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 comprising 84 males and 80 females. Total length ranged from 60 to 100 mm (83.45 ± 0.74 mm), while body weight ranged from 3.5 to 8.6 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 no significant differences in fish size were observed between sexes or among fishing gears ($p > 0.05$). Length–weight analysis showed a negative allometric growth pattern ($b = 1.8856$; $R^2 = 0.8511$), indicating that length increased faster than weight, while the mean Fulton's condition factor ($K = 1.06 \pm 0.02$) suggested generally healthy individuals despite their relatively small body size. The estimated length at first maturity ($Lm50 = 85.70 \pm 0.07$ mm TL) was lower than the length at first capture ($Lc50 = 92.95 \pm 0.06$ mm TL), indicating that most individuals likely reproduce before being captured. 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 (Lc50); Length at first maturity (Lm50)

Introduction

The Snakeskin gourami, *Trichopodus pectoralis* (Regan, 1910), commonly known as the Siamese gourami, is an economically important freshwater fish species**.** It is highly valued by consumers for its taste and year-round availability and is primarily marketed in fresh or salted forms for human consumption. This species naturally inhabits various aquatic environments, including swamps, floodplains, rivers, and lakes [1,2]. In aquatic ecosystems, *T. pectoralis* contributes to the control of water hyacinth growth [3]. They are classified as 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]. The species has also been successfully domesticated using genetic techniques [9]. Other scientists are continually working to improve methods for raising them [10,11].

In Southeast Asia, inland fishery is increasingly recognized as integral to sustainable development, particularly in supporting rural livelihoods, food security, and local economies. In Indonesia, wetland fisheries provide 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 are under 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* face 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 a threatened species [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, thereby contributing 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 are 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, the studies by Rusmilyansari et al. [22] and Mardhiyah et al. [23] did not evaluate the potential interaction 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 continued existence 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 contribute to the sustainable utilization of inland wetland fish resources.

Materials and methods

1.1 Study Sites

This study was conducted at a single sampling location within the wetlands of Palangkaraya City, Central Kalimantan Province, Indonesia (Figure 1), located at 02°23'35" S 113°59'24" E. The study was intentionally restricted to this site to characterize the fish population inhabiting a representative wetland ecosystem where *T. pectoralis* is commonly encountered by local fishers. Research activities, including preliminary survey, specimen collection, and subsequent data analysis, were conducted from March to June 2023.

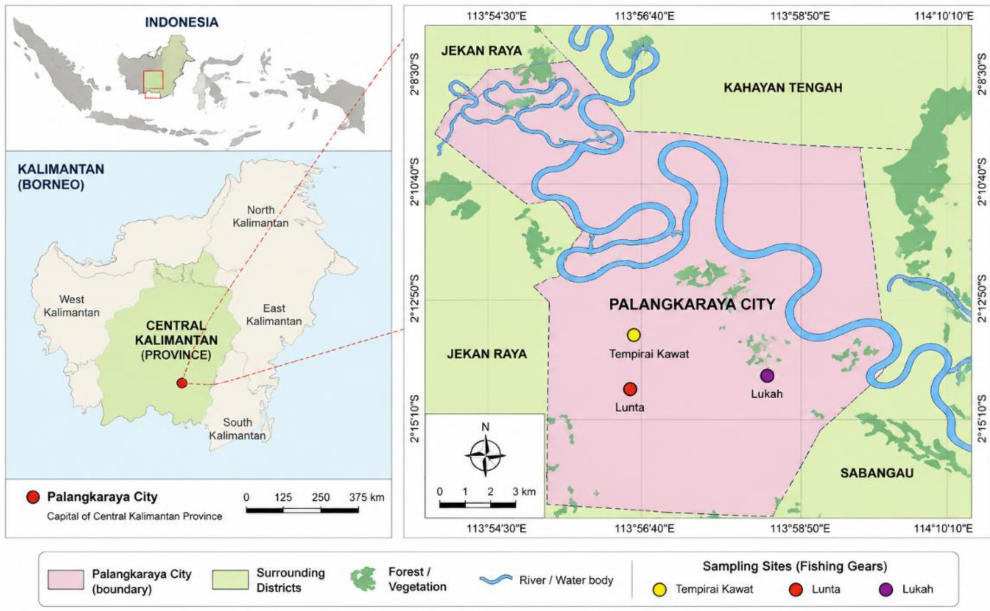

Figure 1: Study area and fishing gear deployment sites in Palangkaraya City, Central Kalimantan, Indonesia: *Tempirai* (yellow), *Lukah* (black), and *Lunta* (red).

1.2 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 ranging from 3.5 to 8.6 g. Fish 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 with no bait. The upper part of *Tempirai* emerged 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 is equipped with 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 relatively 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 dia. 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.

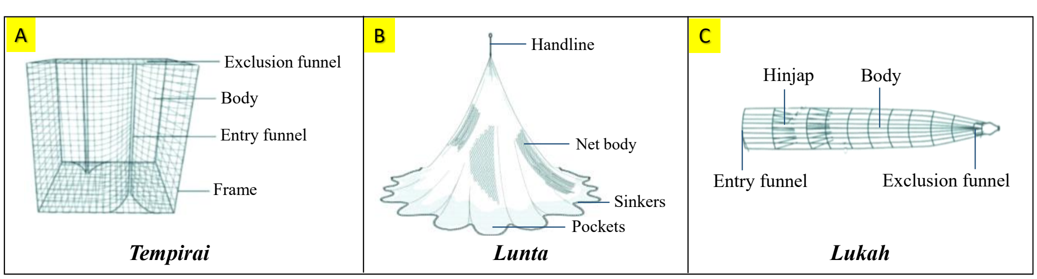

Figure 2: Illustration of traditional fishing gears used for capturing *T. pectoralis* using *Tempirai* (A), *Lunta* (B), and *Lukah* (C).

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 during the sampling period. 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, we acknowledge that a larger sample size and longer sampling period would further improve population representativeness.

1.3 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 consists of individuals of similar length (5 mm intervals) and weight (5 g intervals).

1.4 Sexual Dimorphism

Male and female *T. pectoralis* exhibit clear sexual dimorphism. Males typically display more elongated and pointed dorsal fins with 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]. These morphological differences are illustrated in Figure 3.

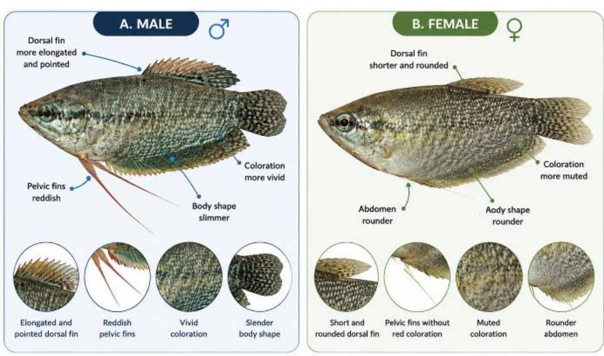

Figure 3: External morphological characteristics of male and female of *Trichopodus pectoralis*

1.5 Sex Ratio

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

1.6 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 tested by Student's t-test to confirm that it was significantly different from the predictions for isometric growth ($b = 3$) [27].

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

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 or 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 fish gains weight faster than 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 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 the relative weight of fish in relation to their total length. This ratio was used only for general characterization of the sampled *T. pectoralis* population and was not intended as part of the LWR analysis.

1.7 Condition Factor

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

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

where K is the 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.

1.8 Length at first maturity

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

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

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 fish. 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.

1.9 Length at First Capture

The length at first capture (Lc_{50}) represents the total length at which 50% of the *T. pectoralis* population is caught by fishing gear. To estimate the Lc_{50}, the cumulative catch frequency (%) was plotted against total length (mm) and fitted to a logistic selectivity curve [30]. The length corresponding to 50% cumulative probability of capture was considered as the Lc_{50} value.

1.10 Statistical analysis

For data analysis, Microsoft Excel and SPSS 18 were used. The statistical results are presented as the mean ± standard error (SE) or as percentages and are 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. All statistical significance was considered at $p < 0.05$.

Results

2.1 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 length-size distribution of fish caught by *Tempirai* was skewed towards larger fish, with the highest proportion recorded in the 85-89 mm size class, followed by the 90–94 mm. The lowest proportion of fish was recorded in the 75-79 mm length class (Figure 4A). These results suggest that *Tempirai* tends to capture relatively larger *T. pectoralis* compared to *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. The lowest proportion of fish was recorded in the 65-69 mm length class (Figure 4C). In other words, *Lukah*'s catch exhibited a comparable size distribution to *Lunta*'s, with a relatively even spread across the length ranges. No significant differences in total length of the catch among the fishing gears used ($p > 0.05$).

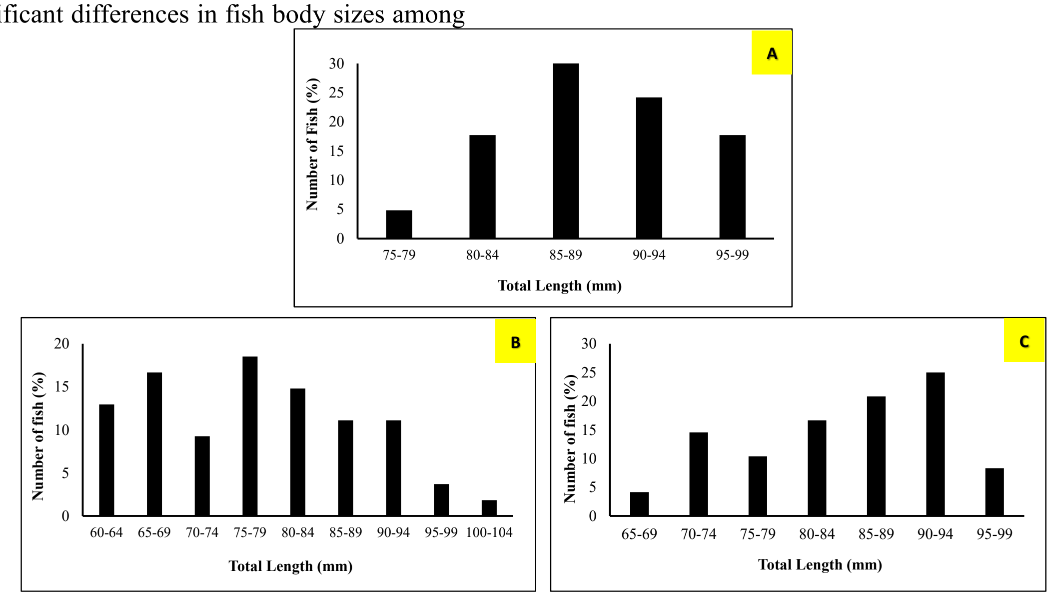

Figure 4: Length-frequency distribution of *T. pectoralis* captured using *Tempirai* (A), *Lunta* (B), and *Lukah* (C).

2.2 Length-Weight Relationship

A total of 164 specimens of *T. pectoralis*, comprising 84 males (51%) and 80 females (49%), were analyzed in this study (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 3.5-8.6 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. The mean size of males was 83.61 ± 1.05 mm and 6.14 ± 0.16 g, while the mean size of females was 83.29 ± 1.06 mm and 6.13 ± 0.16 g. No significant difference in catch size was observed between males and females ($p > 0.05$).

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	3.5 - 8.6	3.5 - 8.6	3.5 - 8.5
• Mean ± SE	6.13 ± 0.11	6.14 ± 0.16	6.13 ± 0.16
LWR Equations	W = 1.8856TL - 2.8422	W = 1.908TL - 2.8868	W = 1.8621TL - 2.7957
Growth pattern	A-	A-	A-
Coefficient of determination (R^2)	0.8511	0.8685	0.8328
Correlation coefficient (*r*)	0.9226	0.9319	0.9126

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

The length-weight relationship (LWR) of sexes pooled, males and females are presented in Figure 5. The results indicated a negative allometric growth pattern, suggesting that fish length increased faster than body weight. The estimated *b* value was 1.8856, with a determination coefficient (R^2) of 0.8511, 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 0.9226 confirms a very strong positive relationship between body length and body weight.

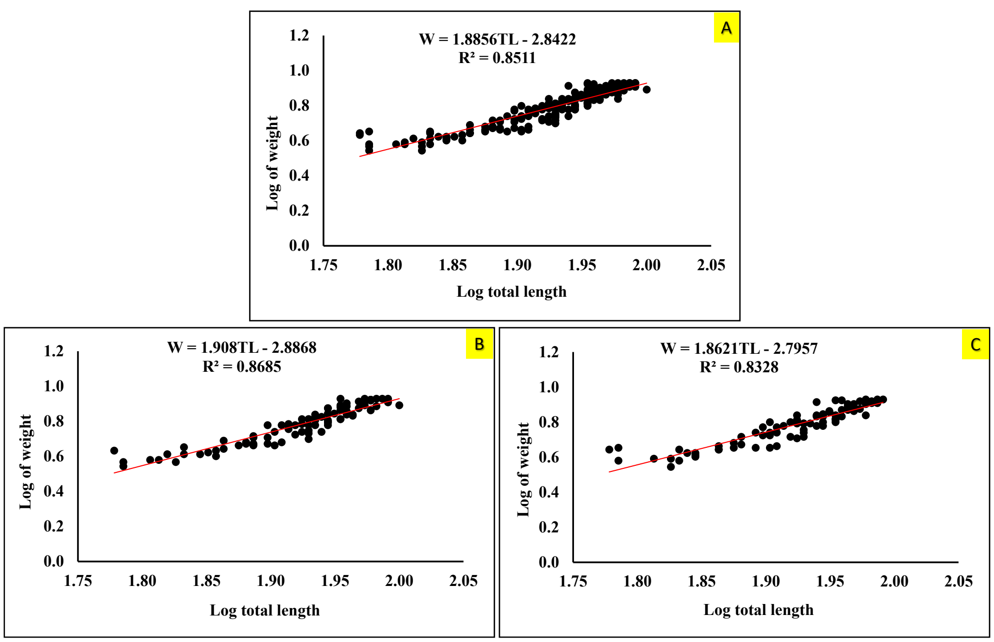

Figure 5: Length–weight relationship curves of the sexes pooled (A), males (B), and females (C) of *T. pectoralis* collected from the wetlands of Palangkaraya City, showing a negative allometric growth pattern ($b < 3$).

2.3 Condition Factor

Statistical analysis revealed that the condition factor (K) of male and female *T. pectoralis* was not significantly different ($p > 0.05$). The K value for males ranged from 0.78 to 1.99 (1.06 ± 0.02), while for females showed values ranging from 0.80 to 2.04 (1.07 ± 0.06). Overall, these values indicate that the fish were in good health.

2.4 Length at First Maturity

The estimated length at first maturity (Lm_{50}) for male and female *T. pectoralis* was 85.76 mm and 85.63 mm, respectively (Table 2). These values were lower than the estimated length at first capture (Table 3), indicating that most individuals likely had the opportunity to reach sexual maturity and reproduce before being captured. No significant difference could be observed in the Lm_{50} between males and females ($p > 0.05$). The combined Lm_{50} value was calculated using pooled data from both sexes to facilitate comparison with Lc_{50} values.

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)
		Range	Mean ± SE	Range	Mean ± SE	
Sexes Pooled	164	60 - 100	83.45 ± 0.74	3.5 - 8.5	6.13 ± 0.11	85.70
Males	84	60 - 100	83.61 ± 1.05	3.5 - 8.6	6.14 ± 0.16	85.76
Females	80	60 - 98	83.29 ± 1.06	3.5 - 8.5	6.13 ± 0.16	85.63

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	88.41 ± 0.68	4.5 - 8.5	6.70 ± 0.17	91.73
Lunta	54	60 - 100	77.33 ± 1.46	3.3 - 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

2.5 Length at First Capture

The estimated Lc_{50} for *T. pectoralis* caught using *Tempirai*, *Lunta*, and *Lukah* is presented in Figure 6. The estimated Lc_{50} values were 91.73 mm, 93.36 mm, and 93.75 mm TL, respectively. These values represent the length at which 50% of the fish population has been 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. However, no significant differences in Lc_{50} values were observed among the fishing gears ($p > 0.05$).

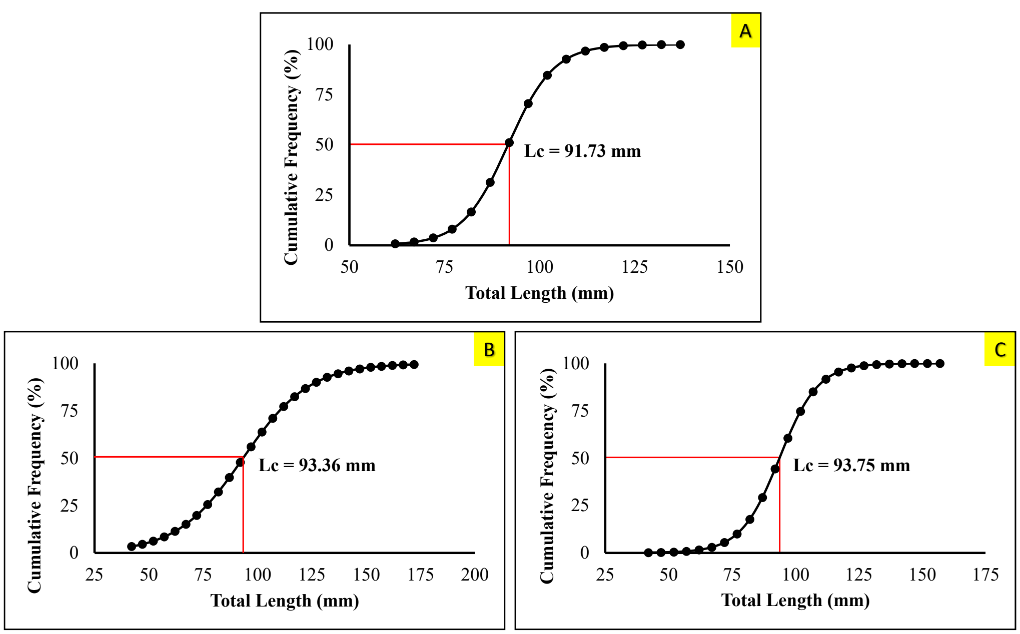

Figure 6: Estimated Lc_{50} for *T. pectoralis* captured using *Tempirai* (A). *Lunta* (B), and *Lukah* (C).

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 (0.07) 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 pattern [20,21,33].

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	0.07	2.8422	1.8856	0.8511	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 samples, W is weight, TL is total length, a is a constant, *b* is the slope or regression, R^2 is the coefficient of determination, A+ is positive allometric, A- is negative allometric, and K is the Fulton's condition factor.

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 gears 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 environmental and fishing conditions may influence size structure variability 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 (1.8856). 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 snowtrout (*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]. Variability in growth coefficients may be influenced by multiple factors, 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 associated with 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 variation in environmental conditions across habitats, including temperature, habitat characteristics, and seasonal dynamics [39,40].

The estimated K value for *T. pectoralis* population in present study was was lower than those reported from other populations, including Sungai Batang [19], Bilah River [20], [21], 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 sex of the fish and maturity stage, its stomach content, food availability etc. [1,21]. This K value provides valuable insights in several key areas, including population comparisons, gonad maturation and feeding activity [17,42]. Understanding the condition factor of fish is crucial for effective aquaculture management, particularly for assessing the fish health and condition of cultured fish. When fish exhibit a decline in condition factor 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 (92.95 ± 0.06 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. Such differences may be related to 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. pectoralis* 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 estimated length at first maturity (85.70 mm) in the present study was lower than the length at first capture (92.95 mm) indicating that most of the fishes had the opportunity to reproduce before being caught. However, the estimated Lm_{50} in the present study was considerably smaller than that reported from Taliwang Lake, Sumbawa, West Nusa Tenggara (136 mm) [43].

Given the narrow sampling period and the fluctuating availability of mature individuals across sampling months, the gonadosomatic index (GSI) analysis was not performed in this study, as gonad weight measurements were not collected during sampling. Although limited by the relatively small sample size, particularly for reproductive analyses, the Lm_{50} estimation was performed using standard logistic regression and provides preliminary information on the reproductive characteristics of this population. These findings are expected to contribute to future studies on the reproductive biology of this species in Central Kalimantan.

It is important to evaluate the performance of the fishing gears used in this study. Both *Tempirai* and *Lukah* are easily placed within the vegetated areas, unlike *Lunta*. These traps utilize a funnel-like entrance to guide fish inward, making escape difficult. However, a significant concern is the potential for 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 the net opening area, coverage range, and the sinking and closing speed of the net 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 minutes 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 spoilage 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, the observed patterns should be interpreted with caution and primarily as biological characteristics of the sampled population. Future studies in this species should focus on the collection of data on reproduction of female fish in addition to the total length and body weight on a much larger number of fish. The GSI along with the body weight and length traits could unravel information that can ultimately help in the management of local fish populations to ensure that livelihoods of fishers are well protected.

To better understand the potential effects of size-selective fishing on *T. pectoralis*, future studies should investigate the characteristics of fishing gear selectivity, as different gear types may target specific size classes.

Additionally, estimating growth and mortality rates across different size groups could provide a better 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}) being 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 dependence of local communities on small-scale inland fisheries, management strategies should also involve participatory 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 sustainable 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.

Conclusions

The *T. pectoralis* exhibited negative allometric growth and reached sexual maturity at a smaller size than its length at first capture, indicating that most individuals are likely able to reproduce before being harvested. These findings suggest that current fishing practices may still support population sustainability. From a management perspective, optimizing gear selectivity and evaluating growth and mortality are essential to maintain population stability. 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
GSI	Gonadosomatic index
IUCN	International Union for Conservation of Nature
LWR	Length-weight relationship
Lc_{50}	Length at first capture
Lm_{50}	Length at first maturity
W/TL	Weight-to-total length
ANOVA	Analysis of Variance
SPSS	Statistical Package for the Social Sciences
SE	Standard error
TL	Total Length

Author Contributions

Ahmadi: Conceptualization, Methodology, Software, Visualization, Writing-Original Draft Preparation, Writing-Review and Editing. **Zulva Ainul Ilma:** Data Curation, Data Collection and Measurement, Visualization. **Irhamsyah:** Validation, Supervision, and Investigation. All authors have read and agreed to 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.

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 the clarity. All outputs were critically reviewed and edited by the authors. The authors take full responsibility for the integrity and accuracy of the work.

Ethical Compliance

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 gears (*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 an existing, non-research-driven catch, formal ethics committee approval was not required under standard institutional criteria for animal research exemption.

Animal Ethics Statement:

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.

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