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Biological Characteristics of Snakeskin Gourami (*Trichopodus pectoralis*) from Central Kalimantan, Indonesia

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Abstract

This study evaluated the growth pattern, condition factor, and reproductive size parameters of snakeskin gourami (*Trichopodus pectoralis*) collected from wetlands in Palangkaraya City, Indonesia. Sampling was conducted from March to June 2023 using three traditional fishing gears (*Tempirai*, *Lunta*, and *Lukah*), yielding 164 specimens, including 84 males and 80 females. Total length ranged from 60 to 100 mm (83.45 ± 0.74 mm), while body weight ranged from 3.4 to 8.5 g (6.13 ± 0.11 g). The sex ratio did not differ significantly from the expected 1:1 ratio ($\chi^2 = 0.098$, $p > 0.05$), and fish size did not differ significantly between sexes or among fishing gears ($p > 0.05$). However, the length-frequency distributions differed significantly among the three fishing gears ($p < 0.05$). Length–weight analysis revealed a negative allometric growth pattern ($b = 1.9006$; $R^2 = 0.8503$), indicating that length increased faster than weight, while the mean Fulton's condition factor (K = 1.06 ± 0.02) suggested that the individuals were generally healthy despite their relatively small body size. The preliminary estimates of length at first maturity (Lm_{50} = 81.97 mm TL) and length at first capture (Lc_{50} = 82.99 mm TL) suggest that *T. pectoralis* may reach the estimated maturity length before being captured. However, because gonadal maturity was not assessed directly, this comparison should be interpreted cautiously. These findings provide baseline biological information on the growth, condition, and reproductive size structure of *T. pectoralis* in the Palangkaraya wetlands, offering empirical evidence for size-based fisheries management. While current fishing practices may still support population sustainability, the predominance of relatively small fish underscores the need for adaptive management through fishing-pressure monitoring, improved gear selectivity, and the integration of biological and socio-economic considerations to sustain *T. pectoralis* populations in this wetland ecosystem.

Keywords:
allometric; condition factor; Fulton's condition factor; length–weight relationship (LWR); length at first capture (Lc_{50}); length at first maturity (Lm_{50})

1. Introduction

The snakeskin gourami, *Trichopodus pectoralis* (Regan, 1910), commonly known as the Siamese gourami, is an economically important freshwater fish species. Consumers highly value it for its taste and year-round availability, and it is primarily marketed fresh or salted for human consumption. This species naturally inhabits various aquatic environments, including swamps, floodplains, rivers, and lakes [1,2]. In aquatic ecosystems, *T. pectoralis* helps control water hyacinth growth [3]. They are classified as an omnivorous species [4] and can survive in low-oxygen water [5]. This species can also be raised in many environments, including rice paddies, fish farms, and even specialized blue tanks [6–8]. Researchers have also successfully domesticated the species using genetic techniques [9]. Other scientists continue refining rearing techniques for this species [10,11].

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In Southeast Asia, inland fisheries are increasingly recognized as integral to sustainable development, particularly in supporting rural livelihoods, food security, and local economies. In Indonesia, wetland fisheries provide an accessible and affordable source of protein while sustaining small-scale economic activities among riparian communities [12]. These systems are also shaped by strong socio-cultural dimensions, including traditional fishing practices that reflect accumulated ecological knowledge and adaptive resource use [1]. However, wetland ecosystems face increasing pressure from environmental degradation, climate variability, and fishing intensity, thereby requiring integrated approaches that link ecological understanding with development priorities [3,9].

Despite their ecological importance, *T. pectoralis* faces significant threats, including water pollution from chemical contaminants (e.g., potassium), overfishing, and wetland degradation [13]. Recognizing these threats, the IUCN Red List classifies this species as threatened [14]. Various conservation initiatives have been implemented to address these challenges and protect wild populations [15, 16].

The length-weight relationship (LWR) is a fundamental tool in fisheries science, providing insights into fish growth patterns, condition factors, and overall health. By analyzing specimens from diverse freshwater systems over time, researchers can estimate expected weights at various lengths within a species, thereby informing assessments of population structure and dynamics [17]. However, reliance on LWR alone may overlook other critical aspects of fish biology. Parameters such as age, sex, gonadosomatic index (GSI), condition factor, and feeding behavior provide additional information related to reproductive status, energy allocation, and ecological adaptation. When integrated with LWR data, these biological indicators improve comparative assessments across regions and species, which contributes to more effective fisheries management and conservation efforts [18].

Although numerous studies on *T. pectoralis* have been conducted, much of the previous research has primarily focused on aquaculture performance, domestication, feeding ecology, reproductive biology, and length–weight relationships in specific habitats [1,2,9]. Several studies have also investigated growth patterns and condition factors in different freshwater ecosystems across Southeast Asia [19–21]. However, information regarding the interaction between traditional fishing practices and the biological characteristics of *T. pectoralis* populations remains limited, particularly in wetland ecosystems of Central Kalimantan. In addition, studies integrating growth pattern, condition factor, length at first maturity, and length at first capture within a fisheries management context remain scarce.

By addressing these gaps, the present study is expected to expand the existing knowledge of the biological status of *T. pectoralis* in a tropical wetland ecosystem where traditional fishing practices remain important. The findings may provide a scientific basis for assessing the status of the exploited fish population and informing size-based and adaptive fisheries management of *T. pectoralis* in Palangkaraya City.

Several traditional fishing gears have been reported for capturing *T. pectoralis* in South Kalimantan Province, including *Tempirai* (wire stage trap), *Lalangit* (horizontal set gillnet), *Lunta* (cast net), *Hancau* (portable liftnet), *Lukah* (fish pots), and *pancing* (hook and line) [22,23]. However, studies by Rusmilyansari et al. [22] and Mardhiyah et al. [23] did not evaluate potential interactions between fishing practices and the biological characteristics of the captured fish population. In Palangkaraya City, local fishermen are uncertain about how their fishing activities might affect the growth and persistence of *T. pectoralis* populations within their fishing areas.

Therefore, this study aims to assess the growth pattern, condition factor, length at first maturity, and length at first capture of *T. pectoralis* in the wetlands of Palangkaraya City, providing evidence to support sustainable fisheries management. The findings are expected to contribute baseline biological information for size-based fisheries management and support the sustainable utilization of inland wetland fish resources.

2. Materials and Methods

2.1. Study Sites

This study was conducted within a single wetland study area in Palangkaraya City, Central Kalimantan Province, Indonesia (Figure 1), located at 02°23′35″ S 113°59′24″ E, where three fishing-gear deployment sites were used for *Tempirai*, *Lunta*, and *Lukah*. The study was intentionally restricted to this site to characterize the fish population in a representative wetland ecosystem where local fishers commonly encounter *T. pectoralis*. Research activities, including a preliminary survey, specimen collection, and subsequent data analysis, were conducted from March to June 2023.

2.2. Data Collection

A total of 164 *T. pectoralis* specimens were collected, comprising 84 males and 80 females, with total length ranging from 60 to 100 mm and body weight from 3.4 to 8.5 g. Fish

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were captured by local fishers using *tempirai*, *lunta*, and *lukah* (Figure 2) at a common fishing area. Therefore, the number of specimens analyzed was limited to the fish naturally captured during the sampling period. The characteristics of each fishing gear are described below:

1. *Tempirai* is a heart-shaped wire trap measuring 575 mm in height and 525 mm in width, with a 25 mm wide entrance slit. It is deployed in shallow water adjacent to plants and other aquatic vegetation without bait. The upper part of *Tempirai* emerges from the water, giving fish access to air. The size of *Tempirai* used in this study was relatively larger than that reported from Manarap Village, Banjar District [24].
2. *Lukah* is a tube-shaped fish trap made of bamboo measuring 1.5 m in length and 230 mm in diameter. Each trap has an entry funnel (160 mm diameter) and an exclusion funnel (60 mm diameter). A one-way valve, known as a *hinjap*, made of elastic bamboo (50 mm diameter), prevents fish from escaping. Compared to the *Lukah* used in Martapura Subdistrict [22], the *Lukah* used in this study was smaller. The trap is submerged at an angle of approximately 15 degrees to allow fish access to atmospheric oxygen at the water surface. It is typically deployed in shallow water near plants and other aquatic vegetation.
3. *Lunta* is a circular cast net constructed from monofilament nylon with a mesh size of 15 mm. The net, approximately 2.2 m in length with a 6-m radius, is equipped with iron rings weighing 3.5 kg. A 3.2 m handline with a diameter of 10 mm is used to cast and retrieve the net. The *Lunta* used in this study was smaller than that commonly found in Martapura Subdistrict [22]. It is operated in streams connected to the swamp waters.

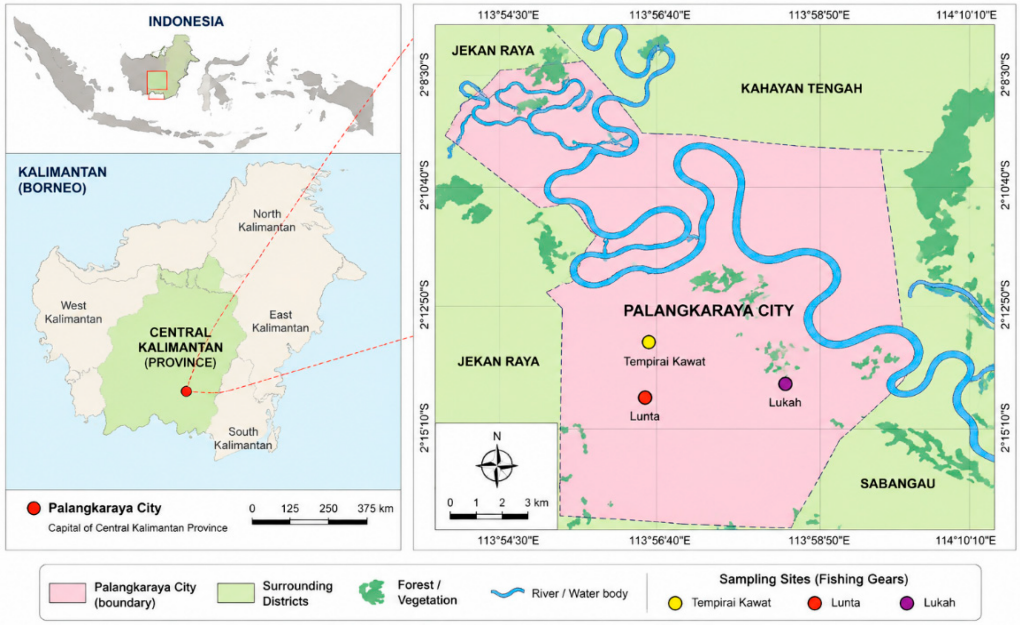


Figure 1: Study area and fishing gear deployment sites in Palangkaraya City, Central Kalimantan, Indonesia: *Tempirai* (yellow), *Lukah* (purple), and *Lunta* (red).

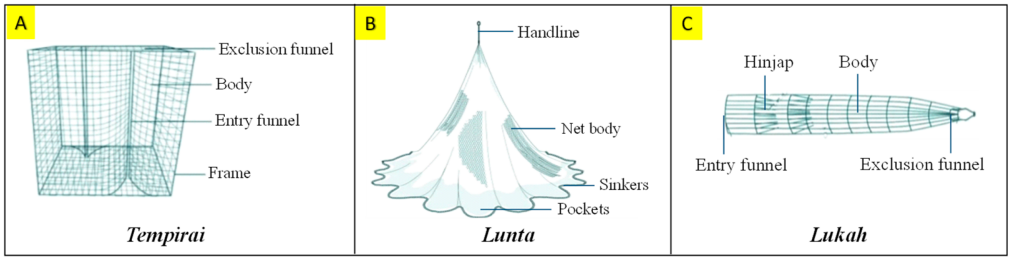


Figure 2: Illustration of traditional fishing gear used to capture *T. pectoralis* using *Tempirai* (**A**), *Lunta* (**B**), and *Lukah* (**C**).

Although the sample size (n = 164) was relatively limited for a four-month sampling period, it reflected the actual catch availability of *T. pectoralis* in the study area. Sampling was conducted consistently using traditional fishing gears at the designated sampling site, and the collected specimens represented a broad range of body sizes and both sexes, allowing the assessment of growth pattern, condition factor, and reproductive parameters. Nevertheless, it is acknowledged that a larger sample size and longer sampling period would further improve population representativeness.

2.3. Measurement and Size Distribution

The total length of each fish was measured from the tip of the snout to the end of the caudal fin to the nearest millimeter using a ruler calibrated against a Vernier caliper. Body weight was measured using a digital scale with 0.01 g precision (Dretec KS-233, Japan). Subsequently, the specimens were grouped into size classes for analysis. Each class consisted of individuals of similar length (5 mm intervals) and weight (5 g intervals).

2.4. Sexual Dimorphism

Male and female *T. pectoralis* exhibit pronounced sexual dimorphism. Males typically have more elongated, pointed dorsal fins, reddish pelvic fins, vivid coloration, and a slimmer body shape. In contrast, females have shorter and more rounded dorsal fins without reddish coloration, a more muted color pattern, and a rounder abdomen [2]. Figure 3 illustrates these morphological differences.

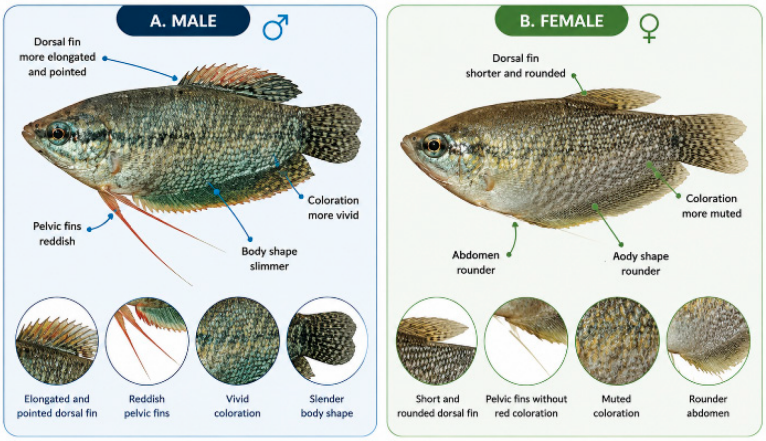


Figure 3: External morphological characteristics of (**A**) Male (**B**) Female *Trichopodus pectoralis*.

2.5. Sex Ratio

The sex ratio was determined by comparing the numbers of male and female specimens collected during the sampling period, following standard fisheries population analysis methods [25].

2.6. Length-Weight Relationship

The length-weight relationship (LWR) of the *T. pectoralis* specimens was analyzed using the equation [26]:

$$W = aL^b$$

where W is body weight (g), L is total length (mm), *a* is the intercept, and *b* is the slope. It was linearized through logarithmic transformation (log W = log *a* + *b* log L). Residual analysis was conducted, and potential outliers were excluded to improve model accuracy. The significance of the *b* values for each sex was assessed using Student's *t*-test to confirm that it was significantly different from the predictions for isometric growth (*b* = 3) [27].

$$t = \left(\frac{SD(x)}{SD(y)}\right)\left(\frac{|b-3|}{\sqrt{1-R^2}}\right)(\sqrt{n-2})$$

where *t* represents the Student's *t*-test statistic; SD(x) and SD(y) refer to the standard deviations of log-transformed length and weight, respectively; *b* is the slope of the regression; R^2 is the coefficient of determination; and *n* is the total number of fish samples.

Ideally, the *b* value should be between 2.5 and 3.5 to assess the overall health of the fish population [28]. If *b* = 3 (isometric growth), the fish grows proportionally and keeps its shape. If *b* > 3 (positive allometric growth), the

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fish gains weight faster than in length. If $b < 3$ (negative allometric growth), the fish increases in length faster than in weight. The determination coefficient (R^2) and correlation coefficient (r) of the length-weight relationship were also calculated.

The weight-to-total length (W/TL) ratio was calculated for each individual as a simple body condition metric to describe fish weight relative to total length. This ratio was used only to characterize the sampled *T. pectoralis* population and was not intended as part of the LWR analysis.

2.7. Condition Factor

The length–weight relationship (LWR) data were subsequently used to estimate Fulton's condition factor [29].

$$K = 100\left(W/L^3\right)$$

where K is Fulton's condition factor, L is the total length (cm), and W is the weight (g). The multiplication factor of 100 standardizes the value to approximately 1, facilitating interpretation, where a higher condition factor value generally indicates better fish condition and health status.

2.8. Length at First Maturity

Length at first maturity (Lm_{50}), defined as the size at which 50% of females reach sexual maturity, was estimated using a logistic curve [25].

$$P = 1/\left(1 + e^{-a\ (TL - Lm50)}\right)$$

where P represents the proportion of mature females at a given total length (TL), e is the exponent, a is the intercept, b is the slope, and Lm_{50} is the estimated length at which 50% of the population is sexually mature. The Lm_{50} is calculated using the logarithmic transformation: $Lm_{50} = -a/b$.

The analysis included individuals across all observed length classes, comprising both immature and mature individuals. Due to technical constraints, detailed gonadal examination and gonad maturity stage classification were not conducted, and gonad weight measurements were not collected; therefore, gonadosomatic index (GSI) analysis could not be performed in this study. Consequently, the estimated Lm_{50} should be considered a preliminary approximation of the reproductive size characteristics of the sampled population.

2.9. Length at First Capture

The length at first capture (Lc_{50}) was estimated from the cumulative length-frequency distribution of *T. pectoralis*. For each analytical group, fish were classified into length classes, and the cumulative catch proportion was calculated as the number of fish up to each length class divided by the total number of fish in that group. The cumulative catch proportions were then plotted against total length (mm) to estimate the length corresponding to 50% cumulative catch frequency [30]. Estimates were calculated separately by sex (males, females, and sexes pooled) and by fishing gear (*Tempirai*, *Lunta*, and *Lukah*). The sex-based estimates were used to describe differences between the length distributions of males and females, whereas the gear-based estimates were used to compare the length distributions of fish caught by the three fishing gears.

2.10. Statistical Analysis

For data analysis, Microsoft Excel and SPSS 18 were used. Statistical results are presented as mean ± standard error (SE) or as percentages and summarized in tables and figures. The Lilliefors test was applied to assess data normality and homogeneity [31]. Differences in catch size and condition factor between sexes were evaluated using a *t*-test. The male-to-female sex ratio was analyzed using a chi-square test. One-way ANOVA was applied to examine significant differences in fish body sizes among the three fishing gears. Statistical significance was set at $p < 0.05$.

3. Results

3.1. Length Frequency

The overall size distribution of *T. pectoralis* caught using three traditional fishing gears showed a predominant length range of 60–100 mm. The size distribution of fish caught by *Tempirai* skewed toward larger fish, with the highest proportion in the 85–89 mm size class, followed by the 90–94 mm size class. The lowest proportion of fish was recorded in the 75–79 mm length class (Figure 4A). These results suggest that *Tempirai* tends to catch relatively larger *T. pectoralis* than *Lunta* and *Lukah*.

The size-frequency distributions of *T. pectoralis* caught by *Lunta* and *Lukah* were more evenly distributed across length classes than those of *Tempirai*. *Lunta* primarily caught *T. pectoralis* in the 75–79 mm length range, followed closely by the 65–69 mm and 80–84 mm length ranges. The lowest proportion of fish was recorded in the 100–104 mm length class (Figure 4B). Meanwhile, *Lukah*'s catch increased gradually toward larger sizes, with the highest percentage of catch in the 90–94 mm length class. The lowest proportion of fish was recorded in the 65–69 mm length class (Figure 4C). In other words,

Lukah's catch showed a size distribution comparable to *Lunta*'s, with a relatively even spread across the length ranges. No significant differences in total catch length were observed among the fishing gears used ($p > 0.05$).

3.2. Length-Weight Relationship

This study analyzed 164 specimens of *T. pectoralis*, comprising 84 males (51%) and 80 females (49%) (Table 1). The chi-square test revealed that the observed sex ratio did not significantly differ from the expected 1:1 ratio ($\chi^2 = 0.098$, $p > 0.05$). The fish measured 60–100 mm in total length (83.45 ± 0.74 mm) and weighed 3.4–8.5 g (6.13 ± 0.11 g). The mean weight-to-total length (W/TL) ratio was 0.07, with values ranging from 0.05 to 0.09. Males averaged 83.61 ± 1.05 mm and 6.14 ± 0.16 g, while females averaged 83.29 ± 1.06 mm and 6.12 ± 0.16 g. Catch size did not differ significantly between males and females ($p > 0.05$).

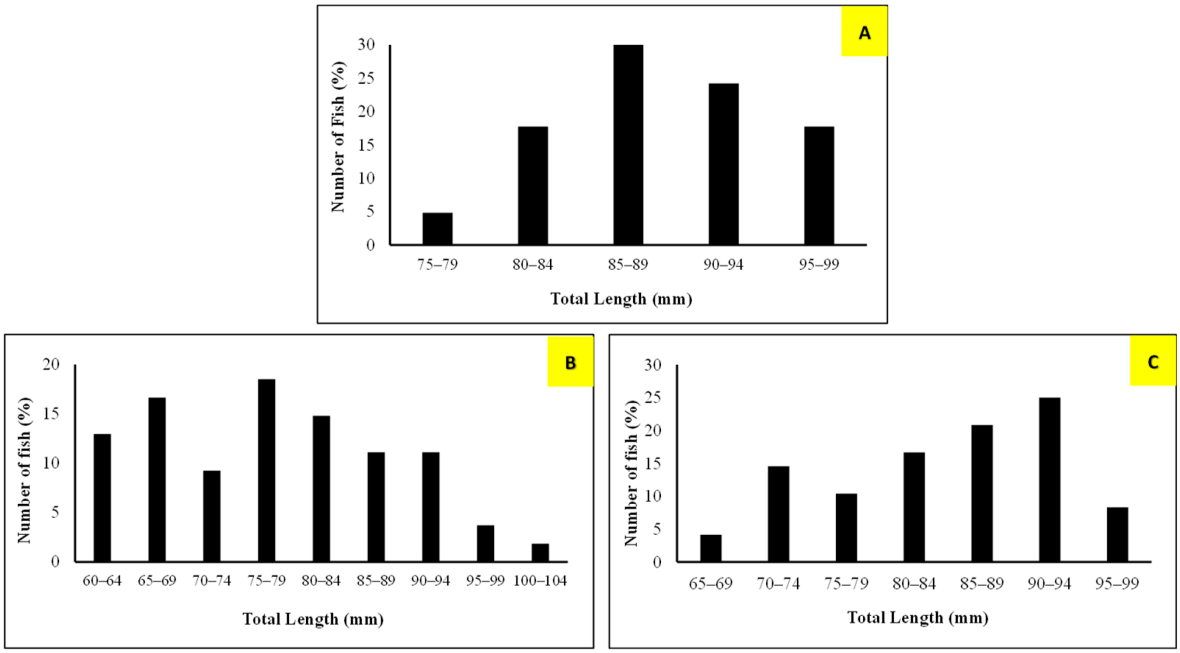


Figure 4: Length-frequency distribution of *T. pectoralis* captured using *Tempirai* (**A**), *Lunta* (**B**), and *Lukah* (**C**).

Table 1: Descriptive statistics and length-weight relationship parameters of *T. pectoralis* collected from the wetlands of Palangkaraya City.

Parameter Observed	Sexes Pooled	Males	Females
Number of fish (n)	164	84	80
Total length (mm) range	60–100	60–100	60–98
• Mean ± SE	83.45 ± 0.74	83.61 ± 1.05	83.29 ± 1.06
Weight (g) range	3.4–8.5	3.5–8.5	3.4–8.5
• Mean ± SE	6.13 ± 0.11	6.14 ± 0.16	6.12 ± 0.16
LWR Equations	W = 1.9006TL − 2.8714	W = 1.908TL − 2.8868	W = 1.8621TL − 2.7957
Growth pattern	A-	A-	A-
Coefficient of determination (R^2)	0.8503	0.8685	0.8314
Correlation coefficient (r)	0.9221	0.9319	0.9118

Note: W is weight, TL is total length, and A- is negative allometric.

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Figure 5 presents the length-weight relationships (LWR) for pooled sexes, males, and females. The results indicated a negative allometric growth pattern, suggesting that fish length increased faster than body weight. The estimated b value was 1.9006, with a determination coefficient (R^2) of 0.8503, indicating that over 85% of the variation in body weight is explained by length, reflecting a strong model fit. Furthermore, a very high correlation coefficient (r) of 0.9221 confirms a strong positive relationship between body length and body weight.

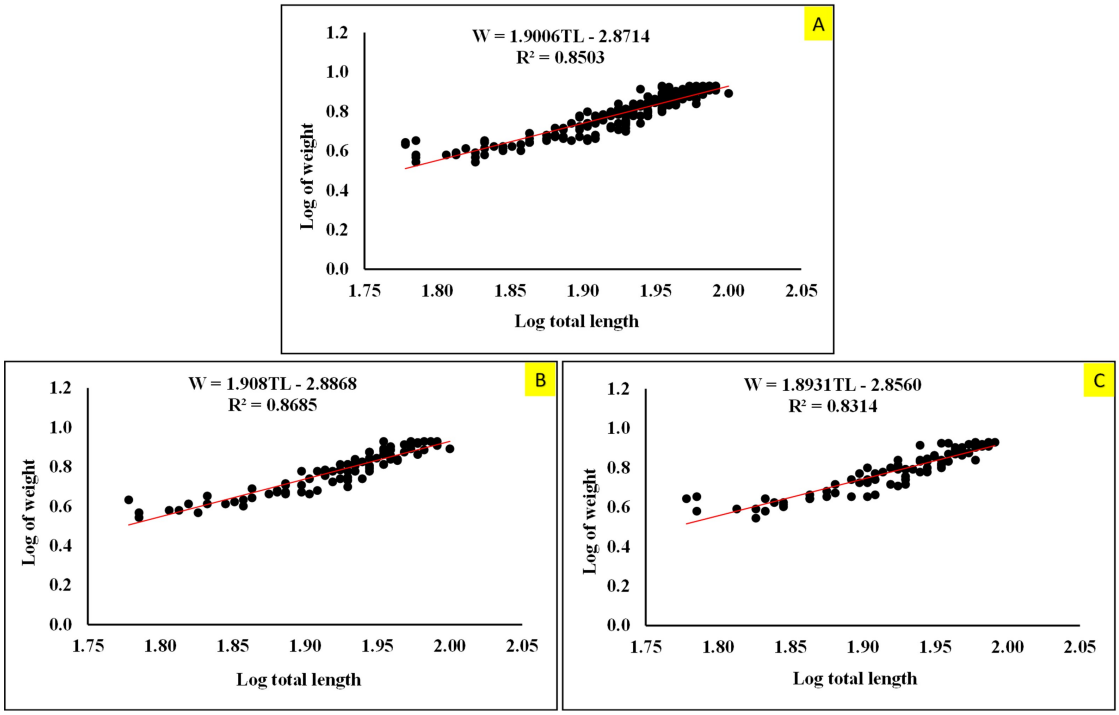


Figure 5: Length–weight relationship curves of the sexes pooled (**A**), males (**B**), and females (**C**) of *T. pectoralis* collected from the wetlands of Palangkaraya City, showing a negative allometric growth pattern ($b < 3$).

3.3. Condition Factor

Statistical analysis showed that the condition factor (K) of male and female T. pectoralis did not differ significantly ($p > 0.05$). The K value for males ranged from 0.78 to 1.99 (1.06 ± 0.02), while for females, values ranged from 0.80 to 2.04 (1.07 ± 0.02). Overall, these values indicate that the fish were in good health.

3.4. Length at First Maturity

The preliminary Lm_{50} estimates for male and female *T. pectoralis* were 82.00 mm and 81.93 mm TL, respectively. Both estimates were slightly lower than the corresponding sex-specific Lc_{50} estimates (Table 2). This pattern may suggest that fish could attain the estimated maturity length before capture. However, because gonadal maturity was not assessed directly, the estimates do not confirm that individual fish had reached sexual maturity or reproduced before capture. The pooled Lm_{50} estimate was calculated to facilitate comparison with the corresponding pooled Lc_{50} estimate. These results should be interpreted cautiously, particularly given the absence of direct reproductive data.

3.5. Length at First Capture

Figure 6 presents the estimated Lc50 for *T. pectoralis* caught using *Tempirai*, *Lunta*, and *Lukah*. The estimated Lc_{50} values were 84.66, 74.82, and 82.75 mm, respectively. These values represent the length at which 50% of the fish population is captured by each fishing gear. Variations in the curve shape and estimated Lc_{50} value may be influenced by population characteristics, sample size, and local fishing practices. Statistical analysis revealed significant differences in length-frequency distributions among the three fishing gears ($p > 0.05$), indicating that the gears captured fish with different size distributions. The observed total-length ranges of *T. pectoralis* caught by each gear are summarized in Table 3.

Table 2: Comparative analysis of length at first maturity (Lm_{50}) of *T. pectoralis* between sexes.

Sex	n	Total Length (mm)		Weight (g)		Lm_{50} (mm)	Lc_{50} (mm)
		Range	Mean ± SE	Range	Mean ± SE		
Sexes Pooled	164	60–100	83.45 ± 0.74	3.4–8.5	6.13 ± 0.11	81.97	82.99
Males	84	60–100	83.61 ± 1.05	3.5–8.5	6.14 ± 0.16	82.00	83.93
Females	80	60–98	83.29 ± 1.06	3.4–8.5	6.12 ± 0.16	81.93	82.03

Table 3: Comparative analysis of length at first capture (Lc_{50}) of *T. pectoralis* among fishing gears.

Fishing Gears	n	Total Length (mm)		Weight (g)		Lc_{50} (mm)
		Range	Mean ± SE	Range	Mean ± SE	
Tempirai	62	77–98	88.23 ± 0.68	4.5–8.5	6.70 ± 0.17	91.73
Lunta	54	60–100	77.33 ± 1.46	3.4–7.8	5.32 ± 0.16	93.36
Lukah	48	65–98	84.17 ± 1.25	3.8–8.5	6.34 ± 0.21	93.75

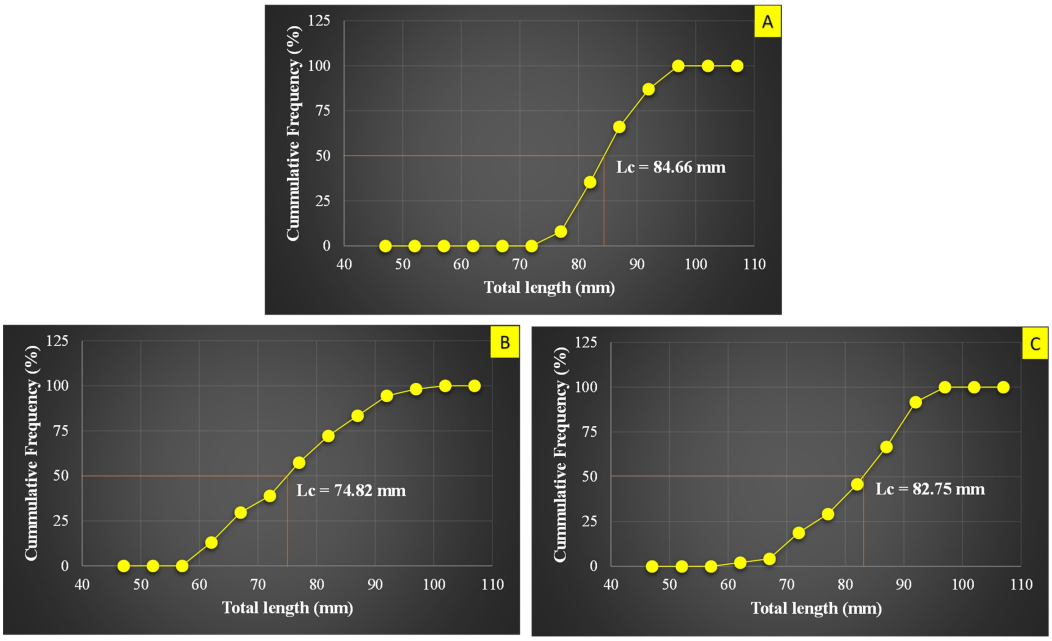


Figure 6: Estimated Lc_{50} for *T. pectoralis* captured using *Tempirai* (**A**), *Lunta* (**B**), and *Lukah* (**C**).

4. Discussion

The length distribution of *T. pectoralis* observed in the present study was generally smaller than those reported from several other freshwater ecosystems in Southeast Asia (Table 4). This is reflected by the relatively low W/TL ratio (0.073) and the smaller average body size of fish collected from the wetlands of Palangkaraya City compared with populations from Sungai Batang, Semayang Lake, Lubuk Lampam floodplain, Agusan Marsh, and Esperanza Lake [1,2,12,19,32], all of which also showed negative allometric growth patterns. In contrast, *T. pectoralis* populations from Bilah River, Patra Tani, and Sunye Lake exhibited higher W/TL ratios and positive allometric growth patterns [20,21,33].

The predominance of relatively small-sized individuals in the present study may be associated with environmental conditions, food availability, habitat characteristics, or fishing pressure within the wetland ecosystem [13,19]. In addition, the use of traditional fishing gear may selectively capture smaller size classes. Despite the relatively small body size, the condition factor indicated that the sampled fish were generally in good physiological condition. These findings suggest that local environmen-

tal and fishing conditions may influence variability in size structure among *T. pectoralis* populations across different regions.

A key finding of the present study was the negative allometric growth pattern of *T. pectoralis*, indicated by a relatively low *b*-value (1.9006). This value was lower than those reported in previous studies, which ranged from 2.6409 to 3.2588. Similar low growth coefficients ($b < 2$) have also been reported in several freshwater fish species, such as fishes from the Imo River, Nigeria [34], and snow trout (*Schizothorax richardsonii*) from the Rajouri River, Himalayas [35], possibly due to seasonal fluctuations. When the *b*-value is below 3, fish tend to allocate more energy toward increasing body length rather than body weight [36]. Multiple factors may influence variability in growth coefficients, such as life stage, growth phase, genetics, habitat condition, and food availability [37,38]. The negative allometric growth observed in the present study may also be linked to the early onset of the dry season, which could influence water availability, habitat quality, and food resources. In addition, regional differences in growth patterns and condition factors among fish populations may partially reflect environmental variation across habitats, including temperature, habitat characteristics, and seasonal dynamics [39,40].

Table 4: Comparison of length-weight relationship and condition factor for *T. pectoralis* across different regions.

Locations	n	W/TL Ratio	*a*	*b*	R^2	Growth Pattern	K	Sources
Palangkaraya City, Indonesia	164	0.073	2.8714	1.9006	0.8503	A-	1.06	Present study
Patra Tani, Indonesia	196	0.245	0.0108	3.1076	0.9469	A+	1.50	[21]
Lakea Dua, Indonesia	53	0.356	0.0240	2.8360	0.796	A-	1.61	[41]
Bilah River, Indonesia	70	0.448	4.8267	3.2588	0.9123	A+	4.62	[20]
Lubuk Lampam, Indonesia	566	0.538	0.0000	2.940	0.8650	A-	-	[2]
Sungai Batang, Indonesia	848	0.660	0.0000	2.8366	0.9164	A-	1.65	[19]
Semayang Lake, Indonesia	994	0.536	0.0393	2.6409	0.8402	A-	-	[12]
Patra Tani, Indonesia	943	0.522	0.0110	3.0820	0.9780	A+	-	[13]
Sunye Lake, Myanmar	76	0.279	0.0000	3.0970	0.9270	A+	-	[33]
Esperanza Lake, Philippines	23	0.354	0.0806	2.6671	0.9086	A-	-	[32]
Agusan Marsh, Philippines	27	0.833	0.0170	2.9040	0.9550	A-	-	[1]

Note: n is the number of fish sampled, W is weight, TL is total length, *a* is a constant, *b* is the slope of the regression, R^2 is the coefficient of determination, A+ is positive allometric, A- is negative allometric, and K is Fulton's condition factor.

The estimated K value for the *T. pectoralis* population in the present study was lower than those reported from other populations, including Sungai Batang [19], Bilah River [20], and Lakea Dua [41]. Despite this, individuals inhabiting the swamp were generally in good condition. Variations in the K value may be influenced by physiological factors and environmental conditions, including intraspecific competition for space and food resources, interspecific interactions, the fish's sex and maturity stage, its stomach contents, food availability, etc. [1,21]. This K value provides valuable insights in several key areas, including population comparisons, gonadalmaturation, and feeding activity [17,42]. Understanding the condition factor of fish is crucial for effective aquaculture management, particularly for assessing the health and condition of cultured fish. When fish condition factor declines with increasing length, it signals a need for management intervention. Strategies to address this may include improving feed quality, optimizing feeding ratios, and adjusting fish stocking density to minimize competition for food and space.

The estimated length at first capture (Lc_{50}) of *T. pectoralis* in the present study (82.99 mm) was considerably lower than the Lc_{50} value (173.10 mm) observed in Semayang Lake, East Kalimantan [12]. This indicates that individuals were generally recruited into the fishery at smaller sizes. These differences may reflect variation in fishing gear characteristics, fishing practices, habitat conditions, and population structure between locations. These findings highlight the importance of monitoring catch size composition and improving gear selectivity as precautionary measures for sustainable management of *T. pectoralis* in wetland fisheries. High exploitation rates exceeding the optimum level have been reported for *T. pec-*

toralis populations in the Patra Tani floodplain and Semayang Lake (E = 0.53 and 0.62, respectively), whereas the population in Kayu Ara Baru, South Sumatra, was categorized as underexploited (E = 0.06) [12,13]. The preliminary Lm_{50} estimate (81.97 mm TL) was slightly lower than the pooled Lc_{50} estimate (82.99 mm TL). This difference suggests that fish may be captured at lengths marginally greater than the estimated maturity length. Nevertheless, this comparison does not establish that the fish had reached sexual maturity or reproduced before capture, because gonadal maturity was not assessed directly. The estimated Lm_{50} was also lower than the value reported for *T. pectoralis* in Taliwang Lake, Sumbawa, West Nusa Tenggara (136 mm) [43]. This regional comparison should be interpreted cautiously because differences in sampling design, maturity assessment, and estimation methods may affect the reported values.

Given the narrow sampling period and the fluctuating availability of mature individuals across sampling months, this study did not perform gonadosomatic index (GSI) analysis, as gonad weight measurements were not collected during sampling. Although the Lm_{50} estimate provides a preliminary indication of the potential reproductive size of the sampled population, its interpretation is limited by the absence of direct gonadal maturity data. Future studies should incorporate maturity-stage classification and adequate sample sizes across length classes to obtain more robust estimates of Lm_{50} for *T. pectoralis* in Central Kalimantan.

Evaluating the performance of the fishing gear used in this study is important. Both *Tempirai* and *Lukah* are easily deployed within the vegetated areas, unlike *Lunta*. These traps utilize a funnel-like entrance to guide fish inward, making escape difficult. However, a major concern is potential bycatch, including juveniles and non-target species. This issue demands immediate attention and requires effective solutions [24]. In contrast, operating *Lunta* requires considerable skill and experience during casting and catch handling, unlike the traps. Additional effort is often needed when the net-bag accumulates debris and mud, or becomes entangled in submerged vegetation. *Lunta* can be operated from either the riverbank or a small boat. The number of fish captured depends on factors such as net opening area, coverage range, and the net's sinking and closing speed during retrieval.

Conversely, the catch efficiency of *Tempirai* and *Lukah* is constrained by the shape, size, and number of trap entrances. Fish captured by *Lunta* generally remain alive because the net is retrieved approximately every 10 min during operation. In contrast, *Tempirai* and *Lukah* are deployed for longer periods (hours or overnight), which may increase the risk of predation (e.g., by snakehead or otter) or natural mortality caused by stress or exhaustion. This may occur despite providing space within the traps for fish to access air. Therefore, regular cleaning and inspection are crucial to prevent deterioration of both the catch and the gear. Similar observations have been reported in previous studies [22,23].

Although differences in size distribution among captured fish may partially reflect gear selectivity, the present study did not directly assess changes in reproductive behavior or life-history strategy associated with fishing pressure. Therefore, interpret the observed patterns with caution and primarily as biological characteristics of the sampled population. Future studies in this species should focus on collecting reproductive data on female fish, in addition to total length and body weight, from a much larger number of fish. The GSI along with body weight and length traits could reveal information that can ultimately help in the management of local fish populations to ensure that the livelihoods of fishers are well protected.

To better understand the potential effects of size-selective fishing on *T. pectoralis*, future studies should examine fishing-gear selectivity, as different gear types may target specific size classes. Additionally, estimating growth and mortality rates across different size groups could improve understanding of population dynamics. Such information is important for evaluating the biological and ecological impacts of fishing pressure on this species.

The findings of this study have broader implications beyond biological assessment, particularly for sustainable development in wetland-dependent communities. The estimated length at first maturity (Lm_{50}), which was lower than the length at first capture (Lc_{50}) suggests that most individuals reproduce before capture, potentially supporting natural stock replenishment and ecological sustainability. This condition is particularly important for local economic stability, as small-scale fisheries remain a key source of income and food for surrounding communities [20]. In addition, the continued use of traditional fishing gear reflects low-cost, socially embedded livelihood strategies that may contribute to community resilience [23].

Nevertheless, the relatively small body size and negative allometric growth observed in this study may indicate environmental limitations or increasing ecological pressures, underscoring the need for adaptive fisheries management. Management measures such as size-based regulations, improved gear selectivity, and participatory governance could help maintain both ecological balance and equitable access to resources [44–46]. Given the de-

pendence of local communities on small-scale inland fisheries, management strategies should also involve collaborative approaches that incorporate local fishing practices and community-based resource management. Furthermore, regional variation in biological parameters emphasizes the importance of locally adapted, ecosystem-based management approaches [47,48]. Beyond its biological significance, the present study also has socio-economic relevance for wetland-dependent communities in Central Kalimantan, where small-scale inland fisheries contribute to local livelihoods and food security [49,50]. Therefore, integrating biological information into effective fisheries management practices is important to support the long-term sustainability of inland fisheries and their contribution to environmental, economic, and social development in Southeast Asia.

5. Conclusions

T. pectoralis exhibited negative allometric growth, while the preliminary estimates of Lm_{50} and Lc_{50} suggested that the estimated maturity length was slightly lower than the length at first capture. However, because gonadal maturity was not assessed directly, this comparison cannot confirm that fish had reached sexual maturity or reproduced before capture. Therefore, the reproductive implications of these estimates should be interpreted cautiously. Further studies incorporating direct gonadal maturity assessment and fishing-gear selectivity analysis are needed to support more reliable size-based fisheries management. In addition, the present study has potential socio-economic relevance for wetland-dependent communities in Central Kalimantan, where *T. pectoralis* fisheries may support local livelihoods and contribute to food security. Therefore, integrating biological indicators with socio-economic considerations is critical to support sustainable fisheries that contribute to food security, local livelihoods, and the long-term resilience of wetland ecosystems.

List of Abbreviations

A-	Negative Allometric
ANOVA	Analysis of Variance
GSI	Gonadosomatic Index
IUCN	International Union for Conservation of Nature
Lc_{50}	Length at First Capture
Lm_{50}	Length at First Maturity
LWR	Length-Weight Relationship
SE	Standard Error
SD	Standard Deviation
SPSS	Statistical Package for the Social Sciences
TL	Total Length
W/TL	Weight-to-total Length

Author Contributions

Conceptualization, Methodology, Software, Writing—original draft, and Writing—review and editing: A.; Investigation and Data curation: Z.A.I.; Validation, Supervision, and Investigation: I.; Visualization: A. and Z.A.I. All authors read and approved the published version of the manuscript.

Availability of Data and Materials

All summary data supporting this study's findings, including descriptive statistics, length--weight relationship parameters, condition factor estimates, and length-at-first-maturity and length-at-first-capture values, are presented in the manuscript's tables and figures. The raw specimen-level dataset (individual total length, body weight, sex, and fishing gear used for all 164 specimens) generated during this study is available from the corresponding author upon reasonable request.

Ethics Committee Approval

This study was exempt from institutional animal ethics committee review because it involved no experimental manipulation, invasive procedures, or intervention in live animals. All *T. pectoralis* specimens were obtained from routine, pre-existing fishing activities conducted by local fishermen using traditional fishing gear (*Tempirai*, *Lunta*, and *Lukah*), independent of and unaltered by the research protocol. Researchers subsequently took non-invasive external measurements (total length and body weight) of the captured specimens; no experimental treatment, dissection, or handling of live fish specifically for research purposes was conducted. As the research was limited to non-invasive measurement of a pre-existing catch unrelated to the research, formal ethics committee approval was not required under standard institutional criteria for animal research exemption.

Animal Rights

The research was conducted and reported in accordance with the ARRIVE guidelines. The study involved fish specimens obtained from routine fishing activities and did not involve experimental manipulation or research-specific intervention in live animals.

Conflicts of Interest

The authors declare no conflicts of interest.

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AI Declaration

During the preparation of this manuscript, the authors used ChatGPT solely for language refinement and clarity enhancement. The authors critically reviewed and edited all outputs. The authors take full responsibility for the integrity and accuracy of the work.

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