Original Research Article

Seven pelagic-neritic fish species from the Leiognathidae family at the Sundarban delta estuarine mouth of the Bay of Bengal in West Bengal, India: condition factor, length-weight correlations, and morphometric features

ABSTRACT

Aims: First-hand data regarding the length-weight relationship (LWR) and condition factor of seven pony and slipmouth fishes (family: Leiognathidae) from the Sundarbans delta estuarine mouth of the Bay of Bengal in West Bengal, India, with special focus on morphometric relationship, is presented in this study.

Study design: Established the Length-Weight relationship through *Log W = Log a + b Log L* and condition factor *(K)* through $K=100*W/L^3$. Morphometric characters percentage with total length (% of TL) of seven commercially important pelagic pony and slipmouth fishes from the Estuarine mouth of the Bay of Bengal, West Bengal. To maximize output and preserve fish health, it is essential to comprehend the growth dynamics and condition of fish in such systems.

Place and Duration of Study: Between January 2024 and July 2025, fish samples were collected at 10- to 20-day intervals from various brackish water islands and fish landing centres in South 24 Parganas and the Sundarbans estuarine islands, West Bengal.

Methodology: The specimens were collected from several fish landing centers using scoop nets (1 × 1 mm to 6 × 6 mm mesh size), gillnets (4.0–40 mm mesh size), and cast-nets (5 × 5 mm to 10 × 10 mm mesh size spanning up to 4.5 m^2 areas). Additionally, they were obtained from the local fishing community.

Results: Based on our research family *Leiognathidae* showed negative allometric development ($b < 3$), meaning that their length increases more quickly than their weight. The correlation coefficient (R^2) value is between 0.8523 to 0.9582, and the condition factor (K) has respective values between 0.979 to 1.78. Fishery research, stock assessment, conservation, and evaluation of the fish condition of the Sundarbans delta estuarine will all benefit from this study.

Conclusion: From this Fishery research, stock assessment, conservation, and the assessment of the fish condition of the Sundarbans estuarine islands, West Bengal, India.

Keywords: Length-weight relationships; Condition factor; Correlation coefficient; allometric growth; the Sundarbans delta estuarine mouth; Leiognathidae family.

1. INTRODUCTION

In addition to providing information on the stock structure and measuring fish condition, length-weight relationships are used to estimate the weight corresponding to a specific length [1,2,3,4]. Length-weight relationships are important tools that enable the estimation of fish condition and biomass from length observations [5,6,7,8]. Someone additionally allows the estimation of weight at age and the stock assessment model [9,10]. Biometric interactions are essential to study and manage fisheries. They assist in converting unprocessed field data into significant indices and offer insightful information on fish populations and their fluctuations [11]. Since it describes the mathematical relationship between the length and weight of an individual fish or a population of fish, the length-weight relationship (LWR) of fish is a fundamental concept in fisheries biology and ecology. Researchers and fisheries managers can use the relationship to determine a fish's weight based on its length or vice versa. This area is home to many freshwater and brackish fish species [12]. Fish can achieve isometric, negative, or positive allometric growth [13]. When an organism grows, its body dimensions remain constant, a phenomenon known as isometric growth. Positive allometric growth means that the fish gets comparatively stouter or deeper-bodied as it gets longer, whereas negative allometric growth suggests that the fish gets thinner as it gets longer. An essential metric for evaluating the fishery's overall health, growth, habitat quality, and stock composition is the length–weight relationship (LWR) [14]. Such a mathematical relationship facilitates life cycle characterization and morphological comparisons across various fish species or populations by acting as a useful metric for understanding survival, growth, maturity, reproduction, and general well-being [15]. Fish length and body mass are related mathematically by LWR, which makes it easier to convert length annotations into weight estimates for biomass assessment [16]. Additionally, it provides information for comparing two populations under specific feeding, density, climate, and other conditions; figuring out when a species goes through gonadal maturation; and monitoring the level of food consumption of a species to make sure it is effectively using its feeding source [17]. Assessing the condition factor is crucial to comprehending the life cycle of fish species and aids in the proper management of the species, consequently preserving the ecosystem's equilibrium [18]. The weight divergence of a single specimen from the average weight at length is measured by the relative condition

factor (K), which is computed from the LWR. The specimen's fatness, the environment's appropriateness, the gonad development [19], and fitness or well-being can all affect the condition factor. Relationships between length and weight provide important insights into biology, ecology, physiology, population dynamics, and general circumstances. For local populations, the fisheries of West Bengal's varied, species-rich coastal region, which is distinguished by numerous estuaries connected to upstream river systems, are an essential source of income [20].

Current research species Slipmouths and ponyfishes are common names for silverbellies (Family: Leiognathidae, Order: Acanthuriformes) [21]. It is widely dispersed throughout sandy, muddy, and estuarine habitats in the tropical and sub-tropical Indo-Pacific Oceans, and it is a significant part of the marine fisheries that exploit the coastal fishing grounds in the Indo-Pacific and Western Central Atlantic Oceans. This species of silverbellis is widely found in mangrove habitats, estuaries, and shallow coastal waters [22]. It is distinguished by its downward protractible mouth. Because of its large amount of bone and fat-free flesh, which are excellent sources of calcium and protein, it is one of the most commercially significant "bycatch" fish species [23]. Information on fisheries for the species found in various locations is limited. To support live growth, biomass estimation, stock assessment models, and population research in the Sundarban delta estuarine brackish zone, it's also a vibrant sector with diverse aquatic life and a sub-tropical temperate zone. The current study presents the LWR and condition factor of seven live ponyfish species. It also facilitates stock comparisons, which helps manage the live bait resource in the Sundarban estuarine waters. The LWR of seven pony and slip-mouth fish was notably reported in a prior study. This study expands on that information by adding seven additional species: *Deveximentum insidiator* (Bloch, 1787), *Aurigequula fasciata* (Lacepède, 1803), *Eubleekeria splendens* (Cuvier, 1829), *Gazza minuta* (Bloch, 1795), *Karalla dussumieri* (Valenciennes, 1835), *Leiognathus equula* (Forsskål, 1775) and *Photopectoralis bindus* (Valenciennes, 1835). As a result, the current study of LWR and related condition factors (K) of the seven pelagic-neritic brackish Leiognathidae family from the Sundarban estuarine mouth of the Bay of Bengal coastal water, Sundarban, hasn't been assessed yet.

2. MATERIALS AND METHODS

2.1 Area of study

One of India's most abundant areas for biodiversity is the Sunderbans, sometimes referred to as Badabon locally. Mangroves, which act as a biological buffer between the land and the sea, are a feature of this UNESCO World Heritage site. The forest, which is dispersed over 104 islands and 26,000 square kilometers, is a component of the Ganga-Brahmaputra delta. In the Bay of Bengal, the Sundarbans are situated inside the delta created by the meeting of the Ganges, Brahmaputra, and Meghna rivers. The landform is made up of an intricate network of islands and mudflats that were created as silt from rivers accumulated on their Himalayan roots. Anastomotic canals and tidal streams separate these sediment loads. Estuaries have tidal amplitudes between 3.5 and 4 meters, with seasonal variations between 1 and 28 meters. With an approximate area of 10,000 km^2, the Sundarbans are located between latitudes 21°32′ to 22°40′N and longitudes 88°05′ to 89°51′E. Interestingly, Bangladesh makes up 62% of this region, with India making up the remaining 38%.

Between January 2024 and July 2025, fish samples were collected at 10- to 20-day intervals from various brackish water islands and fish landing centers in South 24 Parganas and the Sundarban estuarine islands, West Bengal (Figure 1). The recent study was conducted at different important fish landing centres, rural isles, and the Tiger reservoir islands of the delta region of the Sundarban of South 24 Parganas district of West Bengal, as follows: Kakdwip Fish landing centre (Site-1; 21°51'55"N

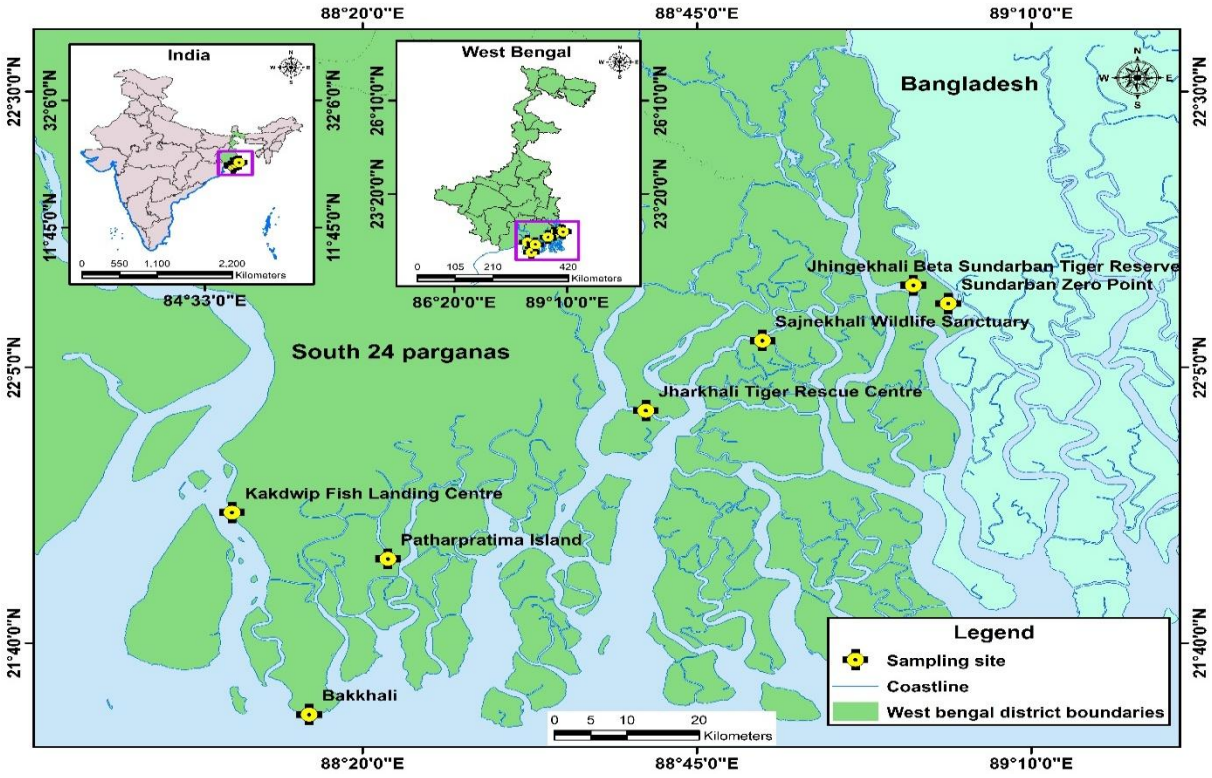


Fig. 1. Map showing the precise location of the research area, Sundarbans delta, W.B

88°10'14"E, Elevation-12 m), Bakkhali (Site-2; 21°33'31"N 88°16'11"E, Elevation-18 m), Jhingekhali Beat (Site-3; 22°12'26.92"N 89°01'10.85"E, Elevation-14 m), Pathar Pratima islands (Site-4; 21°47'38.75 "N 88°21'53.96"E, Elevation-16 m), Sajnekhali Wildlife Sanctuary (Site-5; 21°07'26.01"N 88°41'11.21"E, Elevation-17 m), Jharkhali Tiger Rescue centre (Site-6; 22°01'05.19"N 88°41'09"E, Elevation- 23 m), Sundarban Zero Point (Site-7; India-Bangladesh International Water Border, 22°10'47.67"N 89°03'47.62" E, Elevation-15 m) and adjacent areas. Using a hoist and encircling nets with 25 to 30 mm mesh sizes and working at depths of 2 to 17 m.

2.2 Collection of Samples

A total of 821 pony fish and slipmouth (fam. Leiognathidae) samples were gathered utilizing a variety of fishing tools, including gillnets, cast nets, and drag nets. For length measurements, a Vernier calliper (Mitutoyo, Japan) was used from the tip of the snout to the expanded tip of the caudal fin, within 0.1 mm, and weighed by the digital weighing machine to the closest 0.01 g (total weight). Specimens were gathered using scoop nets (1 x 1 mm to 6 × 6 mm mesh size), gillnets (4.0–40 mm mesh size), and cast-nets (5 × 5 mm to 10 × 10 mm mesh size covering up to 4.5 m^2 areas). They were also acquired from the local fishing population. TL, which stands for total length; SL, which stands for standard length; HL, which stands for head length; P1L, length of the pectoral fin, length of the pelvic fin, eye diameter (ED), body depth (BD), dorsal fin (D), anal fin (A), pectoral fin (P1), and pelvic fin (P2). The specimens were identified using the techniques of [24,25]. Standard identification keys and published documents were used to identify fish species, which were consulted to confirm the scientific names [26]. Precise measurements of fish length to the closest millimeter (mm) and total weight (W) to the nearest gram (g) were recorded to establish the length-weight relationship.

2.3 Length-Weight Relationship (LWR)

Froese used the parabolic equation to analyze the LWR of pony and slipmouths [1]. $W=aL^b$, where W is the fish's weight in grams, L is its length in centimeters, a is constant, and b is an exponential that represents the length-weight relationship. The parameters "a" and "b" were estimated by log-transforming the equation. Graphically, the connection ($W = aL^b$) is represented by a straight line when transformed into the logarithmic form;

$$\text{Log } W = \text{Log } a + b \text{ Log } L$$

where Log an is a constant and b is the line's slope. Allometric growth is indicated by values greater or less than 3, while the regression coefficients for isometric growth have a value of 3. If the correlation coefficient is greater than three, positive allometry is indicated; if it is less than three, negative allometry is indicated. The isometric growth null hypothesis was evaluated using the t-test [27].

2.4 The Fulton's condition factor (K)

Using the equation, the condition factor is used to compare the fish's condition, fatness, and level of wellbeing in their habitat (Fulton, 1904); and 100 is a factor used to bring the value of K near unity.

$$K=100*W/L^3$$

where 100 is a factor to bring the value of K close to unity, W is the weight (g), L is the length (cm), and b is the value derived from the length-weight equation.

2.5 Analysis of Mathematical Data

Microsoft Windows Excel 2021 was used to execute all of the mathematical calculations mentioned above.

3. RESULTS AND DISCUSSION

3.1 Length-Weight Relationship (LWR) of Pony and Slip-mouths

The morphometric analysis about TL% for each of the seven species in the Leiognathidae family is list ed in Table1. 821 specimens of pony fish representing seven different fish species were collected for t his study from the aforementioned several estuarine locations in the Bay of Bengal, Sundarban delta, India.Table 2 shows descriptive characteristics regarding seven pony species, including total length (TL) and total weight (TW) ranges, species numbers (n), average total length ($\bar{x}$), and average total weight ($\bar{y}$). All seven species sampled throughout the investigation had an observed range of total length (TL) and total weight as follows i.e; *Devexim*entum *insidiator* (4.96-11.34 cm; TL) and observed total weight (3.92-11.42 g; TW), *Aurigequula fasciata* (5.89-13.7 cm; TL) and observed total weight (11.9-33.54 g; TW) along with *Eubleekeria splendens* (5.31-10.77cm; TL) and (6.11-15.7 g; TW), *Gazza minuta* which specimen respectively (4.76-9.65 cm; TL) and (5.9-13.66 g; TW), *Karalla dussumieri as follows* (4.77-

11.67 cm; TL) and (6.88-15.6 g; TW), *Leiognathus equula* (9.21-21.44 cm; TL) and (51.7-152.67 g; TW) and finally *Photopectoralis bindus* was TL and TW ranges as follows (4.65-11.44 cm; TL) and (2.45-10.48 g; TW). According to this morphometric investigation, *Leiognathus equula* was the longest of the Pony fish species, while *Gazza minuta* had the shortest length, followed by *Eubleekeria splendens*, and so on. The Regression equation Length weight relationship (LWR) of seven different pony fishes is as follows, i.e, *D. insidiator* (Log W=2.908+0.5924 Log L; b=0.5924, p <0.001), *A. fasciata* (Log W=2.7921+0.9384 Log L; b=0.9384, p <0.001), *E. splendens* (Log W=-1.3678+1.001 Log L; b=1.001, p <0.001), *G. minuta* (Log W=1.8315+0.8727 Log L; b=0.8727, p <0.001), *K. dussumieri* **(**Log W=1.9275+0.8485 Log L; b=0.8727, p <0.001), *L. equula* (Log W=7.1798+0.9762 Log L; b=0.9762, p <0.001) and *P. bindus* **(**Log W=-1.9856+1.4183 Log L; b=1.4183, p <0.001). Among them, *D. insidiator* had the lowest 'b' value (0.5924), while *P. bindus* had the highest 'b' (1.4183) (Table 3) here all species show that the (b<3), which indicates the hypo-allometric growth of all seven species**.** According to growth type, this study's length-weight association revealed that all pony and slip mouth displayed a negative allometric growth or hypo-allometric (b<3), meaning that the fish gets lighter (negative allometric) for a given length and develops longer relative to its weight. The correlation coefficient (R^2) has values between 0.8523 to 0.9582 (Table 3), which is extremely high. Remarkably, the coefficients of determination (R^2) for each of the seven species of pony fish are as follows: *D. insidiator* (R^2=0.8523), *A. fasciata* (R^2=0.8529), *E. splendens* (R^2=0.8689), *G. minuta* (R^2=0.8756), *K. dussumieri* (R^2=0.9189), *L. equula* (R^2=0.909), and *P. bindus* (R^2=0.9582). Therefore, this study found that *Photopectoralis bindus* has the highest R^2 value, whereas *Deveximentum insidiator*, *Aurigequula fasciata*, and others have the lowest. The scatter diagram displaying the log LTs with Log TWs of the species being studied is shown in Figure 2-8.

An ideal fish, b typically stays constant at 3.0. asserts that fish may not maintain the same body outline or shape throughout their lives. The value of "b" provides details about the health and growth of fish. Fish b values are species-specific and change according to the fish's sex, age, seasons, physiological state, growth increment, and nutritional status [28,13]. Generally speaking, several variables, including sample size, length range covered, habitat type, ontogenetic development, fish gonadal development, area/season, population, sex, gonad maturity, degree of stomach fullness, diet, health, disease, and

parasite loads of the fish, and preservation method, can be responsible for variations in b values in the LWRs [16].

Table 1. Morphometric measurements as a percentage of total length (TL), species-wise, of the Leiognathidae family.

Sl.No	Species	n	SL	HL	ED	P1L	BD	P2L
1	***Deveximentum insidiator***	108	73.8% TL	22.4%TL	8.9% TL	19.5% TL	46,1% TL	7.5% TL
2	***Aurigequula fasciata***	98	79.4% TL	26.9% TL	10.5% TL	16.6% TL	37.6% TL	11.7% TL
3	***Eubleekeria splendens***	112	75.7% TL	23.3%TL	9.7%TL	19.2% TL	32.3% TL	10.15 TL
4	***Gazza minuta***	127	71.6% TL	21.8%TL	8.2% TL	14.6% TL	38.1% TL	9.6% TL
5	***Karalla dussumieri***	85	76.7% TL	22.2% TL	9.1% TL	17.6% TL	41.2% TL	10.6% TL
6	***Leiognathus equula***	101	74.4% TL	25.6% TL	8.7% TL	18.8% TL	39.3% TL	11.5% TL
7	***Photopectoralis bindus***	189	78.6% TL	24.6% TL	8.6% TL	14,7% TL	45.7% TL	7.9% TL

***Abbreviation n=species numbers, SL=Standard Length, HL= Head Length, ED= Eye diameter, P1L=Pectoral fin length, BD=Body Depth and P2L=Pelvic fin length**

Table 2. The study evaluated the Total length, Total weight, Average length-weight association variables of fish from the Sundarbans delta estuarine mouth of the Bay of Bengal in West Bengal

Sl.No	Species	n (number of species)	Total length (cm)	Total weight (g)	Average length ($\bar{x}$)	Average weight ($\bar{y}$)
1.	***Deveximentum insidiator***	108	4.96-11.34	3.92-14.2	8.22	10.159
2.	***Aurigequula fasciata***	98	5.89-13.7	11.9-33.54	11.091	26.767

3.	***Eubleekeria splendens***	112	5.31-10.77	6.11-15.7	8.732	11.987
4.	***Gazza minuta***	127	4.76-9.65	5.9-13.66	7.519	10.652
5.	***Karalla dussumieri***	85	4.77-11.67	6.88-15.6	9.106	12.546
6.	***Leiognathus equula***	102	9.21-21.44	51.7-152.67	16.982	114.166
7.	***Photopectoralis bindus***	189	4.65-11.44	2.45-10.48	9.128	16.092

Table 3. Correlation coefficient "R^2", value of constant "a" and "b", Conditional factor (K), and Growth pattern of Seven *Leiognathidae* fishes from the Sundarbans delta estuarine mouth of the Bay of Bengal in West Bengal, India.

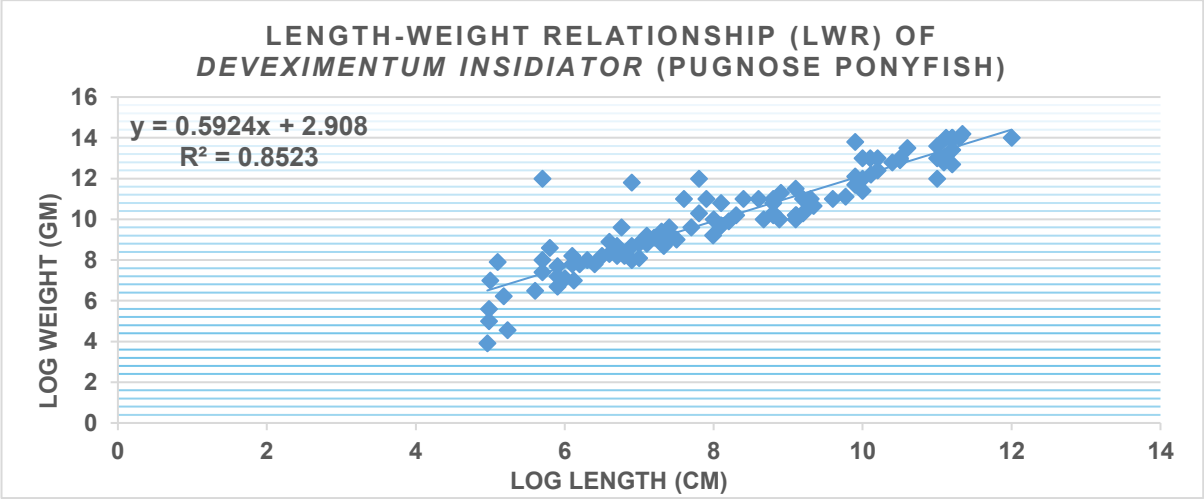
Species	Regression equation	a-value	b value	R^2	K-value	Growth pattern
Deveximentum insidiator	Log W=2.908+0.5924 LogL	2.908	0.5924	0.8523	0.9981	Hypo-allometric
Aurigequula fasciata	Log W=2.7921+0.9384 LogL	2.7921	0.9384	0.8529	1.003	Hypo-allometric
Eubleekeria splendens	Log W=-1.3678+1.001 LogL	1.3678	1.001	0.8689	1.002	Hypo-allometric
Gazza minuta	Log W=1.8315+0.8727 LogL	1.8315	0.8727	0.8756	1.002	Hypo-allometric
Karalla dussumieri	Log W=1.9275+0.8485 LogL	1.9275	0.8485	0.9189	0.979	Hypo-allometric
Leiognathus equula	Log W=7.1798+0.9762 LogL	7.1798	0.9762	0.909	1.003	Hypo-allometric
Photopectoralis bindus	Log W=-1.9856+1.4183 LogL	1.9856	1.4183	0.9582	1.78	Hypo-allometric

All of the recorded values are plotted on a scatter plot to generate the graph, with length on the X-axis and weight on the Y-axis. Furthermore, a linear relationship that can be seen in the graph (Fig. 2-8) is produced when the measured values of weight and total length are plotted on the X and Y axes, respectively. To create a straight-line relationship for the length-weight relationship calculation, these quantities have been converted to logarithmic values (Fig. 2-8). As a result, all length-weight relationship calculations are based on log values rather than the original values. Understanding fisheries research and population dynamics requires evaluating length-weight connections, especially when taking direct weight readings in the field is time-consuming. This analytical technique has many uses, such as figuring out weight-at-age, evaluating fish health, and comparing life history patterns across different regions. To compute weight variations based on individual or group lengths, a strong mathematical relationship between length and weight must be created. By highlighting key advancements in fish

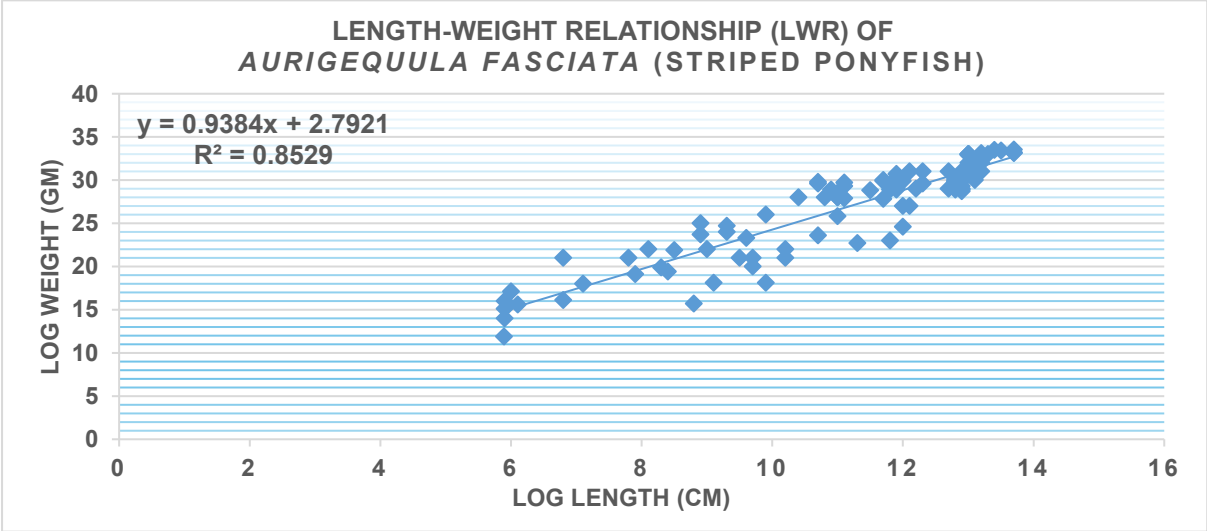
history, this association offers valuable insights for effective population management and conservation techniques in fisheries research [29-30]. By providing basic details on seven pony fish and slip-mouth species, the current study lays a helpful foundation for future biological research in fisheries science. This information aids in the effective conservation and management strategy for the live pony and slipmouth fishes and fish resources in the Sundarbans estuarine sectors which is the one of the largest fish production and fish catchment province of India and also these species are highly demanded commercially and provide economic support in different sectors of the seas food industries along with the addition of a plethora of other biological traits. Further research is needed to assess the quantity of other fish stocks in the surrounding area to conserve the chosen habitat.

3.2 Condition Factor (K) of Pony and Slip mouths

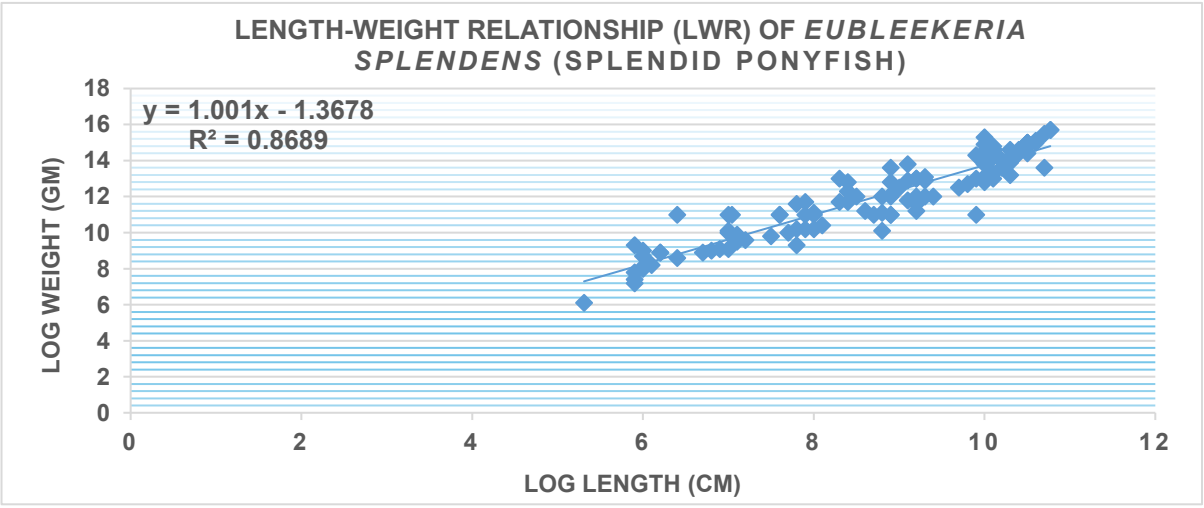
For this current research, seven species of Pony and slipmouth, the Fulton's condition factor (K) was as follows: *D. insidiator* (K=0.9981), *A. fasciata* (K=1.003), *E. splendens* (K=1.002), *G. minuta* (K=1.002), *K. dussumieri* (K=0.9189), *L. equula* (K=1.003), and *P. bindus* (K=1.78), with a range of 0.979 to 1.78 and an average Fulton's condition factor (K) of seven species estimated that 1.109 that is a good indication of suitable ecological habitat of that an indicator of fish health or condition, the Fulton's condition factor is calculated using the condition factor (K) unit. The value of K larger than 1 was obtained from the condition factor analysis for each length group in the current study. Thus, it may be concluded that the suggested fish species is a good fit for the environment. This implies that the fish and its environment are doing well. The K value depends on several factors, including fish size, sex, season, and the level of gonadal development. Parasitism, food availability, and ecological factors all have a significant effect on the health of the fish. The samples appeared to be in good health based on the length-weight association. Further studies are needed to assess the abundance of different fish stocks about their conditions to preserve the selected environment.



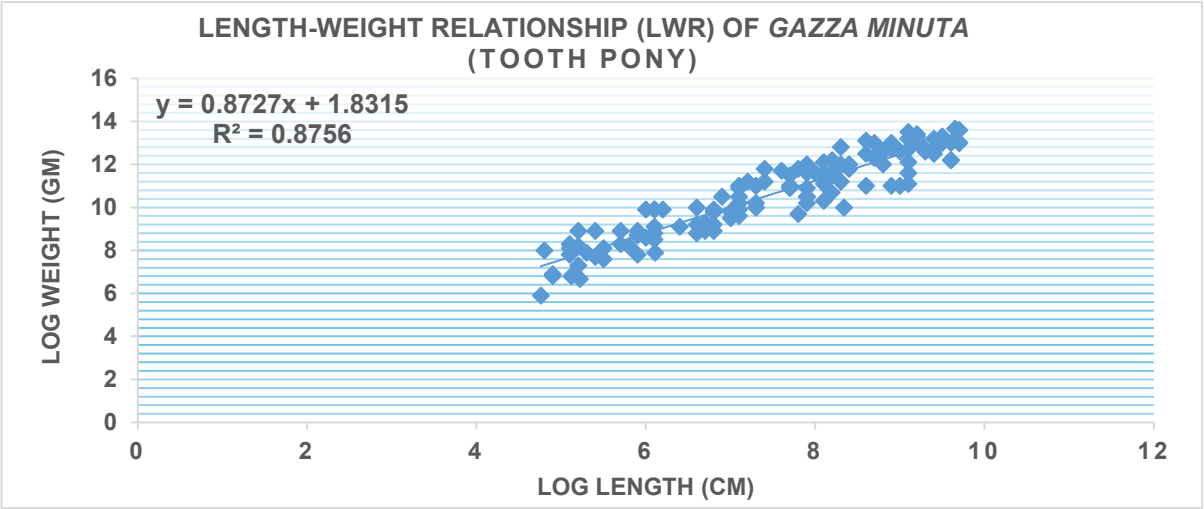
217 **Fig. 2. Scatter Graph plot between Log TL and Log TW of *Deveximentum insidiator* (Bloch, 1787)**



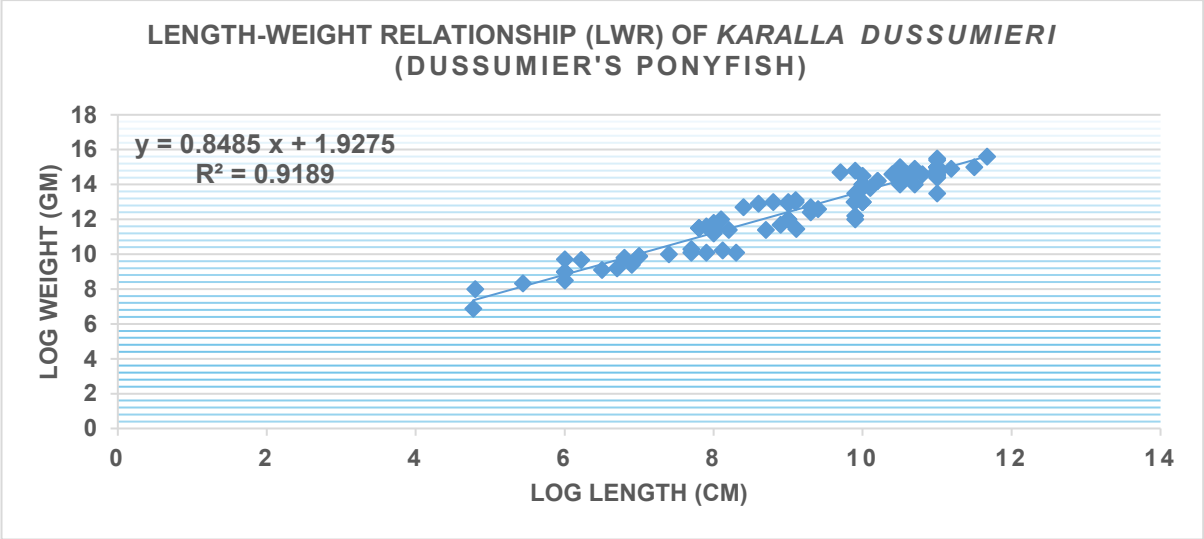
218 **Fig. 3. Scatter Graph plot between Log TL and Log TW of *Aurigequula facsciata* (Lacepède,**
219 **1803)**



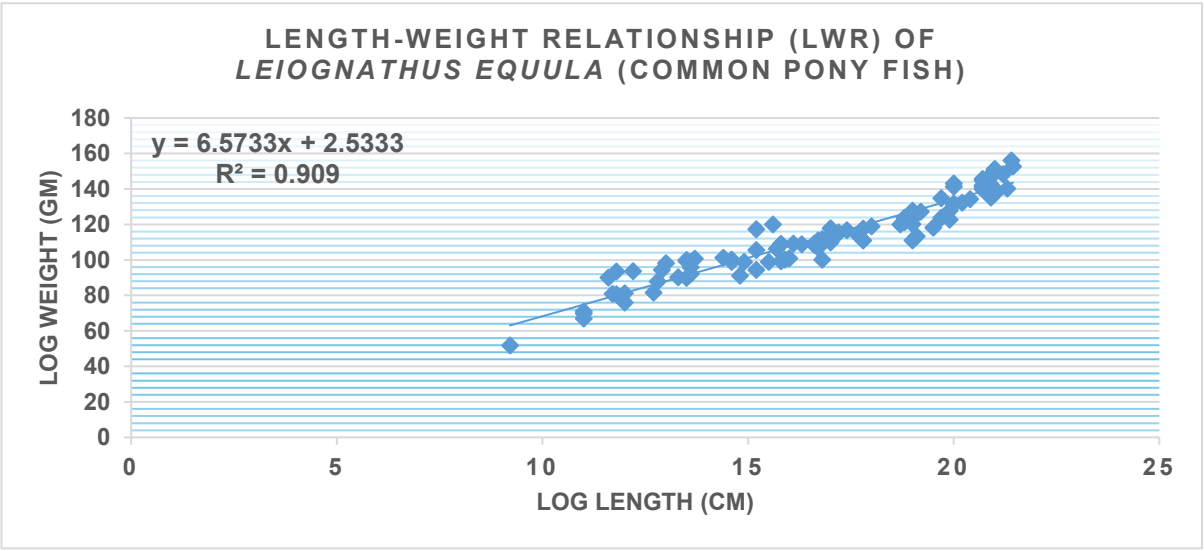
220 **Fig. 4 . Scatter Graph plot between Log TL and Log TW of *Eubleekeria splendens* (Cuvier,**
221 **1829)**



222 **Fig. 5 . Scatter Graph plot between Log TL and Log TW of *Gazza minuta* (Bloch, 1795)**



223 **Fig. 6. Scatter Graph plot between Log TL and Log TW of *Karalla dussumieri* (Valenciennes,**
224 **1835)**



225 **Fig. 7. Scatter Graph plot between Log TL and Log TW of *Leiognathus equula* (Forsskål, 1775)**

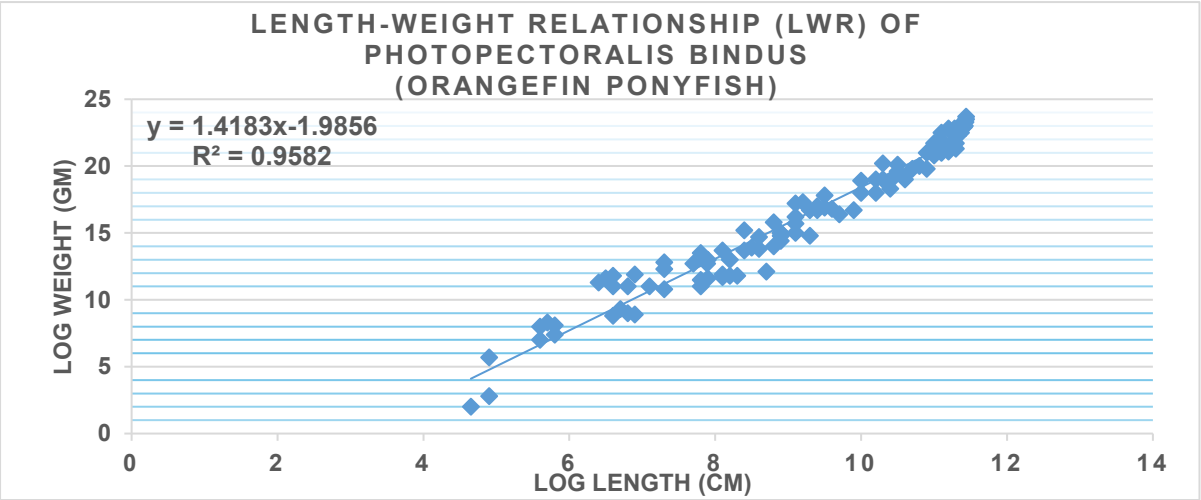


Fig. 8. Scatter Graph plot between Log TL and Log TW of *Photopectoralis bindus* (Valenciennes, 1835)

4. CONCLUSION

With a focus on length, weight, and condition parameters, the comprehensive study of seven Pony and Slip-mouth fish species—a total of n=821—in this mangrove zone from the Sundarban delta estuarine mouth of the Bay of Bengal in West Bengal, the first LWR in this particular Leiognathidae family, has helped to illuminate the morphometric differences between the species under investigation and offered insight into their overall health and welfare. Important details regarding the growth habits and size distribution of these fish species have been revealed by analyzing their length and weight characteristics. Furthermore, a comprehensive view of the general fitness and health state of the fish populations has been provided by the computation of condition variables. Aside from this, delta mangroves experienced atmospheric low pressure and high cyclones, which may be detrimental to aquatic life. This must be observed through frequent monitoring by government and non-governmental organizations involved in fisheries management. In order to preserve the delicate balance of the estuarine and marine ecology and guarantee the viability of the fisheries sector in the Sundarbans delta estuarine mouth near the Bay of Bengal and throughout India, these specifically important commercially edible fish species must be constantly tracked.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during the writing or editing of this manuscript.

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