

Locational variations in morphological diversity of *Channa striata* (Bloch, 1793) cultured in the Mekong Delta, Vietnam

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Abstract. This study explored the morphological characteristics of striped snakehead fish, *Channa striata* (Bloch, 1793) cultivated in four regions of the Mekong Delta, Vietnam. The findings revealed that snakehead fish from this area exhibit a long, rounded body, a flattened tail, a broad, flat head, and a robust physique. Juvenile fish displayed a pink coloration, while adults featured distinctive black stripes along their bodies. The head was adorned with large, panel-shaped scales, and fractured lateral lines, a gray dorsal surface, and a white belly characterized the body. Additionally, some individuals exhibited irregular black stripes and rows of black spots on the abdomen. The dorsal, anal, and caudal fins were marked with black spots formed by fin ray lines. The fin ray counts were recorded as follows: 40-44 for dorsal rays, 24-27 for anal rays, 5-6 for pelvic rays, and 15-16 for pectoral rays. Furthermore, the growth patterns of snakehead fish from the four locations conformed well to the allometric growth model $Y = aX^b$, with correlation coefficients ranging from $R^2=0.9655$ to $R^2=0.9787$. These findings are crucial for assessing fish condition, managing species, and conducting fisheries and stock evaluations.

Key Words: *Channa striata*, striped snakehead fish, morphological characteristics.

Introduction. The striped snakehead fish, scientifically known as *Channa striata* (Bloch, 1793), belongs to the Channidae family and thrives in a variety of habitats, including rivers, swamps, ponds, canals, lakes, and rice paddies. This species is widely distributed across South Asia (Hossen et al 2019) and plays a crucial role in the local diet, particularly in Vietnam's Mekong Delta. In this region, four species of snakehead fish are cultivated, including *Channa striata*, *Channa micropeltes*, *Channa lucius*, and *Channa gachua* (Tran et al 2013), with *Channa striata* being the most dominant in aquaculture.

The farming conditions in the provinces of Dong Thap, Can Tho, Vinh Long, and Tra Vinh vary significantly in terms of water salinity, climate, and feeding practices. These differences may influence the phenotype of striped snakehead fish, making it essential to explore potential morphological variations. While fish morphology does not capture all functional roles, it serves as a valuable indicator of key biological functions and offers more insights than a taxonomy-based approach (Leitão et al 2018; Su et al 2019).

Research has shown that environmental factors, such as salinity, can affect fish morphology. For instance, Collyer et al (2007) demonstrated that higher salinity levels in pupfish (*Cyprinodon tularosa*) led to a decrease in body circumference relative to the total length. Similarly, elevated water temperatures have been found to impact growth and development rates, as seen in juvenile zebrafish (*Danio rerio*), which exhibited significant phenotypic variability when reared at different developmental temperatures (Atkinson 1995; Sfakianakis et al 2011). The relationships between length and weight and between different length measurements are essential tools for assessing fish stocks

and populations (Ricker 1992). In aquatic species, size is often more critical biologically than age, primarily because many ecological and physiological characteristics are more influenced by size than by age. As a result, researchers commonly use length-weight regressions to estimate a fish's weight based on its length, as direct measurements of weight can be labor-intensive in field studies (Sinovčić et al 2004). Allometric relationships typically follow the power law equation $Y = aX^b$ or its logarithmic equivalent $\log Y = b \log X + \log a$. In this context, X and Y represent measured quantities, a serves as the normalization constant, and b is known as the scaling exponent. Additionally, the growth coefficient (b), or the slope of the growth curve, is instrumental in predicting fish growth patterns (Froese 2006). Previous studies have highlighted morphological differences among snakehead fish. For example, Nguyen & Duong (2016) explored morphological characteristics and the cytochrome C oxidase subunit I (COI) gene across four snakehead species in various regions, revealing diversity in morphology and COI sequence in the square-head striped snakehead fish, projected lip snakehead, and triangle-head snakehead fish from Can Tho, Hau Giang, and Vinh Long provinces. However, this study did not address morphological differences specific to the fish groups or farming areas of Hau Giang, Can Tho, and Vinh Long.

This study focused on the snakehead fish cultured in four regions with distinct farming conditions. By grouping the fish by weight, we aimed to investigate their morphological characteristics and contribute to the understanding of locational variations in morphological diversity among snakehead fish in the Mekong Delta.

Material and Method

Materials. Striped snakehead fish, weighing between 200 g and over 1,200 g, were collected directly from ponds in various farming regions of the Mekong Delta. The specific locations include: (1) Phu Tho A hamlet in Phu Tho commune, Tam Nong district of Dong Thap province (DT); (2) Phuoc Hung hamlet in Phu Thanh commune, Tra On district of Vinh Long province (VL); (3) Dong Son hamlet in Dong Phuoc commune, Chau Thanh A district of Hau Giang province (HG) (freshwater); and (4) Giong Lon B hamlet in Dinh An commune, Tra Cu district of Tra Vinh province (TV) (brackish water). The fish were transported alive in plastic containers filled with water from their ponds to the laboratory, a journey that took no more than three hours. Once at the lab, the fish were allowed to acclimate for about 2-3 hours before measurements were conducted. They were sorted into four weight categories (g per fish): under 300 g, 300 g to nearly 500 g, 500 g to nearly 800 g, and 800 g or more.

Morphological classification and measurement. The body shape, head shape, fins, and position and size of the mouth of 240 fish samples were determined using the method outlined by Pravdin (1973). Morphological parameters were measured based on the guidelines provided by Nguyen et al (2011) and Pravdin (1973).

Biometric measurements. The biometric characteristics of farmed striped snakehead fish in the 4 regions were measured and analyzed following the method outlined by Sarfraz (2022) based on fish weight. Upon arrival at the laboratory, the striped snakehead fish were measured for weight, total length, standard length, head length, body width, caudal fin length, distance between eyes, and eye diameter.

Statistical analysis. All experiments were conducted in triplicate. The results are presented as means \pm SD. All the statistical analyses were carried out using the Stagraphics Centurion (version 16.2) software (StatPoint Technologies, VA, USA). The results were analyzed using one-way ANOVA to test for significance between means. Significant differences between the mean values ($p < 0.05$) were determined by the least significant difference (LSD).

Results and Discussion

Morphological characteristics of snakehead fish. The results of the fundamental morphological characteristics of striped snakehead fish cultured in four regions of the Mekong Delta are displayed in Figure 1.



Figure 1. Fundamental morphology of farmed *Channa striata* (Bloch, 1793) (source: the authors).

The striped snakehead fish featured a head length that constituted about one-fourth of its total length. The front part of its body had a round cross-section that gradually tapered to a flattened shape near the base of the tail. The dorsal line ran almost straight from the snout to the caudal fin's base. Its body and head were covered with large scales, while smaller scales can be found at the base of the pelvic fins and on the tail. The dorsal fin was elongated and lacked stiff spines, with the base extending from the tail to the level of the operculum. In contrast, the anal fin base was shorter than that of the dorsal fin. The dorsal fin was slightly curved and very long, while the anal fin was also long but did not connect to the caudal fin. The pectoral fins were positioned near the back of the gill covers on either side of the fish and were shaped like circular fans. The pelvic fins were small and situated close to the ventral edge, with their bases positioned closely together. The anal fin began at the same level as the 8th to 10th rays of the dorsal fin, tapering to a pointed tip that reached the caudal peduncle. The caudal fin was round and undivided, with a short peduncle. The entire body and head were covered in large scales, with 5-6 notably large scales on the top of the head, while smaller scales were present on the caudal peduncle and pelvic area. The dorsal surface of the fish ranged from dark blue to blackish-brown, fading to a milky white on the ventral side. Black spots adorned the dorsal, anal, and caudal fin, extending across the fin rays. The fin ray counts included 41 to 43 for the dorsal fin, 24 to 26 for the anal fin, 5 to 6 for the pelvic fins, and 15 to 16 for the pectoral fins (Table 1). These findings were consistent with earlier research by Ng & Lim (1990).

Meristic characteristics are crucial for distinguishing between different fish species, as they can reveal whether early development took place in different locations or under varying conditions. Factors such as genetics and environmental variables, including salinity, dissolved oxygen, and temperature, contribute to these meristic variations (Chase 2014). In this study, there were no significant differences in the number of fin rays correlated with weight or farming location. Consequently, it appears that environmental factors and stock density across the four regions did not affect the meristic traits of *C. striata*.

Table 1

Range, mode, and frequency of meristic parameters of *Channa striata* (Bloch, 1793) at four farming areas of the Mekong Delta

Farming area	Body mass of fish (g)	Dorsal fin rays	Anal fin rays	Pelvic fin rays	Pectoral fin rays
Dong Thap	< 300	42±2.0	25±1.0	5.0±1.0	15±1.0
	300÷500	42±1.0	25±1.0	5.0±1.0	15±1.0
	500÷800	42±2.0	25±1.0	5.0±1.0	15±1.0
	>800	42±2.0	26±1.0	6.0±0.0	16±0.0
Hau Giang	< 300	42±1.0	24±1.0	5.0±1.0	15±1.0
	300÷500	41±1.0	25±1.0	5.0±1.0	15±1.0
	500÷800	41±1.0	25±1.0	5.0±1.0	15±1.0
	>800	42±2.0	25±1.0	6.0±0.0	16±0.0
Tra Vinh	< 300	42±1.0	25±1.0	5.0±0.0	16±0.0
	300÷500	41±1.0	25±1.0	6.0±0.0	16±0.0
	500÷800	42±1.0	25±1.0	6.0±0.0	15±1.0
	>800	41±1.0	26±1.0	6.0±0.0	16±0.0
Vinh Long	< 300	43±1.0	25±1.0	6.0±0.0	15±1.0
	300÷500	42±1.0	25±1.0	6.0±0.0	15±1.0
	500÷800	43±1.0	25±0.0	5.0±1.0	15±1.0
	>800	43±1.0	26±0.0	6.0±0.0	16±0.0

Biometric characteristics of farmed *Channa striata* (Bloch, 1793). Overall, there were statistically significant differences in the biometric characteristics of fish from the four farming areas related to fish weight and location at $p < 0.05$. Within the same farming location, biometric traits varied significantly based on the body mass of fish. Similarly, for fish within the same body mass category, significant differences were observed in biometric characteristics depending on the location (Table 2). All biometric characteristics of striped snakehead fish from four farming areas increased with the body mass of the fish. The observations from this study were those published by Jannat et al (2022) for native and Vietnam-originated striped snakeheads in Bangladesh.

Table 2

Mean of morphometric measurements of *Channa striata* (Bloch, 1793) at four farming areas of the Mekong Delta

Farming area	Body mass of fish (g)	Total length (cm)	Caudal fin length (cm)	Head length (cm)	Eye diameter (cm)	Distance between eyes (cm)
Dong Thap	<300	31.2±0.99 ^{CA}	5.10±0.23 ^{AA}	7.50±0.12 ^{CA}	0.80±0.05 ^{AA}	2.00±0.15 ^{CA}
	300÷500	34.9±1.93 ^{CB}	5.46±0.59 ^{AA}	8.68±0.15 ^{CB}	0.87±0.02 ^{AB}	2.39±0.07 ^{CB}
	500÷800	40.1±1.13 ^{CC}	5.52±1.22 ^{AB}	9.68±0.67 ^{CC}	0.97±0.07 ^{AC}	2.68±0.21 ^{CC}
	>800	46.5±1.91 ^{CD}	7.58±1.11 ^{AC}	10.96±0.44 ^{CD}	1.17±0.05 ^{AD}	3.12±0.04 ^{CD}
Hau Giang	<300	30.4±0.88 ^{BCA}	5.18±0.13 ^{BA}	7.06±0.47 ^{BA}	0.81±0.03 ^{BA}	1.95±0.16 ^{BCA}
	300÷500	34.2±2.34 ^{BCB}	5.72±1.56 ^{BA}	8.34±0.61 ^{BB}	0.92±0.06 ^{BB}	2.27±0.06 ^{BCB}
	500÷800	39.5±1.70 ^{BCC}	7.86±1.27 ^{BB}	9.20±0.50 ^{BC}	1.01±0.03 ^{BC}	2.67±0.13 ^{BCC}
	>800	46.8±1.07 ^{BCD}	8.30±1.98 ^{BC}	10.72±0.28 ^{BD}	1.25±0.04 ^{BD}	3.12±0.04 ^{BCD}
Tra Vinh	<300	28.0±0.59 ^{AA}	4.78±0.48 ^{AA}	6.14±0.09 ^{AA}	0.78±0.01 ^{AA}	1.72±0.04 ^{AA}
	300÷500	32.3±1.25 ^{AB}	5.24±0.30 ^{AA}	7.40±0.23 ^{AB}	0.87±0.03 ^{AB}	2.09±0.03 ^{AB}
	500÷800	38.4±1.77 ^{AC}	5.86±0.39 ^{AB}	8.56±0.46 ^{AC}	0.99±0.05 ^{AC}	2.51±0.16 ^{AC}
	>800	45.3±1.05 ^{AD}	6.98±0.39 ^{AC}	10.46±0.36 ^{AD}	1.19±0.02 ^{AD}	3.08±0.07 ^{AD}
Vinh Long	<300	29.5±0.78 ^{ABA}	4.70±0.70 ^{ABA}	6.66±0.33 ^{AA}	0.78±0.01 ^{ABA}	1.89±0.04 ^{ABA}
	300÷500	33.0±1.06 ^{ABB}	5.38±0.59 ^{ABA}	7.66±0.11 ^{AB}	0.87±0.02 ^{ABB}	2.21±0.03 ^{ABB}
	500÷800	38.8±1.42 ^{ABC}	5.90±0.53 ^{ABB}	9.02±0.37 ^{AC}	1.05±0.05 ^{ABC}	2.58±0.08 ^{ABC}
	>800	45.8±1.08 ^{ABD}	8.02±1.34 ^{ABC}	10.30±0.51 ^{AD}	1.21±0.04 ^{ABD}	3.04±0.03 ^{ABD}

Different superscript letters in the same column indicate significant differences ($p < 0.05$). Lowercase letters represent differences in farming areas, while uppercase letters represent differences in the body mass of fish.

Table 3

The mean of morphometric measurements of *Channa striata* (Bloch, 1793) at four farming areas of the Mekong Delta

Farming area	Body mass of fish	Standard length/Head length	Standard length/Body depth	Head length/Eye diameter	Head length/Distance between eyes	Total length/Body width
Dong Thap	< 300	3.45±0.16 ^{bc}	5.83±0.21 ^{abA}	7.83±0.36 ^{ba}	3.75±0.20 ^{aA}	7.25±0.27 ^{aA}
	300÷500	3.49±0.09 ^{bBC}	5.62±0.14 ^{abB}	8.09±0.31 ^{bb}	3.63±0.15 ^{aA}	7.11±0.42 ^{aB}
	500÷800	3.55±0.17 ^{bAB}	5.41±0.19 ^{abC}	8.39±0.33 ^{bc}	3.62±0.31 ^{aA}	7.19±0.25 ^{aAB}
	>800	3.55±0.06 ^{ba}	5.22±0.11 ^{abd}	8.46±0.37 ^{bd}	3.51±0.18 ^{aA}	6.91±0.23 ^{aC}
Hau Giang	< 300	3.52±0.12 ^{bc}	5.74±0.18 ^{aA}	7.85±0.32 ^{ba}	3.69±0.25 ^{aA}	7.31±0.32 ^{aA}
	300÷500	3.42±0.15 ^{bBC}	5.68±0.16 ^{ab}	8.09±0.37 ^{bb}	3.66±0.22 ^{aA}	7.21±0.35 ^{aB}
	500÷800	3.46±0.13 ^{bAB}	5.40±0.13 ^{aC}	8.25±0.41 ^{bc}	3.45±0.14 ^{aA}	7.28±0.30 ^{aAB}
	>800	3.59±0.09 ^{ba}	5.32±0.16 ^{ad}	8.54±0.25 ^{bd}	3.43±0.16 ^{aA}	6.94±0.19 ^{aC}
Tra Vinh	< 300	3.57±0.15 ^{aC}	5.38±0.15 ^{dA}	7.84±0.29 ^{aA}	3.56±0.12 ^{bb}	7.27±0.14 ^{aA}
	300÷500	3.61±0.13 ^{aBC}	5.28±0.19 ^{ab}	8.35±0.26 ^{ab}	3.54±0.14 ^{bb}	7.21±0.19 ^{ab}
	500÷800	3.71±0.17 ^{aAB}	5.13±0.27 ^{dC}	8.62±0.24 ^{aC}	3.42±0.17 ^{bb}	7.18±0.26 ^{aAB}
	>800	3.67±0.11 ^{aA}	5.02±0.16 ^{dd}	8.80±0.42 ^{ad}	3.40±0.15 ^{bb}	6.91±0.16 ^{aC}
Vinh Long	< 300	3.60±0.18 ^{aC}	5.68±0.33 ^{ba}	8.11±0.36 ^{aA}	3.56±0.12 ^{bb}	7.23±0.34 ^{aA}
	300÷500	3.69±0.12 ^{aBC}	5.51±0.16 ^{bb}	8.32±0.26 ^{ab}	3.49±0.13 ^{bb}	7.12±0.33 ^{aB}
	500÷800	3.64±0.11 ^{aAB}	5.45±0.23 ^{bc}	8.60±0.23 ^{aC}	3.47±0.16 ^{bb}	7.16±0.19 ^{aAB}
	>800	3.67±0.13 ^{aA}	5.21±0.28 ^{bd}	8.81±0.31 ^{ad}	3.38±0.23 ^{bb}	6.85±0.25 ^{aC}

Different superscript letters in the same column indicate significant differences ($p < 0.05$). Lowercase letters represent differences in farming areas, while uppercase letters represent differences in the body mass of fish.

The results presented in Table 3 indicated no significant differences in the standard length-to-head length ratio for fish weighing less than 300 g from Hau Giang, Vinh Long, and Tra Vinh. In general, the ratios of standard length to body depth, head length to the distance between eyes, and total length to body width decreased as fish weight increased. Conversely, the ratios of head length to eye diameter increased with rising fish weight (Table 3). For the group of fish under 300 g, the ratios of standard length to head length ranged from 3.45 to 3.71 and fish from Dong Thap exhibited the lowest ratio at 3.45 ± 0.16 . The ratios of standard length to body depth, head length to eye diameter, and head length to distance between eyes were not significantly different between Dong Thap and Hau Giang, but they were significantly different when compared to those from Tra Vinh and Vinh Long. Notably, the standard length-to-body depth ratios for fish from Tra Vinh were significantly lower than that of the other groups, measuring at 5.38 ± 0.15 . Conversely, fish from Vinh Long had the highest head length-to-eye diameter ratio at 8.11 ± 0.36 (Table 3).

Overall observations revealed variations in certain biometric characteristics of striped snakehead fish across the four farming regions, likely influenced by farming practices such as feeding, density, and diet. The standard length of snakehead fish was found to be approximately 5.02 to 5.83 times that of the body depth (Table 3). As these fish develop from juvenile to adult stages, the ratio of head length to the distance between eyes fluctuates, either increasing or decreasing depending on their developmental phase. In this study, the ratio of head length to the distance between eyes for striped snakehead fish was in the range of 3.38 to 3.75 (Table 3). Growth patterns in snakehead fish are inconsistent throughout their developmental stages; they primarily increase in length during the early phases, while larger individuals tend to gain weight more rapidly. In their natural habitat, the growth of striped snakehead fish is irregular and largely determined by the availability of food in the aquatic environment (Ahmadi & Ansyari 2022).

Length-weight relationship (LWR) of *Channa striata* (Bloch, 1793). The relationship between fish length and weight serves as a valuable indicator for assessing growth rates, and age structures, and can play a significant role in fisheries management (Mahmood et al 2012). This length-weight relationship is also utilized to estimate a fish's weight based on its length when captured. Growth encompasses the increase in fish size and weight over time due to metabolic processes. It is often irregular and significantly affected by various factors, including nutrition, ecology, and physiology (Alam et al 2013). Growth patterns are specific to each species, with the increase in length and weight represented by a regression correlation equation established by Pauly (1998). The findings regarding the length-weight relationship of snakehead fish raised in the four farming regions showed a strong correlation (Figure 2).

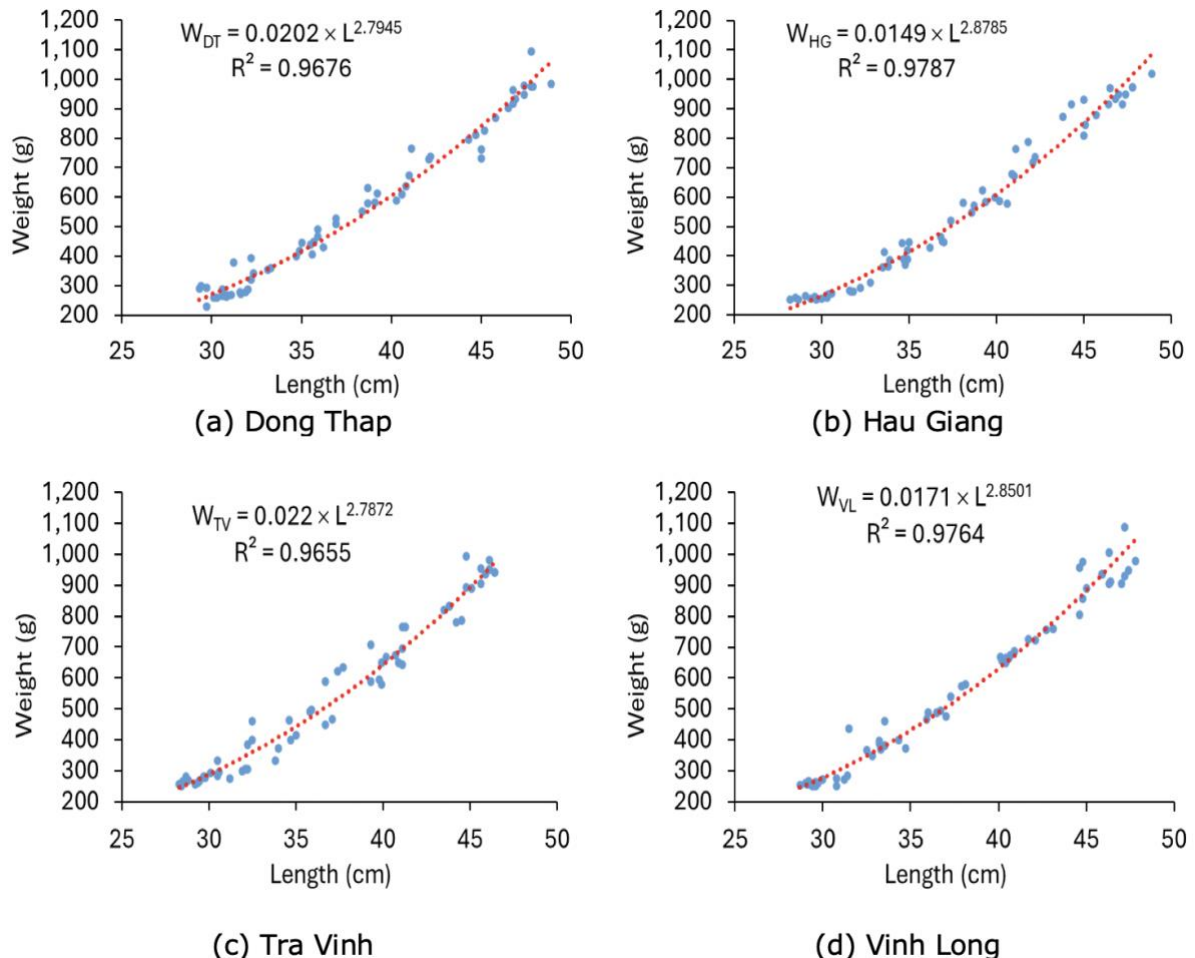


Figure 2. Standard length versus weight relationship of *Channa striata* (Bloch, 1793) at farming in Mekong Delta. Dashed lines indicate a 95% confidence interval for the regression line.

The relationship between the length and weight of striped snakehead fish across the four farming areas demonstrated a strong regression correlation. In the Dong Thap region, the LWR equation was $W_{DT}=0.0202 \times L^{2.7945}$, with a determination coefficient $R^2=0.9676$. For Hau Giang, the LWR equation was $W_{HG}=0.0149 \times L^{2.8785}$, yielding $R^2=0.9787$. The LWR equation for the Tra Vinh farming area was $W_{TV}=0.022 \times L^{2.7872}$, with a determination coefficient of $R^2=0.9655$. The LWR equation for Vinh Long was $W_{VL}=0.0171 \times L^{2.8501}$, with a determination coefficient $R^2=0.9764$ (where W represents the weight in grams of the fish and L represents the total length in centimeters of the fish). The LWR equations for four farming areas reveal scaling exponent values of $b < 3$ ($b=2.7872 - 2.8785$), indicating that the length-weight relationship of striped snakehead fish is negative allometric and that their growth is non-isometric. The same results have been published by Noor et al (2021) for the green mussel *Perna viridis* cultured on the south-

east coast of the Bay of Bengal, Bangladesh, and Azrita et al (2024) for eleven freshwater fish species in Koto Panjang Reservoir, Indonesia, and Rahman et al (2024) for eight fish species from the catchment area of Kaptai lake, Bangladesh. The LWR findings aligned with previous research on snakehead fish in the Central region, which found the relationship as $W=0.0002 \times L^{2.93829}$, with $R^2=0.98$ (Le & Nguyen 2009). Similarly, the correlation for giant snakehead fish in the Mekong Delta region was $W=0.008505 \times L^{3.007121}$ (Duong 2003). The strong correlation between total length (L) and weight (W) was particularly evident when fish length reached 28 cm, continuing until around 42 cm. During this period, increases in length were consistent with weight increases. However, after exceeding 42 cm, weight gain became less uniform. At this stage, the fish entered sexual maturity, leading to a slowdown in length growth while weight continued to increase rapidly. When fish reached 45 cm or more, the correlation between length and weight strengthened again. The findings revealed that during this phase, both length and weight increased, but after the fish exceeded 1,100 g, the growth patterns diverged, with weight gain slowing significantly as fish size increased. This variability in the relationship between length and weight is consistent with findings by Haniffa et al (2006) regarding *C. gachua* in India. Overall, the analysis indicates that the growth patterns of black snakehead fish align with the typical growth trends observed in tropical fish species. The results of the present study were consistent with those published by Rosli & Isa (2012) for *Plicofollis argyropleuron*, Ali et al (2013) for *Channa diplogramma*, *C. marulius*, and *C. striata*, Moutopoulos & Stergiou (2002) for fish species from the Aegean Sea (Greece) and Khairul et al (2024) for *Betta raja* in Sumatra Island, Indonesia.

Conclusions. The analysis revealed no significant differences in the meristic parameters of *C. striata* across the four farming regions, indicating that environmental variations and farming conditions did not impact the fish's meristic traits, such as fin ray counts. Consequently, no species variation based on location was observed. However, slight differences in certain biometric characteristics of striped snakehead fish were noted among the farming regions, likely influenced by factors such as feeding practices, stock density, water salinity, and temperature. The findings also highlighted that the growth patterns of snakehead fish are not uniform throughout their developmental stages; they primarily exhibit length growth in the early stages, while weight gain accelerates in the later stages.

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Conflict of interest. The authors declare that there is no conflict of interest.

References

- Ahmadi A., Ansyari P., 2022 Food habits, growth pattern and condition factor of snakehead (*Channa striata*) from Danau Bangkai, Indonesia. *AAFL Bioflux* 15(6):3181-3196.
- Alam M. M., Jahan S. N., Hussain M. A., De M., Goutham-Bharathi M. P., Magalhães A. L. B., Mazlan A. G., Simon K. D., 2013 Length-length relationship, length-weight relationship and condition factor of freshwater fish species of Bangladesh. *Aquaculture, Aquarium, Conservation & Legislation* 6(5):498-509.
- Ali A., Dahanukar N., Raghavan R., 2013 Length-weight and length-length relationship of three species of snakehead fish, *Channa diplogramma*, *C. marulius* and *C. striata* from the riverine reaches of Lake Vembanad, Kerala, India. *Journal of Threatened Taxa* 5(13):4769-4773.
- Atkinson D., 1995 Effects of temperature on the size of aquatic ectotherms: exceptions to the general rule. *Journal of Thermal Biology* 20(1-2):61-74.
- Azrita A., Syandri H., Aryani N., 2024 Length weight relationship, condition factor, and morphometric Characteristics of eleven freshwater fish species in Koto Panjang Reservoir, Indonesia. *International Journal of Zoology* 2024(1):9927705.

- Chase P. D., 2014 Meristics. In Stock Identification Methods. Academic Press. Pp. 171-184.
- Collyer M. L., Stockwell C. A., Adams D. C., Reiser M. H., 2007 Phenotypic plasticity and contemporary evolution in introduced populations: evidence from translocated populations of white sands pupfish (*Cyprinodon tularosa*). *Ecological Research* 22(6):902-910.
- Duong L. N., 2003 [Freshwater aquaculture technology textbook]. Department of Freshwater Aquaculture Technology, Faculty of Aquaculture, Can Tho University. 194 p. [in Vietnamese].
- Froese R., 2006 Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. *Journal of Applied Ichthyology* 22(4):241-253.
- Haniffa M. A., Nagarajan M., Gopalakrishnan A., 2006 Length-weight relationships of *Channa punctata* (Bloch, 1793) from Western Ghats rivers of Tamil Nadu. *Journal of Applied Ichthyology* 22(4):308-309.
- Hossen M. A., Paul A. K., Hossain M. Y., Ohtomi J., Sabbir W., Rahman, O., Jasmin J., Khan M. N., Islam M. A., Rahman M. A., Khatun D., Kamruzzaman, S., 2019 Estimation of Biometric Indices for Snakehead *Channa punctata* (Bloch, 1793) through Multi-model Inferences. *Jordan Journal of Biological Sciences* 12(2):197-202.
- Jannat B., Kanon K. F., Sultana N., Alam MD. S., Alam M. S., 2022 Morphological variations between native and Vietnam-originated striped snakeheads (*Channa striata*) in Bangladesh. *Bangladesh Journal of Fisheries* 34(1):41-52.
- Khairul K., Dimenta R. H., Machrizal R., 2024 Morphological characteristics and length-weight relationship of endemic wild betta in Sumatra Island. *AAFL Bioflux* 17(1):421-430.
- Le T. N. T., Nguyen H. S., 2009 [Growth characteristics of *Channa striata* Bloch, 1797 in the central region, Vietnam]. *Hue University Journal of Science* 55:105-113. [in Vietnamese]
- Leitão R. P., Zuanon J., Mouillot D., Leal C. G., Hughes R. M., Kaufmann P. R., Villéger S., Pompeu P. S., Kasper D., Paula F. R., Ferraz A. F. B., Gardner T. A., 2018 Disentangling the pathways of land use impacts on the functional structure of fish assemblages in Amazon streams. *Ecography* 41(1):219-232.
- Mahmood K., Ayub Z., Moazzam M., Siddiqui G., 2012 Length-weight relationship and condition factor of Ilisha melastoma (*Clupeiformes: Pristigasteridae*) of Pakistan. *Pakistan Journal of Zoology* 44(1):71-77.
- Moutopoulos D. K., Stergiou K. I., 2002 Length-weight and length-length relationships of fish species from the Aegean Sea (Greece). *Journal of Applied Ichthyology* 18(3):200-203.
- Ng P. K. L., Lim K. K. P., 1990 [Snakeheads (Pisces: Channidae): Natural history, biology and economic importance]. *Essays in zoology: papers commemorating the 40th anniversary of the Department of Zoology. National University of Singapore.* Pp. 127-152.
- Nguyen H. V., Nguyen P. D. T., Nguyen T. H. T., 2011 [Two fish species in the walking snakehead group of genus *Channa* (Channidae, Perciformes) in Vietnam]. *Journal of Science and Development* 9(6):954-965. [in Vietnamese]
- Nguyen N. T. T., Duong, T. Y., 2016 Morphological and genetic differences between cultured and wild populations of *Channa striata* in Viet Nam and its phylogenetic relationship with other *Channa* species. *Songklanakarin Journal of Science & Technology* 38(4):427-434.
- Noor A. R., Shakil A., Hoque N. F., Rahman Md. M., Akter S., Talukder A., Ahmad-Al-Nahid Sk., Wahab Md. A., Nahiduzzaman Md., Rahman Md. J., Asaduzzaman Md., 2021 Effect of eco-physiological factors on biometric traits of green mussel *Perna viridis* cultured in the south-east coast of the Bay of Bengal, Bangladesh. *Aquaculture Reports* 19:100562.
- Pauly D., 1998 Tropical fishes: Patterns and propensities. *Journal of Fish Biology* 53:1-17.

- Pravdin I. F., 1973 [Fishes biology research guide]. Science and Technology Publishing House, Hanoi. 276 p. [in Vietnamese]
- Rahman M. K., Rahman, B. M. S., Lima R. A., Ali A., Mahmud Y., 2024 Biometric indices of eight fish species from the catchment area of Kaptai lake, Bangladesh. *Ecological Frontiers* 44(5):1061-1068.
- Ricker W. E., 1992 Back-calculation of fish lengths based on proportionality between scale and length increments. *Canadian Journal of Fisheries and Aquatic Sciences* 49(5):1018-1026.
- Rosli N. A. M., Isa M. M., 2012 Length-weight and length-length relationship of longsnouted catfish, *Plicofollis argyropleuron* (Valenciennes, 1840) in the northern part of Peninsular Malaysia. *Tropical life sciences research* 23(2):59-65.
- Sarfraz M., 2022 Recent Advances in Biometrics. IntechOpen, London. Pp. 89-114.
- Sfakianakis D. G., Leris I., Laggis A., Kentouri M., 2011 The effect of rearing temperature on body shape and meristic characters in zebrafish (*Danio rerio*) juveniles. *Environmental Biology of Fishes* 92:197-205.
- Sinovčić G., Franičević M., Zorica B., Čikeš-Keč V., 2004 Length-weight and length-length relationships for 10 pelagic fish species from the Adriatic Sea (Croatia). *Journal of Applied Ichthyology* 20(2):156-158.
- Su G., Villéger S., Brosse S., 2019 Morphological diversity of freshwater fishes differs between realms, but morphologically extreme species are widespread. *Global Ecology and Biogeography* 28(2):211-221.
- Tran D. D., Shibukawa K., Nguyen T. P., Ha P. H., Tran X. L., Mai V. H., Kenzo U., 2013 [Fishes of the Mekong Delta, Viet Nam]. Can Tho University Publishing House. Pp. 124-125. [in Vietnamese]

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