

Length-Weight Relationship and Condition Factors of *Tenualosa ilisha* During Spawning Season in Labuhanbatu Estuary

¹Fristi Ariani, ^{2*}Rusdi Machrizal, ³Ilham Hakiki Harahap

^{1,2,3}Department of Biology Education, Faculty of Teacher Training and Education, Universitas Labuhanbatu, Rantauprapat, Indonesia *Corresponding Author e-mail: rusdimachrizal@gmail.com

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Abstract: The main objective of the study on *Tenualosa ilisha* was to analyze the length-weight relationship and condition factors of this species during the peak spawning period in the Bilah Rivers, located in Labuhanbatu Regency, North Sumatra. The study was conducted during the peak spawning period of *Tenualosa ilisha*, which was recorded to occur from February to April at two main sites Bilah River. The study used exploratory methods, which involved visual and physical observations of fish and their environment. The analysis conducted was the biological aspects of the fish length-weight relationship using the linear allometric model (LAM), while the ecological aspects measured were condition factors using the K Fulton equation and the relative weight equation (Wr). The results of the study the coefficient value (b) was determined to be 1.3181 for males and 1.4617 for females, the value of the condition factor for males (K) was 1.372, and for females (K) 1.474, the value of the relative weight (Wr) for males 100.128 and females 1.474 indicates that the growth of fish length is faster than the weight of fish. Analysis of the condition factor shows that the river environment is still in good condition to support the life of *Tenualosa ilisha*.

Keywords: length weight; condition factor; Tenualosa ilisha

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INTRODUCTION

The condition of the estuary in Labuhan Batu Regency, shows that physical and chemical parameters can vary significantly due to pollution from agricultural runoff and domestic sewage, leading to elevated levels of BOD and COD. In addition, sedimentation problems, such as those observed in the Bilah River estuary, highlight the impact of land use change and tidal flooding, which can exacerbate siltation problems (Zakiah et al., 2024). These findings suggest that the Labuhan Batu estuary may face similar challenges, including water quality degradation and sedimentation, which require effective management strategies to maintain ecological balance and support local livelihoods.

Tenualosa anadromous fishes, such as Hilsa shad (Tenualosa ilisha), are unique species that migrate between marine and freshwater habitats to spawn, similar to salmon (Das et al., 2018). These fish belong to the family Clupeidae and are commercially important in various Asian countries, including Bangladesh and India (Yin et al., 2022; Sarker et al., 2019). T. ilisha anadromous fish species are found worldwide, with specialized studies focusing on different regions. In India, T. ilisha, commonly known as Hilsa, has been studied in the Brahmaputra River, showing growth parameters and population characteristics. The taxonomv of Tenualosaspecies, including T. ilisha, T. toli, and T. macrura, has been studied using genetic analysis, revealing phylogenetic relationships and population dynamics (Thamrin et al., 2021).

Anadromous fish, such as Hilsa, play an important role in nutrient delivery to freshwater ecosystems, as seen in the case of anadromous herring in Virginia (Palm et al., 2017). The habitat of Anadromous *T. ilisha*, commonly known as Hilsa shad, in Labuhanbatu Regency, North Sumatra Province, Indonesia, is mostly found in the Bilah River. Research shows that the distribution of hilsa shad in the Bilah River is clustered, with a negative allometric growth pattern (Machrizal et al., 2019a). Watersheds in Labuhanbatu Regency are home to a variety of nekton species, including *Tenualosa*, a closely related fish species (Desrita et al., 2022). In addition, a study on the implementation of regulations to protect Terubuk fish resources in the region highlighted the importance of conservation efforts to maintain the biodiversity of this fish species in Labuhanbatu Regency (Machrizal et al., 2019a).

The spawning period of anadromous Tenualosa fishes, such as T. macrura and T. ilisha, varies depending on the species and location. In Indonesia, research shows that T. macrura spawns throughout the year in Bengkalis waters (Machrizal et al., 2019a). In addition, hilsa fish (T. ilisha) in Labuhanbatu Regency, North Sumatra Province was found to spawn from February to April, based on research conducted in the Bilah River (Asmita & Machrizal, 2023). These findings suggest that the spawning period of *Tenualosa* anadromous fishes can differ between species and regions, with some fishes spawning throughout the year while others have specific spawning seasons. Understanding the spawning periods of these fishes is crucial for conservation efforts and sustainable management of their populations. Additionally, a study on the implementation of regulations to protect *Tenualosa* fish resources in the region highlighted the importance of conservation efforts to maintain the biodiversity of these fish species in Labuhanbatu Regency (Machrizal et al., 2019b). The population decline of *Tenualosa spp.* in estuarine waters around Labuhan Batu emphasizes the need for conservation efforts to protect this endemic fish species in its natural habitat (Machrizal et al., 2019b). Overall, the habitat of Anadromous *T. ilisha* in Labuhanbatu Regency includes rivers such as Bilah and Barumun, which emphasizes the importance of conservation efforts to preserve the population and biodiversity in the region.

Length-weight relationships (LWR) and condition factors of fish species such as T. ilisha, Placopecten magellanicus, Leiopotherapon plumbeus, and Mystus tengara are influenced by various factors. These factors include sex. location, season, and habitat type, which cause significant variation in growth rates and condition factors (Mabika et al., 2024) (Jana et al., 2022; Radkhah et al., 2019). Environmental variables and spatiotemporal random effects play an important role in increasing (Das et al., 2023). LWR, with the incorporation of such factors improving the precision and accuracy of body weight estimation (Soinski et al., 2020). In addition, fish condition factors reflect their physiological condition, which is influenced by biotic and abiotic environmental variables, feeding habits, parasite load, and physiological condition, ultimately impacting growth patterns and overall welfare (Moslen & Miebaka, 2017). Length-weight relationships and condition factors play an important role in understanding the health and welfare of Tenualosa Anadromous fish. These parameters are essential in fisheries biology to convert length to weight, assess growth characteristics, and determine the physiological condition of fish (Jana et al., 2022; Oginni et al., 2022).

Length-weight relationships help estimate weight from length measurements, aiding biomass calculations and feed management in aquaculture (Jana et al., 2022).

In addition, condition factors reflect the current physical and biological condition of the fish, which is influenced by various intrinsic and extrinsic factors, such as food availability and environmental variability (Brosset et al., 2015). By analyzing these parameters, researchers can gain insight into the growth patterns, health status and overall well-being of *Tenualosa* anadromous fish, thereby contributing to effective management and conservation strategies for this species in aquatic ecosystems.

The purpose of studying length-weight relationships (LWR) and condition factors of fish during peak spawning periods is to assess growth patterns and health status of fish populations, which is critical for effective fisheries management. Research shows that LWR helps estimate the weight corresponding to a given length, while condition factor provides insight into the body condition and overall health of a fish species (Oliveira et al., 2020; Shuaib et al., 2024). For example, studies have shown that condition factor tends to increase as gonads mature towards spawning, reflecting better health and fatness (Nur et al., 2020). In addition, understanding these relationships helps in evaluating habitat conditions and managing population dynamics, which is important for sustainable fisheries practices (Singh et al., 2022) (Shuaib et al., 2024). Overall, these metrics are essential for monitoring fish populations and effectively implementing conservation strategies.

Research conducted on Anadromus *Tenualosa* in Indonesia revealed important findings regarding length-weight relationships and condition factors during peak spawning periods. Studies on other fish species in Indonesian waters, such as *Hemibagrus wyckii* and *Labridae species*, showed a positive correlation between length and weight (Aryani et al., 2016). In addition, the condition factor of these fishes is influenced by gonad maturity and spawning season (Aryani et al., 2016). These findings suggest that similar investigations on Anadromus *Tenualosa* during its peak spawning period in Indonesia could provide valuable insights into its biology, growth patterns and reproductive behavior, which could aid conservation and management efforts. Thus, this research was conducted to to analyze the length-weight relationship and condition factors of this species during the peak spawning period in the Bilah Rivers, located in Labuhanbatu Regency, North Sumatra.

METHOD

This research used the exploration method. In this method, observations were made through visual and physical contact on surface/bottom surface conditions, where all fish caught were taken as samples. To study the long-term relationship between the weight and condition factors of fish during peak spawning times, researchers use various methodologies, including the assessment of length-weight relationship (LWR) and condition factor (K). LWR is usually analyzed using regression equations, such as the one proposed by Ricker, to establish the correlation between length and weight, revealing growth patterns such as allometric or isometric growth (Aryani et al., 2016). Condition factors were calculated using the Fulton equation, which reflects the physiological state of the fish and can indicate environmental influences (Moslen & Miebaka, 2017). In addition, the gonadosomatic index (GSI) is used to determine reproductive status and peak spawning period, providing insight into fecundity and size at first maturity (Zlateva, 2017). This combined approach facilitates a comprehensive understanding of fish health and reproductive biology, essential for effective management and conservation strategies.

Research designs used to investigate the long-term relationships between fish weight and condition factors during peak spawning times typically involve longitudinal studies that collect data over an extended period, often including seasonal variation.

For example, studies on various fish species, such as whitemouth croaker and Pseudotolithus senegalensis, using monthly sampling to assess length-weight relationships (LWR) and condition factors, revealed significant fluctuations in these metrics according to spawning period.

Sampling was carried out every month from January to April 2024 in Bilah River, Hulu Bilah District, Labuhanbatu Regency, North Sumatra Province, Indonesia A total of 94 specimens (56 females and 38 males) of fish (*T. ilisha*) using various sample sizes and collection methods in different areas, sampling locations were carried out at 3 observation stations, each located at (Station 1) 2°28'2.68 "LU; 100°50'4.88 "BT, (Station 2) 2°29'38. 55 "N; 100°6'41.93 'E, (Station 3) 2°30'16.53 'N; 100°7'46.51 "E.



Figure 1. Sampling location map

Located in Bilah River, Hulu Bilah District, Labuhanbatu Regency, North Sumatra Province which was initiated based on information from local fishermen. Sampling of swordfish was carried out once a month from 08.00-16.00 WIB, for four months using gill net fishing gear. Fish caught were then measured for length and weight. Next, the samples were put into crates using ice cubes to maintain their freshness, and then brought to the Labuhanbatu University Campus Laboratory to be measured for length and weight. Samples were selected to study the length relationship and condition factors of *T. ilisha* during the peak period. The main characteristics measured included total length (TL), weight (BW), predicted weight (WS), relative weight (WR), fulton condition factor (K), coefficient of determination (R2), Nila b and Standard deviation to determine the status of length weight relationship and condition factor of fish during peak spawning period.

In the study of the length-length relationship between weight and condition factors of fish at peak spawning, various instruments were used for sampling and measuring fish. The main instrument used was an electronic platform scale integrated with a ruler, which allowed simultaneous measurement of fish weight and length. The device is designed for convenience in operation, portability, and storage, thus improving the efficiency of measuring fish features. In addition, standard methods for measuring fork length and weight are used, often involving the use of trawls and fishing nets for specimen collection, followed by storage in coolers with ice for transportation to the laboratory (Kindong et al., 2017). In some studies, experimental fish biology observation instruments are used, which include aquariums, measuring devices, and temperature control systems to facilitate the observation and recording of fish biological characteristics while minimizing stress on the fish. These instruments and methods are essential for accurately estimating Length-Weight Relationships (LWR) and condition factors, which are important for understanding fish growth patterns and their adaptation to environmental conditions (Dongo et al., 2019).

The length-weight relationship is data obtained from the growth and condition factors of the data obtained using the Length-Weight Relationship Analysis Method of tongue fish (*T. ilisha*) using the Linear Allometric Midel (LAM) equation analysis. The analysis of the length-weight relationship is determined using the equation (Cren, 1951) namely:

 $W = aL^b$

Description:

W : Weight of anchovy (gram)

L : Length of hatchery fish (mm)

a and b : Constanta

If the value of b = 3, then the growth pattern is isometric, namely (weight gain is equal to length growth). If the value of b < 3, it is called negative allometric (length gain is faster than weight gain), and if the value of b > 3, it is called positive allometric, namely (weight gain is faster than length gain).

Condition factor

In this study, the relative weight coefficient (Wr) was calculated to predict the condition factor of each sample relative weight calculation formula (Wr).

$Wr = W/Ws \times 100$

Wr is the relative weight, W is the weight of each sample; Ws is the predicted standard weight based on the same sample because it is calculated based on the combined length-weight regression through the distance between species.

$K = WL^{-}3 X 100$

K is the condition factor; W is the weight in grams; L is the length in cm3 which is the length coefficient to test whether the K value tends to be close to 1.

RESULTS AND DISCUSSION

The results showed that the growth pattern of *T. ilisha* during the peak spawning period was negative allometric, where the growth of fish body length was faster than the growth of body weight. The overall value of the length-weight relationship and condition factor of Anadromus *T. ilisha* based on the results of the study the length (TL) of *T. ilisha* is 22-39.5 (mm) and has a weight (W) in the range of 325.7-720 (g), the predicted body weight (Ws) is in the range of 272,102-640,116 the value of the relative condition factor (Wr) is 83,544-114,859. The coefficient of determination is 1.079-3.059. The (a) value of 4.712413 for (Var) is 0.003292 Furthermore, the b coefficient value of the Bilah river is 3.5180259. The graph of length-weight relationship and condition factor can be seen in Table 1.

Table 1. Results of parameter observations made on male and female *T. ilisha* in the Bilah estuary, Labuhanbatu Regency

Variabel	Jantan	Rata-Rata ±SD	Betina	Rata-Rata ±SD	Keseluruhan	Rata-rata ±SD
Total Panjang Ikan (mm)	24-39	33 ± 3.362	22-39.5	32 ± 4.245	22-39.5	32 ± 3.919

Variabel	Jantan	Rata-Rata ±SD	Betina	Rata-Rata ±SD	Keseluruhan	Rata-rata ±SD
Body Weight	340.5-	470 ± 73.002	325.7-	480± 102.028	325.7-720	476.419 ±
(g)	690.9		720			91.553
Berat yang	310.813-	469.366 ±	272.102-	479.262 ±	272.102-	479.248 ±
diprediksi	589.421	62.588	640.116	90.773	640.116	80.722
Ws (gram)						
Berat relatif	85.312-	100.128 ±	83.544-	100.187 ±	83.544-	100.163 ±
(Wr)	114.859	4.955	109.043	6.037	114.859	5.625
Faktor	1.078-	1.372 ± 0.307	1.103-	1.474 ± 0.369	1.079-3.059	1.433 ±
kondisi	2.463		3.059			0.347
Fulton (K)						
Koefisien	0.889	-	0.913	-	0.895	-
determinasi						
(R2)						
Nilai b	1.318	-	1.462	-	1.408	-
Pola	Allometrik	-	Allometrik	-	Allometrik	-
pertumbuhan	negatif		negatif		negatif	







Figure 3. (A) Length-weight relationship of female *T. ilisha* in the Bilah River estuary, Labuhanbatu Regency; (B) Comparison of observed and predicted length-weight relationships of female *T. ilisha* in the Bilah River estuary, Labuhanbatu Regency



Figure 4. (A) Length-weight relationship of male and female *T. ilisha* in Bilah River Estuary, Labuhanbatu Regency. (B) Comparison of observed and predicted length-weight relationship of male and female *T. ilisha* in Bilah River Estuary, Labuhanbatu Regency

In Figure 2 graphs A and B show the results of observations of the length-weight relationship of male T. ilisha. The total number of male T. ilisha caught during the study was 38 samples. The average length was 33 mm with an average weight of 470 g. Analysis of the length-weight relationship of T. ilisha explained that this study was negative allometric where the b value obtained was 1.318. The Fulton condition factor (K) value was 1.372. The value of the relative weight condition factor (Wr) is 100.128. In Figure 3 graphs A and B there are observations of the length-weight relationship of female *T. ilisha*. The total number of female *T. ilisha* caught during the study was 56. The average length was 32 mm with an average weight of 480 g. Analysis of the lengthweight relationship of *T.ilisha* explained that this study was negative allometric where the b value obtained was 1.462. The Fulton condition factor (K) value was 1.474. The value of the relative weight condition factor (Wr) is 100.187. In Figure 4 graphs A and B there are observations of length-weight relationships as a whole the number of T. *ilisha* fish caught was 94 fish. The average length was 32 mm, with an average weight of 476.419 g. Analysis of the length-weight relationship of *T. ilisha* explains that this study is negative allometric where the b value obtained is 1.408. The Fulton condition factor (K) value was 1.433. The relative weight condition factor (Wr) value was 100.163 (Miguez-Salas et al., 2023).

Based on Figures 2A and 3A, male and female *T. ilisha* show that there is a length-weight relationship, with values of R2 = 0.8892 and R2 = 0.9131. Male fish showed a negative allometric growth pattern with a b value of 1.3181 (b<3), a Fulton condition factor (K) of 1.372, and a relative weight condition factor (Wr) of 100.128, and female fish showed a negative allometric relationship with a coefficient value of b of 1.4617 (b<3), a Fulton condition factor (K) of 1.474, and a relative weight condition factor (We) of 100.1865. These values indicate that the length-weight relationship of Hilsa fish in the Bilah River shows a negative allometric value. The length-weight relationship analysis showed estimated weights (Ws) ranging from 310.8134-589.4209 g for males and 272.119-640.105 g for females, with relative condition factors (We) varying from 85.31205-114.8599 for males 83.54373-109.0431 for females, which provides important information on the biology and ecology of *T. ilisha* in these rivers (Ramili et al., 2024).

As with various other fish species, the length-weight relationship (LWR) and condition factor (CF) of various fish species in Indonesia during spawning have been widely studied. Research conducted in areas such as Banda Aceh (Perdana et al., 2018), Southeast Sulawesi (Asriyana et al., 2020), Riau (Aryani et al., n.d.), and West

Java (Syafei et al., 2022) has provided valuable information. This study showed that fish species such as *Sardinella fimbriata*, *Cheilinus trilobatus*, and *Hemibagrus wyckii* exhibited negative allometric growth patterns (b<3) during spawning, indicating variation in weight to length. In addition, the condition factors (K) of these species were found to be stable, with values greater than 1.6, reflecting good environmental condition factor of fish during the spawning season is crucial for effective fisheries management and conservation efforts in Indonesia (Aryani et al., 2016; Syafei et al., 2022).

Differences in fish growth patterns during the spawning period can be influenced by various factors such as water temperature, salinity, and oxygen levels. Research on species such as *Acanthopagrus butcheri* and *walleye pollock* shows that differences in growth before the spawning period are related to egg size and the amount of energy obtained during the non-spawning season (Tanaka et al., 2020) (Williams et al., 2020). In addition, spawning time may increase with age and spawning experience, which affects egg size and potential growth patterns. Temperature dynamics play an important role in fish spawning phenology, with water temperature determining the lower limit for spawning initiation and previous temperature fluctuations influencing the start of spawning. Understanding these environmental factors and their interactions is critical to comprehensively assessing fish growth patterns during spawning and the implications for population dynamics and ecosystem health (Riar et al., 2022).

CONCLUSION

Based on the research results, it can be concluded that this study provide new and relevant information on *T. ilisha* inhabiting the Bilah River, Labuhanbatu, North Sumatra. (1) The results of this study contribute to the conservation study of *T. ilisha* in the future and can be useful for adequate catch monitoring, because this fish is a species with high commercial value in Labuhanbatu, North Sumatra. (2) Based on the length-weight relationship analysis, it can be concluded that the growth pattern of *T. ilisha* fish in the Bilah river, Labuhanbatu district is negative allometric, which gets a value of b = 1.3181 for males and b = 1.4617 for females, meaning that the increase in length is faster than the increase in fish weight. (3) The results of the condition factor analysis (K) explain that the condition of the estuary is still in good condition to support the life of *T. ilisha* fish.

RECOMMENDATION

Further research is needed that discusses the length-weight relationship and condition factors of *tenualosa ilisha* fish during the peak spawning period and during the non-spawning period.

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