Length-Weight relationship and Condition Factor of *Sardinella gibbosa* (Bleeker, 1849) from the North-West Coast of Sri Lanka

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Abstract: The present study aimed to determine the length-weight relationship and condition factor of *Sardinella gibbosa* (Bleeker, 1849) on the North-West coast of Sri Lanka. The samples were collected every month from three major fish landing centers between 2021-2023. The fish were caught in a small mesh (1.27 cm - 3.81 cm) gill net. The average weight of *S. gibbosa* ranged from 4.2 g to 28.1 g, with a mean of 15.77 g. The length ranged from 6.2 cm to 14.3 cm, with an average of 9.65 cm. The length-weight relationship, $W=aL^b$ and condition factor ($W *100/L^3$) are presented for the *S. gibbosa*. The length-weight relationship of the sardines collected from Chilaw, Negombo, and Puttalam sampling areas were $W=0.11328L^{2.085}$ ($R^2=0.7208$), $W=0.0927L^{2.3319}$ ($R^2=0.7667$), and $W=0.0926L^{2.3562}$ ($R^2=0.7586$), respectively. The condition factor ranged from 1.467 to 1.484 and the regression coefficient indicated negative allometric growth. The data obtained can be used as a baseline for future studies and valuable source for fisheries managers, biologists, and conservationists to save the fisheries resources.

Keywords: Length-weight relationship, *Sardinella gibbosa*, Condition factor, Allometric growth

1. INTRODUCTION

Fish is an essential source of high-nutrient protein and other essential nutrients required for human body development and growth making it a crucial factor in a nation's development (Sikoki, 1999). Fish generally grow in size (length, and weight) during development. The growth of fish is influenced by several factors such as, quantity of food available, number of fish utilizing the same food source, temperature, oxygen, and other water quality factors (Kuriakose, 2014). In addition to the size, the age and sexual maturity of the fish also play a crucial role in their growth.

The length-weight relationship is one of the common methods used for analyzing fisheries data and it also plays a vital role in the fishery biological investigation (Turker *et al*., 2018). It provides useful information on fish species according to the given geographic area (Aura *et al*., 2014). Fishery biologists have been mainly focused on two objectives in the study of the length-weight relationship in fishes. The first one provides a mathematical relationship between the two measurements (as a means of interconversion) and the second one is used to calculate the condition factor (Le Cren, 1951). The length-weight relationship is required for setting up yield equations and sometimes it may be useful as a character to differentiate "small taxonomic units". It also helps in converting one variable to another. Among these parameters, length is preferred for measurement due to its relative ease of determination and its potential for conversion into weight, which is the standard expression for catch quantity. The length-weight relationship also provides a means for finding out the "condition factor". The condition factor is an index reflecting the interaction between biotic and abiotic elements inside the physiological conditions of fishes. Therefore, the condition factor may also vary among fish species in different locations and different seasons (Blackwell *et al*., 2000).

Gold strip *Sardinella* (*Sardinella gibbosa*) belonging to the family Clupeidae is a commercially important small pelagic species. Small pelagic fishes account for about 58% of

the harvest from the coastal waters in Sri Lanka (Anonymous, 2021), with *S. gibbosa* being a significant contributor. They are native to shallow tropical water to 70 m depth. It can grow up to 17 cm and reaches its first maturity stage at 12.7 cm with a common length is 15 cm. However, studies have not been done on the length-weight relationship of *S. gibbosa* from the North-West coast of Sri Lanka. Therefore, the present study was undertaken to examine the size distribution, length-weight relationship parameters and relative condition of *S. gibbosa* from the North-West coast of Sri Lanka.

2. MATERIALS AND METHODS

2.1 Study Area

Fish samples were randomly collected at three landing centers situated along the North-West coast of Sri Lanka, from September 2021 to February 2023. The three collection centers were the Negombo fish landing center (7° 12' 36.8388" N and 79° 49' 52.536" E.), Chilaw fish landing center (7° 33' 43.1604" N and 79° 48' 5.9652" E), and Periya karakkapane fish landing center (8° 02' 10.32" N and 79° 49' 41.88" E) in the Puttalam district (Fig 1).

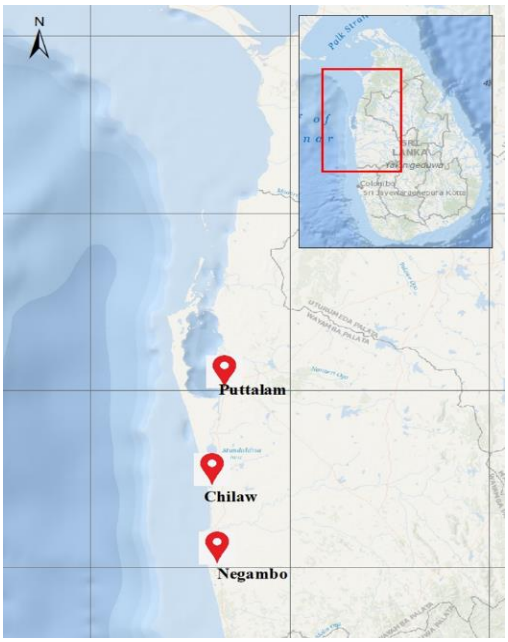

Figure 1: Study area showing the sampling sites in the North-West Coast of Sri Lanka (Puttalam, Chilaw and Negombo). (www.google.com/maps)

2.2 Sampling

The fish were caught by fishermen using the small mesh gill net. Once samples brought to the landing centers, samples were taken and kept in an ice box until they could be transported to the laboratory. In years 2021, 2022 and 2023 respectively 1200, 3600 and 600 samples were collected. The total length of each fish specimen of the *S. gibbosa* was measured from the anterior-most edge of the lower lip (tip of snout) to the posterior-most edge of the caudal fin to the nearest mm using a measuring board (Fafioye and Oluajo, 2005). Weight (W) was measured to the nearest 0.1 g using an electronic balance (SF-400 Electronic balance) after draining the water from the buccal cavity and wiping the moisture content on the body of fish (King, 1996). Any fish whose caudal fins were damaged were discarded. Altogether, total length-weight data of 5400 fish comprising both sexes were measured in the present study.

2.3 Length-weight relationship

The length-weight relationship of sampled fish species was calculated using the following equation (Roul *et al*., 2020).

$$W = aL^b$$

Where W is the weight of the sample (g), L is the length of the fish (cm), a is an intercept / initial growth coefficient or condition factor and b is the slope or growth coefficient (fish relative growth rate). The values of constants "b" and "a" were estimated after the logarithmic conversion of equation $W= aL^b$ (Le Cren, 1951)

$$logW = log\, a + b\, log\, L$$

The condition factor was calculated according to the following formula. Where K is the condition factor, L is the total length (cm) and W is the weight of the sample (g) (Pauly, 1983).

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

3. RESULTS AND DISCUSSION

The present research aims to investigate the length-weight relationship and condition factor of *Sardinella gibbosa* from the north-west coast of Sri Lanka. Specifically, it seeks to determine the relationship between the length and weight of *S. gibbosa* and assess the condition factor of *S. gibbosa* in the study area.

The total length range of the fish samples collected from the Chilaw sampling area was 6.9 cm to 13.3 cm with a mean length of 9.4 ± 0.028 cm (mean ± SD) (Figure 2). Total length range of the fish samples collected from Negombo sampling area was 6.2 cm to 12.4 cm with the mean length of 9.6 ± 0.030 cm (mean ± SD) (Figure 3). Finally, samples collected from Puttalam landing center had a total length range of 6.9 cm to 14.3 cm with the mean length 9.5 ± 0.028 cm (mean ± SD) (Figure 4).

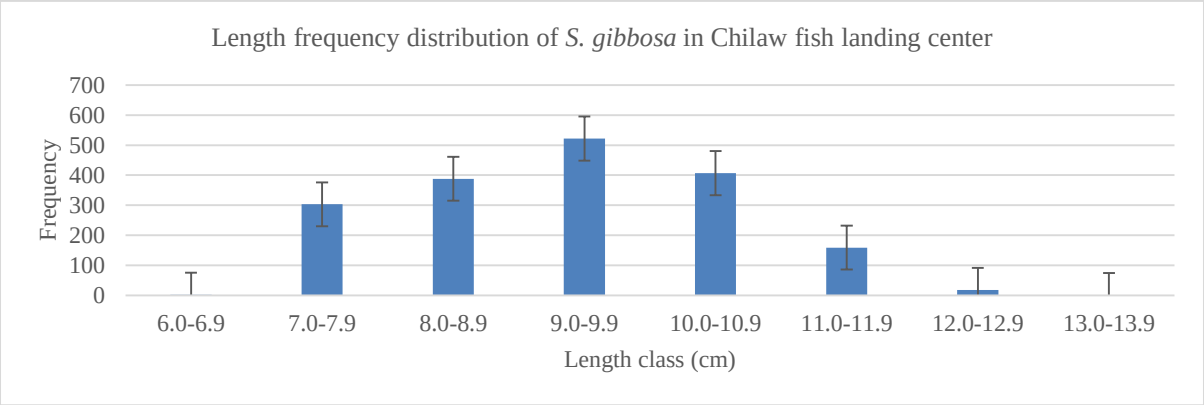

Figure 2: Length frequency distribution of *S. gibbosa* at Chilaw fish landing center

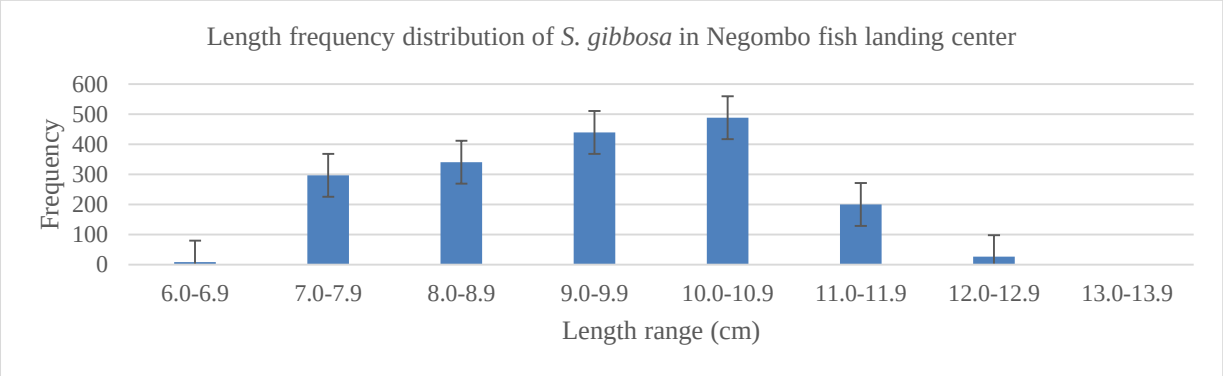

Figure 3: Length frequency distribution of *S. gibbosa* at Negombo fish landing center

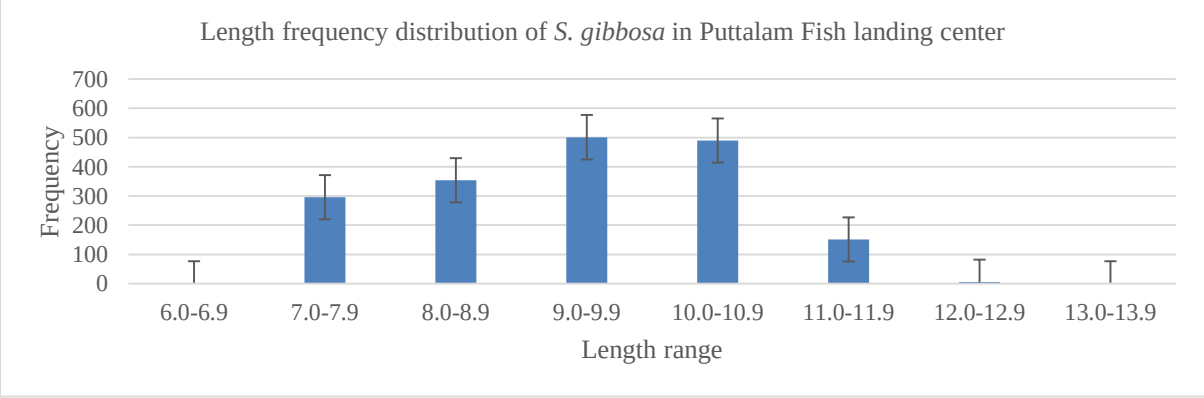

Figure 4: Length frequency distribution of *S. gibbosa* at Puttalam fish landing center

Table 1: Descriptive statistics and length-weight relationship parameters of *S. gibbosa*.

Site	N	Length(cm)		Weight(g)		Relationship parameters		
		Min	Max	Min	Max	a	b	R^2
Chilaw	1800	6.9	13.3	6.0	28.1	0.11328	2.085	0.7208
Negombo	1800	6.2	12.4	4.0	27.1	0.0927	2.3319	0.7667
Puttalam	1800	6.9	14.3	4.2	25.2	0.0926	2.3562	0.7586

N: - number of specimens examined, a: intercept of relationship, b: slope of relationship, R^2: coefficient of determination

Table 2: The parameters of length-weight relationship of sardines from different regions of the world

Species	Sex	R^2	a	b	Region	Growth pattern	Source
Goldstripe *Sardinella*	Both	0.8629	0.00823	2.7972	Ham Thuam Nam District	Negative Allometric	(Nam *et al*., 2016)
Sardinella longiceps	Both	0.819	0.0179	2.858	Pakistan	Negative Allometric	(Nadeem *et al*., 2017)
Sardinella longiceps	Both	0.87	0.0036	3.15-3.36	Sultanate of Oman	Positive Allometric	(Dutta *et al*., 2021)
Sardinella longiceps	Male	0.90	0.00823	3.0	South Eastern Arabian Sea	Isometric	(Rajesh *et al*., 2019)
	Female	0.91	0.00614	3.1		Positive Allometric	
	Both	0.90	0.00695	3.1		Positive Allometric	
Sardines	Male	0.5820	0.0425	2.3707	Middle Adriatic Sea	Negative Allometric	(Mustac and Sinovcic, 2010)
	Female	0.7329	0.0342	2.4645		Negative Allometric	

The weight range of the fish samples collected from three different areas Chilaw, Negombo, and Puttalam were recorded in the present study. In Chilaw, the weight range was between 6.0 g to 28.1 g with a mean weight of 12.2 ± 0.095 g cm (mean ± SD). In Negombo, the weight range was 4.0 g to 27.1 g with a mean weight of =13.1 ± 0.106 g (mean ± SD). The weight range of the fish samples collected from the Puttalam sampling area was 4.2 g to 25.2 g with a mean weight of 12.5 ± 0.096 g (mean ± SD). This is confirmed by the previous studies. The highest total length was 20.5 cm and the weight was 87 g while the lowest length was 13.5 cm and the lowest weight was 35 g (Elahi and Tabassum, 2013). Subsequent research, it was observed that the total length of the sardines ranged from 13.0 to 19.0 cm and the weight ranged from 16.72 to 51.45 g (Mustac and Sinovcic, 2010). Similar results were recorded by Nam, Phuong and Huon, (2016), that the length range of the *S. gibbosa* was recorded from 10.7 cm to 17.0 cm and the weight ranged from 10 g to 41 g (Nam *et al*., 2016).

In the present study, the highest recorded length in the Puttalam sampling area was 14.3 cm, while the highest weight was recorded in the Chilaw sampling area at 28.1 g. The lowest recorded length was 6.2 cm and the lowest weight was 4.0g, both of which were found in the Negombo sampling area.

The “b” value determines the pattern of growth in fishes. If the “b” value is equal to 3 it represents isometric growth and if the value is higher than 3, it is positive allometric growth and if the b value is less than 3, it is negative allometric growth. The “b” values obtained for both sexes of *S. gibbosa* were tested by student t-test to see whether the “b” values differed significantly from 3 or not (Zar, 1984).

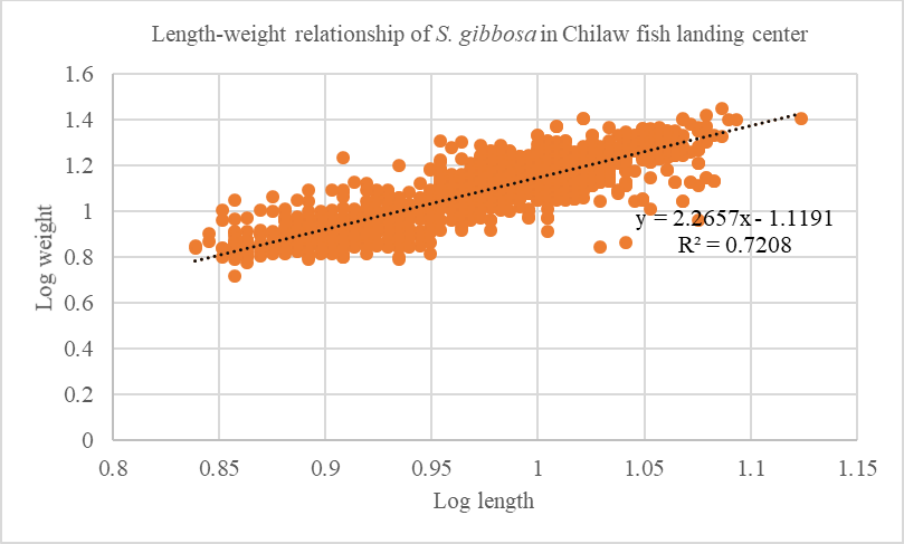

Figure 5: Length-weight relationship of *S. gibbosa* in Chilaw fish landing center

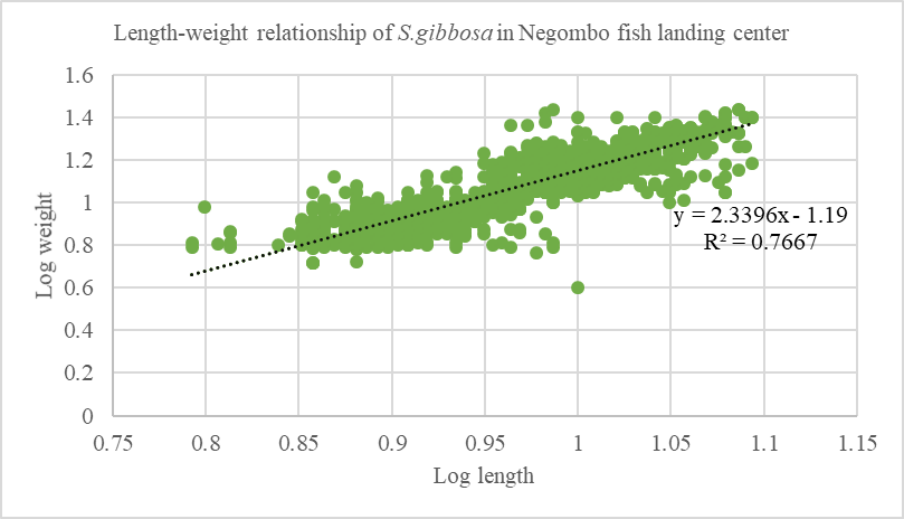

Figure 6: Length-weight relationship of *S. gibbosa* in Negombo fish landing center

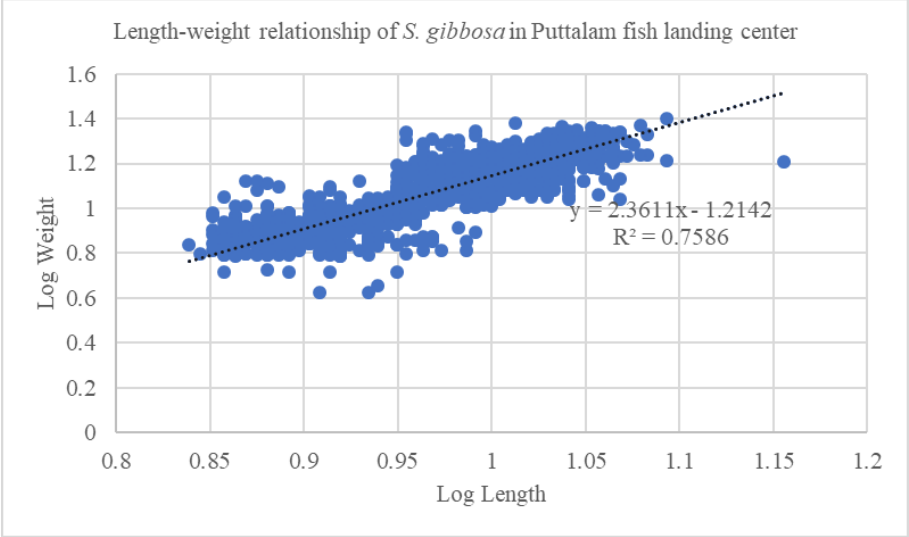

Figure 7: Length-weight relationship of *S. gibbosa* in Puttalam fish landing center.

In the present study, negative allometric growth was observed for *S. gibbosa* collected from three sampling sites (Chilaw = 2.085, Negombo =2.3319, and Puttalam = 2.3562). It is in agreement with the previous studies made in different locations. Several authors observed both positive and negative allometric growth for different sardine species fromvarious water bodies during their study periods. The parameters of length-weight relationship of sardines estimated by various authors from different regions of the world are summarized in Table 2.

A negative allometric growth was observed in a study conducted by Mustac and Sinovcic (2010), where the derived regression parameters were found to be negative. Similarly, in a study conducted by Nam *et al*, (2016), a negative allometric growth was reported for goldstrip *Sardinella*, with a growth coefficient (b) of 2.7972. The Indian oil sardine exhibited both positive and negative allometric growth between 2005 to 2009 (Dutta *et al*., 2021). The study of Mustac and Sinovcic (2010) identified negative allometric growth (b for male = 2.3707 and b for female = 2.4645). Earlier studies on sardines in the mid-Adriatic Sea and north Adriatic showed negative allometric growth (In Mid Adriatic b = 2.851 and in North Adriatic b = 2.757) (Sinovcic, 2000; Alegria, 1983). Safran (1992) and Koutrakis and Tsikliras (2003) reported negative allometric growth for sardine species from the Ionian Sea (Safran, 1992; Koutrakis and Tsikliras, 2003).

Water temperature, salinity level, fish physiology, growth phase, sex, season, stomach fullness, length range and sampling size, habitat, feeding rate, diet, health and food availability can affect the growth coefficient (Le Cren, 1951; Mondol *et al*., 2017 and Mustac and Sinovcic, 2010) and changes of the maturity stages can also affect the growth coefficient (Weatherlay and Gill, 1987).

Table 1 and, Figures 5, 6 and 7 illustrate the length-weight relationship of *S. gibbosa* in three different landing centers in North West coast of Sri Lanka. According to the length-weight relationship parameters, it was found that the coefficient of determination was high in Negombo sampling area, indicating the best fit. The correlation coefficients (r) of *S. gibbosa* were reported as 0.8790 in the Chilaw sampling areas, 0.8952 in the Negombo area, and 0.8805 Puttalam area. Correlation for all three landing sites was highly significant ($p<0.001$). Therefore, it can be expressed that *S. gibbosa* has a good correlation between length and weight.

The value of "a" in the length-weight relationship is often used as an index of 'condition', 'fatness' or 'well-being' for the fish (Bagenal and Tesch, 1978). The condition factor or ponderal index is often used for understanding the changes in weight for length assuming that the length-weight relationship obeys the cube law. The more a fish weighs for a given length, the greater will be its condition factor. An alternative is a condition factor that compares the mean weight of fish in a sample with the predicted weight of fish from a generalized length-weight relationship.

Table 3: The condition factor of *S. gibbosa*

Site	N	Condition factor(K)
Chilaw	1800	1.484±0.006
Negombo	1800	1.467±0.007
Puttalam	1800	1.468±0.007

N - number of specimens examined

The condition of the fish is a common metric for determining its health, survival, reproduction and maturity (Le Cren, 1951). It is a good indicator for measuring the overall health or water quality of fish populations in specific habitats or ecosystems. The condition factor of one or above indicates that the fish is in good condition. If the value is less than one, it can be expressed that the fish is not in good condition (Dutta *et al*., 2021). In the present study, Table 3 shows condition factor obtained in the present study and it was observed that in all sampling sites condition factor was higher than 1. It indicates that the fish were in good condition and

environmental conditions are feasible for the growth of *S. gibbosa* (Ujjania and Soni, 2017).

Elhi and Tabasum (2013) estimated that the condition factor of the Indian oil sardine from the Baluchistan coast was 1.09 and they were in good condition (Elahi and Tabassum, 2013). The study by Mustac and Sinovcic, (2010) estimated that the condition factor showed greater values in Sardine samples from inshore waters (K= 0.8205) than the offshore waters (K= 0.7317) (Mustac and Sinovcic, 2010).

4. CONCLUSION

Ultimately, the study on the length-weight relationship and condition factor of *S. gibbosa* from the northwest coast of Sri Lanka provides valuable insights into the species biology and health in this specific region. The observed relationship between length and weight contributes to our understanding of the fish's growth patterns and additionally, the condition factor offers important information about the overall well-being of *S. gibbosa* in the study area. The correlation coefficient for all three landing sites was highly significant, and it can be expressed that *S. gibbosa* has a good correlation between length and weight.

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6. AUTHORS CONTRIBUTION

P.M.R. Chanaka Supun Bandara Pallemulla - Fieldwork, data recording, original draft, writing, Conceptualization, methodology, visualization
Sivashanthini Kuganathan – Writing, review and editing, referencing, visualization
Jorge Santos - Review, Investigation, Validation
Prabath Jayasinghe - Review, Investigation, Validation

7. REFERENCES

[1]. Alegria, V.H., (1983). A comparison of the length-weight relationship in sardine (*Sardina pilchardus*,Walbaum, 1792) from the northern and central Adriatic fishing grounds. *Rapp commint mer medit*. pp 25-26.

[2]. Anonymous., (2021). Fisheries Statistics 2020. Ministry of Fisheries, Colombo. 1-70.

[3]. Aura, C.M., Anam, R.O., Musa, S. and Kimani, E., (2014). Length-weight relationship and condition Factor (K constant) of *Dentex maroccanus*, Valenciennes 1830 (Family Sparidae) at Malindi, Kenya. *Western Indian Ocean,* 12(1), 79-83.

[4]. Bagenal, J.B. and Tesch, F.W., (1978). Methods for assessment of fish production in freshwaters. *Blackwell Scientific Publication, London*. pp 361.

[5]. Blackwell, B.G., Brown, M.L. and Willis, D.W., (2000). Relative weight (Wr), status and current use in fisheries assessment and management. *Reviews in Fisheries Science,* 8(1), 1-44.

[6]. Dutta, S., Al Jufaili, S.M. and Al Anbouri, I.S., (2021). Length-weight relationships and condition factors of *Sardinella longiceps* (Valenciennes, 1847) from Seeb, Sultanate of Oman. *Indian Journal of Geo- Marine Sciences,* 50(12), 1052-1057.

[7]. Elahi, N. and Tabassum, S., (2013). Seasonal variation in length-weight relationship and relative condition of *Sardinella gibbosa* of Balochistan coast. *Pakistan Journal of Marine Sciences*, 22(1), 15-21.

[8]. Fafioye, O.O. and Oluajo O.A., (2005). Length-weight relationships of five fish species in Epe lagoon, Nigeria. *African Journal of Biotechnology*, 4(7), 749-751.

[9]. King, R.P., (1996). Length-weight relationships of Nigerian coastal water Fishes. *ICLARM*. 53-58.

[10]. Koutrakis, E.T. and Tsikliras, A.C., (2003). Length-weight relationship of fishes from three northern Aegean estuarine systems (Greece). *Journal of Applied Ichthyology*, 19, 285-260.

[11]. Kuriakose, S., (2014). Estimation of Length weight relationship in fishes, Training Manual on Fish Stock Assessment and Management. *Central Marine Fisheries Institute, Kochi*, pp 150.

[12]. Le Cren., (1951). The Length-weight relationship and seasonal cycle in gonad weight and condition inperch, *Perca fluviatile*. *Journal of Animal Ecology*, 20, 201-219.

[13]. Mondol, M.R., Hossen, M.A. and Nahar, D.A., (2017). Length-weight relationships of three fish species from the Bay of Bengal, Bangladesh. *Journal of Applied Ichthyology*.

[14]. Mustac, B. and Sinovcic, G., (2010). Reproduction, length-weight relationship and condition of sardine, *Sardina pilchardus* (Walbaum, 1792), in the eastern Middle Adriatic Sea (Croatia). *Periodicum Biologorum*, 112(2), 133-138.

[15]. Nadeem, A., Kalhoro, M.A., Buzdar, M.A., Tariq, S., Shafi, M., Afzaal, Z. and Saeed, F., (2017). Growth, mortality and exploitation rate of *Sardinelle longiceps* from Pakistani waters based on Length frequency distribution data. *Indian Journal of Geo marine sciences,* 46(8),1693-1703.

[16]. Nam, N.T., Phuong, N.A. and Huan, N.X., (2016). Biological Characteristics of Goldstripe Sardinella *Sardinella gibbosa* (Bleeker, 1849) in the Nearshore Area of Ham Thuan Nam District, Binh Thuan Province. *VNU Journal of Science,* 32(1), 96-102.

[17]. Pauly, D., (1983). Some simple methods for the assessment of tropical fish stocks. *FAO Journal*, 234, 1-52.

[18]. Rajesh, K.M., Rohit, P. and Roul, S.K., (2019). Length-weight relationships (LWRs) of fourteen marine pelagic fish species in the Southeastern Arabian Sea. *International Journal of Marine Sciences*, 36, 371-374.

[19]. Roul, S.K., Akhil, A.R., Retheesh, T.B., Rajesh, K.M., Ganga, U., Abdussamad, E.M. and Rohit, P., (2020). Length-weight relationships of fifty fish species from Indian Waters. *International Journal of Marine Sciences*, 36, 309-314.

[20]. Safran, P., (1992). Theoretical analysis of the length-weight relationships in fish juveniles. *Marine Biology,* 112, 545-551.

[21]. Sikoki, F.D. and Ebiegberi, J.A., (1999). The Land People of Bayelsa State Central Niger Delta. In The land and people of Bayelsa State: central Niger delta. *Onyoma Research Publications*. pp 301-319.

[22]. Sinovcic, G., (2000). Responsible exploitation of the sardine, *Sardina pilchardus* (Walb.), population in the coastal region of the eastern Adriatic. *Periodicum Biologorum,* 102, 47-54.

[23]. Turker, D., Zengin, K. and Tuney, O.K., (2018). Length-weight relationships for nine Chondrichthyes fish species from Edremit Bay (North Aegean Sea). *Turkish Journal of Fisheries and Aquatic Sciences*, 19(1), 71-79.

[24]. Ujjania, N.C. and Soni, N., (2017). Length-weight relationship and condition factor of Indian major carps of Vallabhsagar Reservoir, Gujarat, India. *Indian Journal of Fisheries,* 64(1), 186-189.

[25]. Weatherley, A.H. and Gill, H.S., (1987). The Biology of fish growth - Hardcover. *Academic Press, London.*

[26]. Zar, J.H., (1984). Biostatistical analysis second edition. *Northerly Illinois University, New Jersey*.