caught by gillnet with a 2.5-inch mesh size.

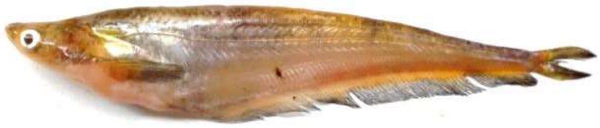

**Figure 2** *Kryptopterus lais* sampled from Waters of Sungai Batang, Indonesia.

Fish traps, cast nets, or hooks and lines were also applicable for collecting them from this river, but in small numbers. As a result, some of the fish were unintentionally caught by these fishing gears and were excluded from data analysis.

*2.2 Data collection*

A total of 170 specimens of *K. lais* consisted of 78 males, and 92 females were directly purchased at the fishing village in the early morning and sampled periodically once every 2-week during the sampling period. The minimum number of fish samples obtained was attributable to uncertainty in daily catch rate, ill-timed sampling, or the fish traders bought the catch earlier than us. Sex identification and body measurement were made separately for males and females. Total length (TL) was measured from the tip of the snout (mouth closed) to the end of the caudal fin. Body depth (BD) was calculated as the greatest vertical distance of the fish body. A standard ruler to the nearest millimeter was used to measure TL and BD of all individual fishes, while a digital scale with an accuracy of 0.01g (CE, SF-400, China) was used to weigh the body weight (W). The ratio of W/TL and BD/TL were empirically determined with the non-dimension number. The length-weight frequency distribution of *K. lais* was fixed at 10-mm interval class.

*2.3 Length-weight relationship (LWR)*

The LWR of *K. lais* was separately assessed for males and females using the standard formula [17]:

$$W = aL^b$$

where L = total length (mm), W = weight (g), *a* = constant and *b* = exponent. According to Bagenal [18], the *b* value varied between 2.5 and 3.5, and it is usually used to outline the growth pattern of fish. If $b = 3$, fish grows isometrically and if $b \neq 3$, fish grows allometrically (negative if $b < 3$ and positive if $b > 3$) [19]. The *b* exponent of male and female was tested with a *t*-test at the 0.05 level of significance to ensure whether the value differs significantly from 3. In addition, the values of the coefficient of determination ($R^2$) and the coefficient of regression (r) derived from the growth curve were also described.

*2.4 Condition factors*

The Fulton's condition factor (K) of *K. lais* was estimated by mean of the given formula [17]:

$$K = 100(W/L^3)$$

where W = weight (g) and L = total length (cm). The K value is served for determining the health condition of individual fish. Further analysis was to calculate the value of relative condition factor (Kn) using the following formula:

$$Kn = W/\hat{}W$$

where W = weight observed (g) and ^W = weight calculated (g) from LWR data. The Kn reflects the general well-being of the fish. When the Kn value is higher, indicating the fish is in healthier condition. Thus, the Kn value is expected to be equal to or close to 1.

*2.5 Length at first capture lethal concentration 50 ($L_{c50}$)*

The $L_{c50}$ was the length at which fish have a 50% probability of being caught by gillnets. It also represents 50% of the stock was fully exploited. The capture probability was projected by drawing the cumulative frequency distribution of catch in percent and the total length in millimeters. A standard selectivity logistic curve was used for analyzing the capture probability and fixed at 50% of the cumulative frequency graph of the results.

*2.6 Length at first maturity ($L_{m50}$)*

The size at first maturity is the length at which 50% of the fish are mature. This information is necessary for fisheries managers to make sound decisions, particularly for fish stock management and conservation of the fish population [20]. The $L_{m50}$ value was estimated by using the Spearman-Karber formula [21]:

$$m = X_k + \frac{X}{2} - (X \Sigma P1)$$

$$\text{antilog}\left[m \pm 1.96\sqrt{X^2 \ \Sigma 1\left\{\frac{P1 \times q1}{n1 - 1}\right\}}\right]$$

where $X_k$ = last log size at which 100% of fish are fully mature

X = log size increment
P1 = proportion of fully mature fish in the first size group
q1 = 1 – P1

The mean size at first maturity is given by antilog (m) = $L_{m50}$

*2.7 Selection factor (SF)*

The selection factor is an index-linked with an escapement factor describing the relation between $L_{c50}$ and the mesh size used. Thus, it was also called the selectivity coefficient. It is calculated by dividing $L_{c50}$ value with mesh size [19]:

$$SF = \frac{L_{c50}}{Mesh\ size}$$

*2.8 Statistical analysis*

The one-way analysis of covariance (ANCOVA) was used to determine whether there were any significant differences in growth patterns between males and females. In addition, a two-sample t-test was applied to compare the means of fish size, condition factor, and size ratio of males and females. All the tests were performed with SPSS-18 software at the 0.05 significance level.

## 3. Results

Table 1-3 shows the estimated values of the length-weight relationship, body size ratio, condition factor, and gillnet selectivity of *K. lais* male and female. The body size of males ranged from 106-200 mm TL (154.08 ± 18.42 mm) and 8-49 g weight (25.99 ± 8.64 g). While the body size of females ranged from 88-215 mm TL (149.76 ± 24.40 mm) and 7-89 g weight (26.61 ± 13.04 g), with male to female ratio was 1.0:1.2.

**Table 1** The estimated body size, length-weight relationship, Fulton's condition factor, and relative condition factor of *K. lais* sampled from Waters of Sungai Batang. (a = constant value, b = the slope of growth curve, $R^2$ = the coefficient of determination, r = the coefficient of regression, A- = negative allometric).

| Sex | n | Total length in mm | | | Weight in g | | | a | b | $R^2$ | r | Growth pattern | K | Kn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | Mean ±SD | Min | Max | Mean ± SD | | | | | | | |
| Male | 78 | 106 | 200 | 154.08 ± 18.42 | 8 | 49 | 25.99 ±8.64 | 0.0002 | 2.3433 | 0.6209 | 0.7880 | A- | 0.70 ± 0.17 | 0.77 ± 0.18 |
| Female | 92 | 88 | 215 | 149.76 ± 24.40 | 7 | 89 | 26.61 ±13.04 | 0.00002 | 2.7624 | 0.9051 | 0.9514 | A- | 0.75 ± 0.11 | 0.93 ± 0.14 |

**Table 2** The body size ratios of *K. lais* derived from the length-weight relationship between males and females. a = constant value, b = the slope of growth curve, $R^2$ = coefficient of determination, r = coefficient of regression, TL = total length, BD = body depth, and W = weight).

| Sex | n | W/TL | a | b | $R^2$ | r | BD/TL | a | b | $R^2$ | r |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Male | 78 | 0.17 ± 0.04 | 0.0002 | 1.3433 | 0.3499 | 0.5915 | 0.22 ± 0.03 | 0.6838 | -0.223 | 0.0460 | 0.2145 |
| Female | 92 | 0.17 ± 0.06 | 0.00002 | 1.7624 | 0.7952 | 0.8917 | 0.25 ± 0.03 | 0.5667 | -0.165 | 0.0707 | 0.2659 |

**Table 3** Descriptive statistics of quantitative data observed for *K. lais* male and female. TL = total length, W = weight, BD = body depth, K = Fulton's condition factor, and Kn = relative condition factor.

| Estimated Parameters | Body size (Mean ± SD) | | t | df | Sig |
|---|---|---|---|---|---|
| | Male (78) | Female (92) | | | |
| TL (mm) | 154.08±18.42 | 149.76±24.40 | 1.283 | 168 | 0.201 |
| W (g) | 25.99 ± 8.64 | 26.61±13.04 | -0.359 | 168 | 0.720 |
| BD (mm) | 34.41 ± 5.09 | 37.22 ± 6.14 | -3.209 | 168 | 0.002 |
| W/TL | 0.16 ± 0.04 | 0.17 ± 0.06 | -0.506 | 168 | 0.614 |
| BD/TL | 0.22 ± 0.03 | 0.25 ± 0.03 | -6.368 | 168 | 0.000 |
| K | 0.70 ± 0.17 | 0.75 ± 0.11 | -2.053 | 168 | 0.042 |
| Kn | 0.77 ± 0.18 | 0.93 ± 0.14 | -6.414 | 168 | 0.000 |

### *3.1. Length-weight relationship*

In this river, the *K. lais* male and female grew negatively allometric (Figure 3A), indicating that the fish had a slimmer body. The length-weight relationships (LWR) for male and female were expressed as: $W = 0.2\times10^{-3}TL^{2.3433}$ and $W = 0.2\times10^{-4}TL^{2.7624}$, respectively. Thereby, the estimated *b* values obtained for males (2.34) and females (2.76) were less than 3. The $R^2$ values ranged from 0.621-0.905, indicating that the length described up to 90% of the variation in weight. While the r-value falls between 0.788 and 0.951, showing that the LWR was highly correlated. Without distinction of the sex, no significant difference in the *b* exponent was observed between smaller and larger-size classes, indicating that *K. lais* grew with the exponent lower than 3. No significant difference was found in the total length, weight, and W/TL ratio of males and females ($p > 0.05$). The mean W/TL ratio of male varied from 0.056 to 0.291 (0.17 ± 0.04) and those of female ranged of 0.074 to 0.414 (0.17 ± 0.06). Such relationship was given by $W/TL = 0.2\times10^{-3}TL^{1.3433}$ ($R^2 = 0.3499$) for male and $W = 0.2\times10^{-4}TL^{1.7624}$ ($R^2 = 0.7952$) for female (Figure 3B).

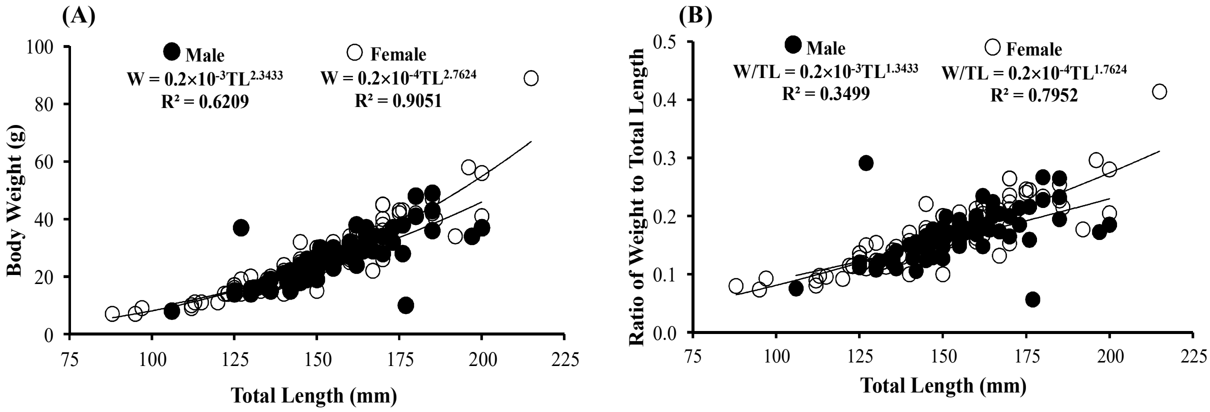


**Figure 3** The *K. lais* grew negatively allometric (A). Females had the W/TL ratio greater than males (B).

Females had body depth greater than males ($p < 0.05$). The mean body depth of males and females was 34.41 ± 5.09 mm and 37.22 ± 6.14 mm, respectively. The body depth increased proportionally to the total length (Figure 4A). The mean BD/TL ratio of female (0.25 ± 0.03) was comparatively higher than that of male (0.22 ± 0.03) ($p < 0.001$). The relationship was expressed as $BD/TL = 0.6838TL^{-0.2230}$ for male and $BD/TL = 0.5667TL^{-0.1650}$ for female (Figure 4B).

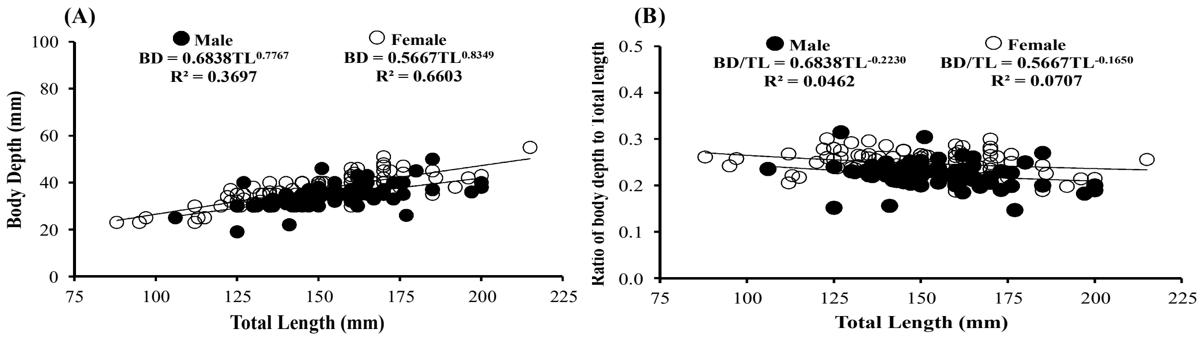


**Figure 4** *K. lais* female had body depth greater than male (A). The body depth increases proportionally to the total length of fish (B). The ratio of BD/TL females seems to be higher than males as a whole.

*3.2. Size distribution*

The size distribution of *K. lais* catches/ tends to be more concentrated in the middle class. It was clearly showed that the highest percentage of catches falls between 140 and 149 mm TL for males (20.51%) and between 160 and 159 mm TL (17.39%) for females. A lower percentage of them were observed for small sizes less than 120 mm and over 180 mm TL for large ones (Figure 5A). The heaviest percentage of catches weighed between 15 and 19 g that was 21.79% for males and 20.65% for females (Figure 5B).

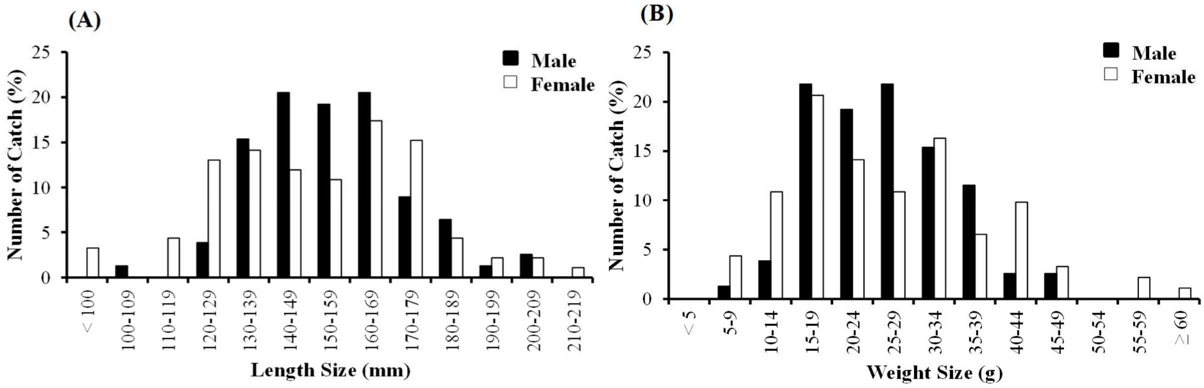


**Figure 5** The distribution of length-size (A) and weight-size (B) represent the percentage of the catch between male and female of *K. lais*.

Statistically, a significant difference was estimated in the class interval of size distribution between males and females ($p < 0.05$), especially in length sizes less than 100 mm and 110-119 mm, as well as in the weight size of 55-59 g (Table 4).

**Table 4** The significant test for the *K. lais* male and female calculated from the length-weight size distribution.

| Length size (mm) | Number of catches | | t | df | Sig |
|---|---|---|---|---|---|
| | Male (78) | Female (92) | | | |
| < 100 | 0 | 3 | -17.104 | 2 | 0.003 |
| 100-109 | 1 | 0 | - | - | - |
| 110-119 | 0 | 4 | -71.467 | 3 | 0.000 |
| 120-129 | 3 | 12 | 0.992 | 13 | 0.340 |
| 130-139 | 12 | 13 | 0.109 | 23 | 0.914 |
| 140-149 | 16 | 11 | 0.644 | 25 | 0.525 |
| 150-159 | 15 | 10 | 1.897 | 23 | 0.071 |
| 160-169 | 16 | 16 | 1.737 | 30 | 0.093 |
| 170-179 | 7 | 14 | 1.191 | 19 | 0.248 |
| 180-189 | 5 | 4 | - 0.547 | 7 | 0.601 |
| 190-199 | 1 | 2 | 0.866 | 1 | 0.546 |
| 200-209 | 2 | 2 | -1.000 | 2 | 0.423 |
| 210-219 | 0 | 1 | - | - | - |
| **Weight size (g)** | **Number of catches** | | **T** | **df** | **Sig** |
| | Male | Female | | | |
| < 5 | 0 | 0 | - | - | - |
| 5-9 | 1 | 4 | 0.000 | 3 | 1.000 |
| 10-14 | 3 | 10 | -0.028 | 11 | 0.978 |
| 15-19 | 17 | 19 | -0.171 | 34 | 0.865 |
| 20-24 | 15 | 13 | -0.207 | 26 | 0.838 |
| 25-29 | 17 | 10 | 1.208 | 25 | 0.238 |
| 30-34 | 12 | 15 | 0.479 | 25 | 0.636 |
| 35-39 | 9 | 6 | 0.701 | 13 | 0.495 |
| 40-44 | 2 | 9 | 0.232 | 9 | 0.822 |
| 45-49 | 2 | 3 | 3.021 | 3 | 0.057 |
| 50-54 | 0 | 0 | - | - | - |
| 55-59 | 0 | 2 | -32.909 | 1 | 0.019 |
| ≥ 60 | 0 | 1 | - | 0 | - |

*3.3. Fulton's condition factor* (K) *and relative condition factor (Kn)*

It was noted that the (K) value (0.75 ± 0.11) of the female specimen was higher than male (0.70 ± 0.17). The mean K value of females ranged from 0.444-1.050, and males ranged from 0.180-1.806. Figure 6 shows the relationship of the K and the W/TL ratio of *K. lais*, and such relationship was expressed as W/TL =

0.2052K$^{0.6529}$ for males and W/TL = 0.1842K$^{0.4454}$ for females. The initial growth index of males was greater than that of females. Therefore, an increase in the W/TL ratio was corresponding to the K value.

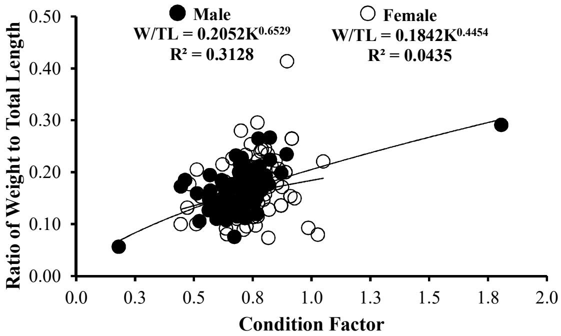


**Figure 6** The condition factor of *K. lais* female was considerably higher than male.

From the available data, we also found that the Kn value (0.93 ± 0.14) of females was greater than males (0.77 ± 0.18). The mean Kn value of females varied between 0.556 and 1.310, and males ranged between 0.198 and 1.999, reflecting the well-being of fish sampled.

*3.4. Length at first maturity ($L_{m50}$)*

Based on the analysis using the Spearman-Karber method, it was clearly found that the size at first maturity of male and female *K. lais* was predicted as 149 and 147 mm TL, which was less than the length at first capture. The proportion of mature individuals by size class distribution was 58.97% for males and 53.26% for females, with a sex ratio of 1.1:1. The highest number of mature individuals was found between 153-155 mm for males and 159-161 mm for females. Meanwhile, the proportion of sexually immature individuals was estimated as 41.03% for males and 46.74% for females, with a sex ratio of 0.9:1. The highest number of immature individuals was found between 133-135 mm for males and 143-145 mm for females.

*3.5 Length at first capture ($L_{c50}$)*

The $L_{c50}$ value was estimated at 150 mm for both males and females, indicating the length size at which 50% of the fish caught by the gill nets. Based on $L_{c50}$, the estimated proportion of smaller and larger individuals of the male was 43.24% (< 150 mm) and 56.76% (> 150 mm), respectively, while for females, the said proportion was being equal (50.00%). Thus the length size of fish was corresponding to the mesh size of gill nets used (Figure 7).

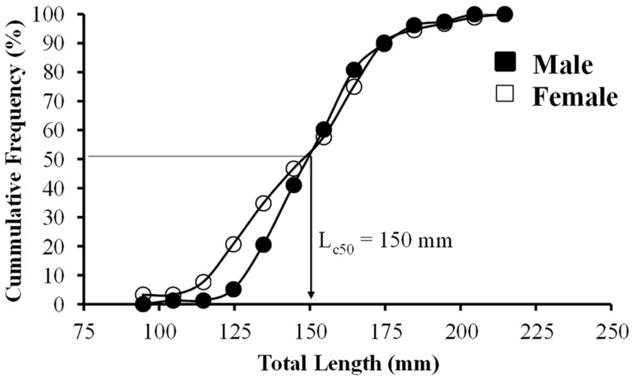


**Figure 7** The length at first capture ($L_{c50}$) of *K. lais* was estimated at 150 mm total length corresponds to the 2.5 inches mesh size used.

*3.6 Selection factor (SF)*

The selection factor estimated for males and females was 2.36 (Table 1). A 63.5-mm stretched mesh size was defined as the main input to calculate the SF value. Thus, the SF value was directly proportional to the corresponding $L_{c50}$ values (150 mm), but it was inversely proportional to the mesh size.

## 4. Discussion

In the present study, *K. lais* exhibited negative allometric growth (*b* = 2.34 - 2.76), and it was in agreement with *K. bicirrhis* from Kampar Kiri River, Riau Province [2], *Ompok hypopthalmus* from Rungan River, Central

Kalimantan [3], *O. bimaculatus* from Tripura River, India [13], *K. palembangensis* from Batu Lake, Central Kalimantan [22], *K. limpok* from Tasik Giam Siak Kecil, Bengkalis Riau [23], *O. hypopthalmus* from Kampar Kiri River, Riau Province [24] or female *O. miostoma* from Mahakam River, East Kalimantan [25]. Contrary to *O. bimaculatus* from Ghaghara River, India [26], it grew positively allometric. Meanwhile, male *O. miostoma* from Mahakam River, East Kalimantan, was reported to have isometric growth patterns [25]. This slope variation is associated with the life history, growth rate, seasonal variation, age, sex, and food availability [2,12, 26]. Table 5 shows a comparative output of our findings with the results of previous studies.

**Table 5** Comparative the sex, body sizes, length-weight relationships, and Fulton's condition factor (K) of some species of family Siluridae from different locations/countries. n = number of fish sampled, b = the slope of growth curve, I = isometric, A- = negative allometric, A+ = positive allometric, P = pooled for both sex, M = male, F = female.

| Locations | Province/Country | Scientific name | Sex | n | Body size (mm) | | Growth pattern | *b* | K | Reference list |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Min | Max | | | | |
| Sungai Batang | South Kalimantan | *Kryptopterus lais* | M | 78 | 106 | 200 | A- | 2.343 | 0.18-1.81 | Present study |
| Sungai Batang | South Kalimantan | *K. lais* | F | 92 | 88 | 215 | A- | 2.762 | 0.44-1.05 | Present study |
| Tasik Giam Siak Kecil | Bengkalis, Riau | *K. limpok* | P | 1,402 | 75 | 380 | A- | 2.547 | - | Suman et al. [23] |
| Kampar Kiri River | Riau | *K. bicirrhis* | M | 30 | 82 | 115 | A- | - | - | Nopiri and Elvyra [2] |
| Kampar Kiri River | Riau | *K. bicirrhis* | F | 10 | 84 | 115 | A- | - | - | Nopiri and Elvyra [2] |
| Batu Lake | Central Kalimantan | *K. palembangensis* | M | 53 | 65 | 97 | A- | 1.769 | - | Aryantoni et al. [22] |
| Batu Lake | Central Kalimantan | *K. palembangensis* | F | 16 | 73 | 116 | A- | 1,038 | - | Aryantoni et al. [22] |
| Mahakam River | East Kalimantan | *Ompok miostoma* | M | 475 | 142 | 220 | I | 2.904 | 0.54-1.08 | Jusmaldi et al.[25] |
| Mahakam River | East Kalimantan | *O. miostoma* | F | 739 | 132 | 227 | A- | 2.547 | 0.56-1.00 | Jusmaldi et al.[25] |
| Rungan River | Central Kalimantan | *O. hypopthalmus* | P | 353 | 120 | 290 | A+ | 3.200 | - | Minggawati et al. [3] |
| Rungan River | Central Kalimantan | *O. hypopthalmus* | P | 200 | 100 | 250 | - | - | - | Minggawati et al. [3] |
| Kampar Kiri River | Riau | *O. hypopthalmus* | M | 224 | 80 | 310 | A- | 2.899 | 0.70-2.51 | Simanjuntak et al. [24] |
| Kampar Kiri River | Riau | *O. hypopthalmus* | F | 249 | 91 | 300 | A- | 2.790 | 0.73-1.34 | Simanjuntak et al. [24] |
| Ganga River | India | *O. bimaculatus* | M | 17 | 100 | 230 | - | - | 0.26 | Sarkar et al. [30] |
| Ganga River | India | *O. bimaculatus* | F | 52 | 120 | 280 | - | - | 0.28 | Sarkar et al. [30] |
| Ghaghara River | India | *O. bimaculatus* | P | 446 | 112 | 290 | A+ | 3.317 | 0.52-0.57 | Mishra et al. [26] |
| Uruwal Oya | Sri Lanka | *O. bimaculatus* | P | 830 | 105 | 365 | - | - | - | Amarasinghe & Pushpalatha [29] |
| Tripura River | India | *O. bimaculatus* | P | 436 | 129 | 307 | A- | 2.851 | 0.42-0.64 | Malla and Banik [14] |
| Tripura River | India | *O. pabda* | P | 240 | 163 | 330 | A+ | 3.104 | 0.67-074 | Banik et al. [12] |

The maximum size of *K. lais* (215 mm TL) in our study was comparatively smaller than other Kryptopterus or Ompok species such as *K. limpok* (380 mm TL) from Tasik Giam Siak Kecil, Bengkalis Riau [23], *K. limpok* (268 mm TL) from Kampar River, Riau Province [27], *O. hypothalamus* (290 mm TL) from Rungan River in Central Kalimantan [3] or *O. bimaculatus* (290 mm TL) from Ghaghara River, India [26]; however, it was greater than the maximum size of *K. palembangensis* (116 mm TL) from Batu Lake, Central Kalimantan [22] or *K. bicirrhis* (115 mm TL) from Kampar Kiri River, Riau Province [2].

In the Waters of Sungai Batang, fishing intensity generally increases between March and April. For fishermen, it is possible to catch *K. lais* smaller than 88 mm TL (7 g weight) using small-mesh nets (< 1 inch), but they don't want to because small fish are not sellable, and it is also against fishery regulation. Therefore, awareness of the importance of fishing gear selectivity should be encouraged [28]. It is also quite possible for fishermen to harvest larger individuals > 215 mm TL (89 g weight); however, our efforts are time-limited as sampling is every two weeks. Therefore, no record of catches and market selling prices is potentially leading to unreported fishing practices. Presumably, the exploitation rate is greater than the growth rate of the fish since fishing activities occur throughout the year.

It was found that the mean K and Kn values of *K. lais* females were comparatively higher than males, and those values close to one, indicating the *K. lais* were in good condition. Similar results were also documented in *O. hypophthalmus* from Kampar Kiri River, Riau Province [24] and *O. miostoma* from Mahakam River, East Kalimantan [25]. The condition factor variation may be attributable to food availability, spawning cycle, feeding intensity, and maturity stages of the fish [12,14]. Therefore, the condition factor of fish is required for managing the aquaculture system, especially to understand survival, reproduction, maturity, and health status of fish and a useful directory for monitoring feeding intensity, age, and growth increment fishes [12,26]. In particular circumstances, the best stock density for *K. lais* was ten fish.m$^{-3}$ giving the highest growth rate (23.7 g) and daily rapid growth (2.55%) of the fish [5].

From available data, the length at first capture ($L_{c50}$) was estimated at 150 mm for both male and female *K. lais*. We also computed the $L_{c50}$ at individuals less than 150 mm TL and roughly estimated about 42.23% of male and 50.00% of female entering the gear was retained. Even so, the precautionary measure was needed to prevent growth overfishing. Since the mesh size of the gillnet was closely related to the size of fish, so the length at fish capture can be adjusted by altering mesh size appropriately. Thus, the use of larger mesh size (> 2.5 inches) was strongly recommended. The $L_{c50}$ value of *K. lais* was comparatively higher than that of *K. palembangensis* (79.22 mm) from Batu Lake of Central Kalimantan [22], but it was lower than *K. limpok* (189 mm) from Tasik Giam Siak Kecil, Riau [23] or *O. bimaculatus* (229 mm) from Uruwal Oya, Sri Langka [29]. Variation in the $L_{c50}$ is closely related to the sampling period, mesh size, type of fishing gear, number, and size of fish observed. Selection factors (SF) vary by species and mesh sizes used. Based on a 2.5 inches mesh size of gillnet, we found the selection factor (2.36) for *K. lais* was relatively lower than *O. bimaculatus* (5.16) from Uruwal Oya Sri Langka [29]. In the present study, the $L_{c50}$ was larger than the $L_{m50}$, indicating that the individuals of *K. lais* have more chances for spawning to maintain the fish population.

Empirically, fishermen in Sungai Batang village used gillnets (2.5 inches mesh size) to collect *K. lais*. In contrast, fishermen in the Mentulik villages of Riau Province worked with a 1.5-inch mesh to catch *K. bicirrhis* [2]. According to Amarasinghe and Pushpalatha [29], excessive use of mesh sizes smaller than 5.8 cm might be detrimental to *O. bimaculatus*. Jusmaldi et al. [25] lately used various mesh sizes of gillnets (1, 1.5, 2, 2.5, and 3 inches) to sample *K. limpok, K. bicirrhis, K. microcinema, K. Apogon, O. hypophthalmus*, and *O. miostoma* from Mahakam River of East Kalimantan, but no specific mesh sizes were recommended for each species. Optionally traditional fish traps (e.g., *lukah*, *sempirai*, *tempirai*) also had some success in catching *Ompok* species in Sumatra waters [8]. However, in the trap, it should not be placed in the tributary paths to the flooding habitat during the spawning season to allow the reproduction process of broodstocks. In other words, mesh size regulation, gears arrangement, time, and fishing location should be completely taken into consideration. At the same time, community-based fisheries management institutions should also be strengthened.

In the present work, gillnet is considered female-biased gear, indicated by female ratio was 1.2 times higher than male. It also means that female was more active than male in term of feeding habits and spawning migration. A similar result was also reported for *O. bimaculatus* (1: 1.65) from Tripura River, India [13], *O. bimaculatus* (1: 2.93) from Ganga River, India [30], and *O. miostoma* (1: 56) from Mahakam River, East Kalimantan [25]. Meanwhile, the male-biased ratio was reported in *O. hypothalamus* (1.56: 1) from Rungan River, Central Kalimantan [3], *K. palembangensis* (3.31: 1) from Batu Lake, Central Kalimantan [22], and *K. bicirrhis* (3: 1) from Kampar Kiri River, Riau Province [2]. Variation in the sex ratio of the fish is greatly influenced by the availability of food, migration cycle, dissolved oxygen (DO), and water temperature [13, 27, 30]. Unlike *K. Apogon*, *K. limpok,* and *K. micronema* from Mahakam River in East Kalimantan [25] or *K. limpok* from Kampar River and Indragiri River in Riau Province [27], the genetic characteristics of *K. lais* in this study are still undisclosed. Therefore, it becomes a great challenge for our future research and improving current fisheries data statistics. Thus, the involvement of stakeholders in the decision-making process for better fisheries management is strongly encouraged.

## 5. Conclusion

The *K. lais* exhibited negative allometric growth and found to be in good condition. They have a greater chance of spawning to maintain the fish population because the length at first maturity was less than at first capture. The length size of fish corresponded to a given mesh size of gill nets. The use of larger mesh size (> 2.5 inches) was recommended as a precautionary measure to prevent growth overfishing while breaking the chain of consumer demand for under-sized fish.

## 6. Ethical approval

This research substantially complied with recognized ethical principles and guidelines for research practices, based on the certificate of approval No: 454/UN.1.27/AK/2020 authorized by the Dean, Faculty of Marine and Fisheries – Lambung Mangkurat University.

## 7. Acknowledgments

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. Thanks to Mrs. Siti Ubaidah for assisting during fieldwork and resultant measurements. Our gratitude goes to the reviewers for significantly improving the contents of the manuscript to a publishable level.

## 8. References

[1] Ng HH, Kottelat M. After eighty years of misidentification, a name for the glass catfish (Teleostei: silurid ae). Zootaxa. 2013;3630(2):308-316.
[2] Nopiri R, Elvyra R. Biology reproduction of Selais Terang Bulan (*Kryptopterus bicirrhis*, Valenciennes 1840) fish in the Mentulik Village Kampar Kiri River, Riau Province. Biospecies. 2018;11(2):98-107.
[3] Minggawati I, Sukoso S, Bijaksana U, Hakim L. Gonad maturity level of catfish *Ompok hypopthalmus* caught in a flooding swamp area of Rungan River Central Kalimantan related to water depth. GJFA. 2015;3(2):205-210.
[4] Gummi S, Ardiannor UPR, Syahrinudin S, Ansari GZ, Komai Y, Taki K, et al. Seasonal yield and composition of an inland artisanal fishery in a humic floodplain ecosystem of Central Kalimantan, Indonesia. Biodivers J. 2018;19(4):1181-1185.
[5] Agusnimar A, Rosyadi R, Anggi VR. Effect of stocking density on growth rate of Selais fish (*Kryptopterus lais*) in floating cages in Tasik Betung Siak Regency, Riau Province. JPK. 2014;29(2):183-190.
[6] Putra I, Pamukas NA. Culturing Selais fish (*Ompok* sp.) using aquaponic recirculation system. J Fish Mar Sci. 2011;16(1):125-131.
[7] Minggawati I, Lukas. Domestication of Lais (*Ompok hypothalamus*) in the fishpond as a sustainable conservation effort. ADRI Int J Agric. 2017;1:7-10.
[8] Alawi H, Asiah N, Priyatama AT. Induced spawning of selais fish *Ompok hypothalamus* under different doses of human chorionic gonadotropin hormone (hCG). JPK. 2013;17:1-10.
[9] Gupta S. A review on feeding and reproductive biology of *Ompok pabda* with an emphasis on its conservation. J Aquac Res Dev. 2018;9(2):525.
[10] Aryani N. Native species in Kampar Kanan River, Riau Province Indonesia. Int J Fish Aquat Stud. 2015;2(5):213-217.
[11] Hanif MS, Iqbal KJ, Javid A, Khan N, Irfan B, Majeed H, et al. Socioeconomic status of fishermen community, south Punjab, Pakistan. Punjab Univ J Zool. 2019;34(2):115-118.
[12] Banik S, Goswami P, Acharjee T, Malla S. *Ompok pabda* (Hamilton-Buchanan, 1822): new reports from freshwater environment of Tripura, India with a note on length-weight relationship and condition factor (K). J Environ. 2012;1:40-44.
[13] Malla S, Banik S. Reproductive biology of an endangered catfish, *Ompok bimaculatus* (Bloch, 1794) in the lotic water bodies of Tripura, North-East India. Int J Fish Aquat Stud. 2015;2(4):251-260.
[14] Bhattacharya P, Banik S. Length-weight relationship and condition factor of the pabo catfish *Ompok pabo* (Hamilton, 1822) from Tripura, India. Indian J Fish. 2012;59(4):141-146.
[15] Hsieh CH, Yamauchi A, Nakazawa T, Wang WF. Fishing effects on age and spatial structures undermine population stability of fishes. Aquat Sci. 2010;72:165-178.
[16] Kottelat M, Whitten AJ, Kartikasari SN, Wirjoatmodjo S. Freshwater fishes of Western Indonesia and Sulawesi. 1st ed. Jakarta: Periplus Ed; 1993.
[17] Froese R. Cube law, condition factor, and weight-length relationships: history, meta-analysis, and recommendations. J Appl Ichthyol. 2006;22:241-253.
[18] Bagenal T. Methods for assessment of fish production in freshwaters. 3rd ed. London: Oxford Blackwell Scientific Publication; 1978.
[19] Pauly D. Fish population dynamics in tropical waters: a manual for use with programmable calculations. 1st ed. Penang: WorldFish; 1984.
[20] Soares BE, Barros TF, Hashiguti DT, Pereira DC, Ferreira KCF, Caramaschi ÉP. Traditional approaches to estimate length at first maturity ($L_{50}$) retrieve better results than alternative ones in a Neotropical heptapterid. J Fish Biol. 2020;97(5):1393-1400.
[21] Udupa KS. Statistical method of estimating the size at first maturity in fishes. Fishbite. 1986;4(2):8-10.

[22] Aryantoni, Tantulo U, Buchar T. Length-weight relationship, reproduction, and feeding of Baji Selais fish (*Kryptopterus palembangensis*) in Batu Lake, Pulangpisau regency [dissertation]. Central Kalimantan: University of Palangka Raya; 2014.

[23] Suman A, Kembaren DD, Amri K, Pane AR, Taufik M, Marini M, et al. Population dynamic and spawning potential ratio of long-barbel sheatsfish (*Kryptopterus limpok*) in Tasik Giam Siak Kecil waters, Bengkalis, Riau Province, Indonesia. AACL Bioflux. 2020;13(2):780-788.

[24] Simanjuntak CP, Rahardjo MF, Sukimin S. Spawning season and fecundity of Selais fish (*Ompok hypophthalmus*) in Kampar Kiri flooded swamp river, Riau. J Fish Sci. 2008;2:251-260.

[25] Jusmaldi, Solihin, DD, Affandi R, Rahardjo MF, Gustiano R. Reproductive biology of silurid catfishes *Ompok miostoma* (Vaillant 1902) in Mahakam River East Kalimantan. J Iktiologi Indonesia. 2018;19(1):13-29.

[26] Mishra SK, Sarkar UK, Trivedi SP, Mir JI, Pal A. Biological parameters of a silurid catfish *Ompok bimaculatus* (Bloch, 1794) from river Ghaghara, India. J Environ Biol. 2013;34:1013-1017.

[27] Elvyra R, Solihin DD. Cytochrome C oxidase 1 gene sequences long-barbel sheatfish, *Kryptopterus limpok* (Bleeker, 1852) from Kampar River and Indragiri River of Riau Province. J Iktiologi Indonesia. 2015;15(3):235-243.

[28] Ahmadi, Rizani A. Light traps fishing in Sungai Sipai flood swamp of Indonesia. Recommendations for future studies. Kasetsart Univ Fish Res Bull. 2013;37(2):17-30.

[29] Amarasinghe US, Pushpalatha KB. Gillnet selectivity of *Ompok bimaculatus* (Siluridae) and *Puntius dorsalis* (Cyprinidae) in the small-scale riverine fishery. J Nat Sci Council Sri Lanka. 1997;25(3):169-184.

[30] Sarkar UK, Agnihotri P, Kumar R, Awasthi A, Pandey BK, Mishra A. Dynamics of inter-population reproductive pattern in Butter catfish, *Ompok bimaculatus* (Bloch, 1794) from different rivers in India. Turkish J Fish Aquat Sci. 2017;17:1061-1071.