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Length-weight relationship of *Terapon puta* (Cuvier, 1829) from Puducherry waters

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Abstract
The present study investigates the length-weight relationship of *Terapon puta* from Puducherry (East coast of India). A total of 485 individuals of different sizes were collected from Puducherry landings centre. Length-weight relationships were calculated for all fish samples. The length weight relationship equations are $W = 0.1313\ L^{1.9890}$; $W = 0.5091\ L^{1.5078}$; $W=0.6090\ L^{1.4752}$; $W = 0.1332\ L^{2.0543}$; $W = 0.1207\ L^{2.0246}$; $W = 0.0841\ L^{2.2074}$ for immature male, immature female, matured male, matured female, total male and total female respectively. The growth exponential (b) values were found to be negatively allometric for all the stages.

Keywords: Length-weight relationship, *Terapon puta,* Allometry, Puducherry waters.

1. Introduction
Aquaculture is one of the developing subjects with reference to brackish water concern. Yet it is to be developed in large scale because of large number of fishes present in both marine as in well as in freshwater systems. In relation to this, biology of all fishes and its adaptation to the different environmental aspects should be known. The length-weight relationships (LWR) are significantly important in fisheries science. In fact, these data become one of the standard methods employed in fishery biology. This information is required for the estimation of weight, where only length data is available and vice versa. Le Cren [1] had suggested that the length - weight relationship is calculated to determine the mathematical relation between the two variables i.e., length and weight, in which if one variable is known, another can be computed. Further it is also used to measure the variations from the expected weight from the length of individual or group fishes as inaction of fatness [2]. These parameters are often used to calculate standard stock biomass, condition indices, ontogenetic changes and other aspects of fish population dynamics. However, the growth parameters estimated for LWR can diverge substantially from true estimates of the population parameters if the sampling designs are inadequate [3].
The application of LWR includes estimation of the mean weight of fish of a given body length and, conversion of the length-growth model to corresponding weight growth model. Antony [4] had reported that the basic information on LWR is of a great importance, but often it is not available or insufficient for a particular species. The studies of LWR for fish resources of India, other than commercial fishes, are limited and the present study is focused on compensating the gap of information in this area. The length-weight relationship of *Terapon puta* has not been studied previously in Puducherry waters. The data of LWR will be very useful for assessment of their maturity, growth and production. Hence, the present study of the length-weight relationship of *Terapon puta* were performed with the objective that whether any differences exists in both the sexes of these species.
The length-weight relationship may give an idea about the variations from the expected weight for a particular length of fish or fish population based on fatness, general wellbeing or gonad development [5]. It also helps to evaluate the condition, reproductive history, life cycle and the general health of fish [6] besides useful in local and interregional morphological and life historical comparisons among fish population. The relationships of fish were originally used to provide information on the condition of fish and to determine whether somatic growth was isometric or allometric [1, 7]. Its importance is pronounced in estimating the average weight at a given length group [8] and in assessing the relative well-being of a fish population [9].

Length-weight regressions have been used frequently to estimate weight from length because direct weight measurement can be time consuming in the field [10]. In fishery biology, length-weight relationships are useful for the conversion of growth-in-length equations to growth-in-weight or use in stock assessment models and to estimate stocks biomass from limited sample sizes [11]. Establishment of a relationship between weight and length is essential for the calculation of production and biomass of a fish population [12-14] and also morphological comparisons among species and among population of the same species from different habitats and/or regions [14].

Length-weight relationships are extensively used in fisheries research and are useful for (1) calculating the weight of a given individual fish of known length or total weight of fish from length-frequency distribution; (2) estimating age structure, weight growth rate and several other aspects of fish population dynamics; (3) converting growth-in-length equations to growth-in-weight equations for use in stock assessment models; (4) estimating indices of condition of fish in a given geographical area; (5) making between region comparisons of life histories and morphology of certain species [15-19].

Seasonal variability of length-weight and physiological condition related to feeding and reproduction has been observed in many fish species inhabiting temperate ecosystems [20-22]. The seasonal variations of growth in fishes in relation to size attained by the individual fish may vary because of variations in food supply, availability of food and these in turn may reflect variations in climatic parameters and in the supply of nutrients or in the degree of competition for food. Thus, a change in size through a certain period of time may indicate a change in average age resulting from those factors. Length at weight data can notably provide important clues to climatic and environmental changes and the change in human subsistence practices [23, 24].

The present study was carried out to understand the length weight relationship of male and female *Terapon puta* for different maturity stages from Puducherry coast. This information provides the comprehensive report on the length weight relationship of *Terapon puta* in this region.

2. Materials and Methods

A total of 250 male and 235 female of *Terapon puta* were collected from Nallavadu fish landing centre, Puducherry from July 2008 to June 2010 for the determination of length and weight. The collected fishes were carried immediately to the laboratory. After thorough wash with tap water the total length of each fish was measured with a measuring scale to the nearest millimeters and the body weight in grams by an electronic balance. Excess water from the fishes was removed with blotting paper before measuring the weight of the fishes.

The log transformed data of the total length and total weight of all specimens were used to calculate the length-weight relationship. The length-weight relationship was calculated by the least square method applying the Le Cren [1] formula

$W = a L^b$ or its logarithmic form, $\log W = \log a + b \log L$

Where,

W is the weight of the fish in grams
L is the length of the fish in cm
'a' and 'b' are Constants

The constants 'a' and 'b' were estimated using the method of least square and the linear equation was fitted separately for male and female. The co-efficient of determination (r^2) was used as an indicator of the quality of the linear regression provided by the value of 'b'. SPSS software package was used for all statistical analysis.

3. Results

3.1. Length-Weight frequency distribution of *Terapon puta*

Among the 485 individuals of *Terapon puta* collected for the present study, the total length of immature male ranged from 11.80 cm to 20.20 cm (mean 15.12±1.41) and that of weight is ranged from 15.72g to 68.14g (mean 29.99±8.73). The total length of immature female varied from 12.40 cm to 17.70 cm (mean 14.58±1.16) and that of weight ranged from 15.77g to 62.10g (mean 30.04±9.30). The total length of matured male varied from 13.90 cm to 19.00 cm (mean 16.37±1.54) and that of weight ranged from 22.56g to 55.34g (mean 38.65±10.10). The total length of matured female varied from 12.50 cm to 21.90 cm (mean 16.61±1.96) and that of weight ranged from 13.16g to 78.43g (mean 44.55±14.20). The total length of overall male varied from 11.80 cm to 20.20 cm (mean 15.28±1.49) and that of weight ranged from 15.72g to 68.14g (mean 31.09±9.36)The total length of overall female varied from 12.40 cm to 21.90 cm (mean 15.99±1.99) and that of weight ranged from 13.16g to 78.43g (mean 40.11±14.52) (Table-01).

Table 1: Estimated parameters of Length-Weight relationship of Mean, Standard variation, minimum and maximum between male and female *Terapon puta* during July 2008 - June 2010

Sexes	Stages	Number of Samples	Length of fish				Weight of fish			
			Mean	S.D	Mini	Maxi	Mean	S.D	Mini	Maxi
Male	Immature	218	15.12	1.41	11.80	20.20	29.99	8.73	15.72	68.14
	Matured	32	16.37	1.54	13.90	19.00	38.65	10.10	22.56	55.34
	Total	250	15.28	1.49	11.80	20.20	31.10	9.36	15.72	68.14
Female	Immature	72	14.58	1.16	12.40	17.70	30.04	9.30	15.77	62.10
	Matured	163	16.61	1.96	12.50	21.90	44.56	14.20	13.16	78.43
	Total	235	15.99	1.99	12.40	21.90	40.11	14.52	13.16	78.43

3.2. Length-Weight relationship of *Terapon puta*

The length-weight relationship, regression parameters and significance of correlation of *Terapon puta* were shown in table-02. The estimates of length-weight equation were calculated separately for immature male and female, matured male and female, total male and female. When the empirical values of length were plotted against their respect weight on an arithmetic scale, smooth curves were obtained by LWR

regression analysis (Fig. 01 - Fig. 06). In the present study, the 'b' value of all stages indicated negative allometric growth, indicating that the increase in length is not proportionate to increase in weight. The observed 'b' values for immature male and female, matured male and female and total male and female were 1.989, 1.5078, 1.4752, 2.0543, 2.0246 and 2.2074, respectively. The computed length-weight relationship, logarithmic transformation, the respective correlation co-efficient and probability values are as follows.

Immature male	$W = 0.1313\ L^{1.9890}$
Immature female	$W = 0.5091\ L^{1.5078}$
Matured male	$W = 0.6090\ L^{1.4752}$
Matured female	$W = 0.1332\ L^{2.0543}$
Total male	$W = 0.1207\ L^{2.0246}$
Total female	$W = 0.0841\ L^{2.2074}$
	(or)
Immature male	$\log W = -0.8817 + 1.9890 \log L$
Immature female	$\log W = -0.2932 + 1.5078 \log L$
Matured male	$\log W = -0.2154 + 1.4752 \log L$
Matured female	$\log W = -0.8754 + 2.0543 \log L$
Total male	$\log W = -0.9182 + 2.0246 \log L$
Total female	$\log W = -1.0754 + 2.2074 \log L$

The probability value is found to be highly significant (p<0.01) indicating good linear correlation suggesting a good adjustment between length and weight. The present findings on the length-weight relationship of *Terapon puta* based on the regression coefficient (b) values were noticed in respect of all the stages are negatively allometric (b<3).

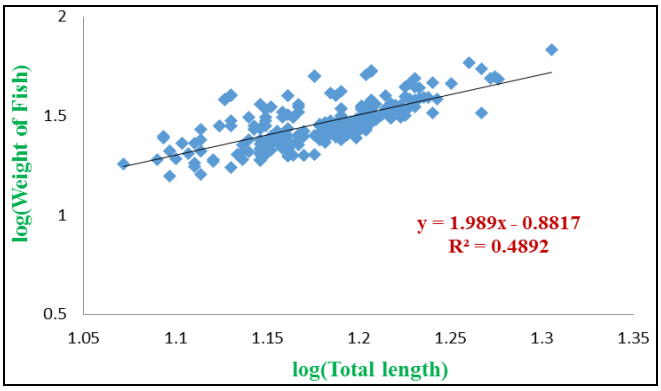

Fig 1: Logarithmic Length-weight relationship of immature male *Terapon puta*

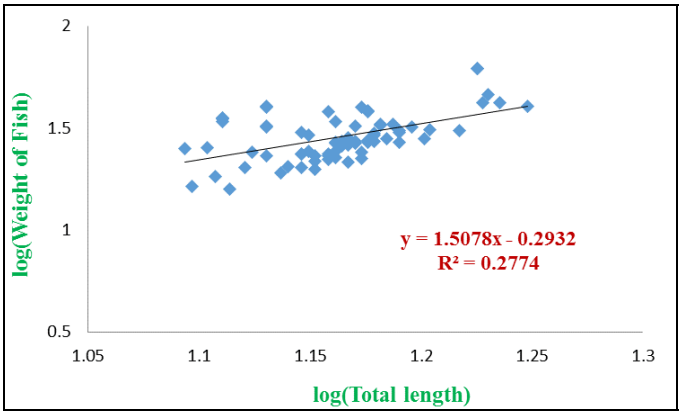

Fig 2: Logarithmic Length-weight relationship of immature female *Terapon puta*

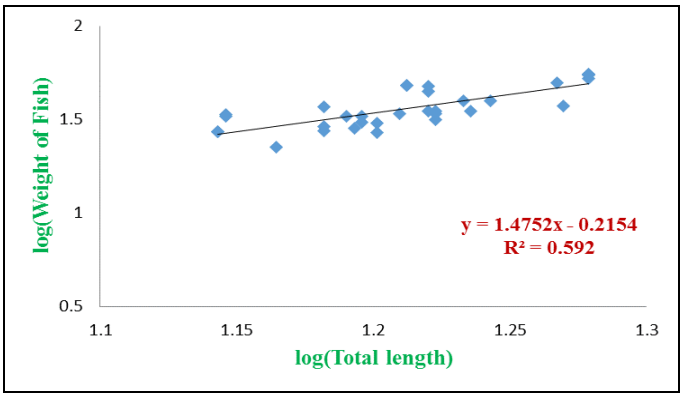

Fig 3: Logarithmic Length-weight relationship of matured male *Terapon puta*

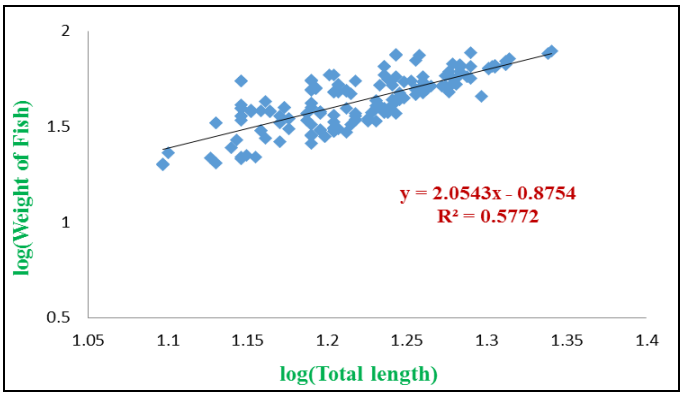

Fig 4: Logarithmic Length-weight relationship of matured female *Terapon puta*

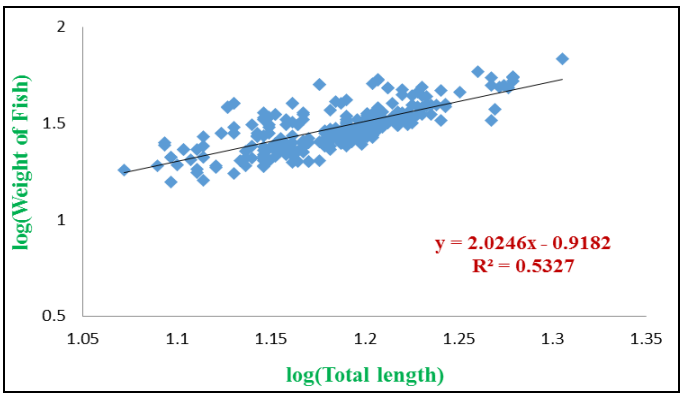

Fig 5: Logarithmic Length-weight relationship of total male *Terapon puta*

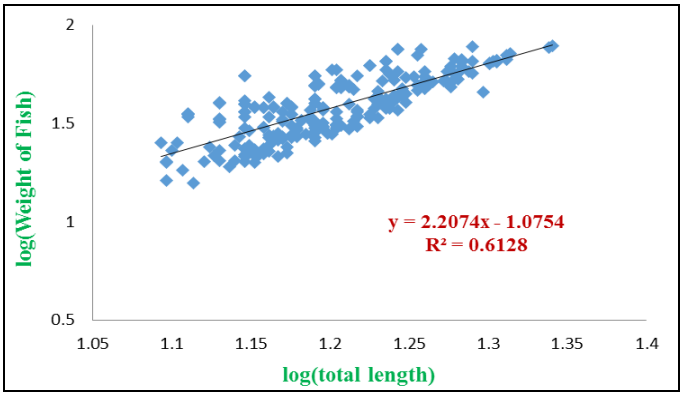

Fig 6: Logarithmic Length-weight relationship of total female *Terapon puta*

Table 2: Estimated parameters of Length-weight relationship and logarithmic length-weight relationship, Correlation and Regression coefficients and growth pattern between male and female *Terapon puta* during July 2008 - June 2010

Sexes	Stages	Length-weight relationship	Logarithmic Length-weight relationship	Reg. Const. 'a'	Reg. Const. 'b'	Correlation Coefficient (*r*)	Regression coefficient (R^2)	Growth pattern
Male	Immature	$W = 0.1313\ L^{1.9890}$	log W = - 0.8817 + 1.989 log L	0.1313	1.9890	0.668**	0.4892	NA
	Matured	$W = 0.6090\ L^{1.4752}$	log W = - 0.2154 + 1.4752 log L	0.6090	1.4752	0.531**	0.5920	NA
	Total	$W = 0.1207\ L^{2.0246}$	log W = - 0.9182 + 2.0246 log L	0.1207	2.0246	0.678**	0.5327	NA
Female	Immature	$W = 0.5091\ L^{1.5078}$	log W = - 0.2932 + 1.5078 log L	0.5091	1.5078	0.411**	0.2774	NA
	Matured	$W = 0.1332\ L^{2.0543}$	log W = - 0.8754 + 2.0543 log L	0.1332	2.0543	0.747**	0.5772	NA
	Total	$W = 0.0841\ L^{2.2074}$	log W = - 1.0754 + 2.2074 log L	0.0841	2.2074	0.763**	0.6128	NA

** Correlation significant at 0.01 levels, a: y-intercept, b: slope, r: correlation coefficient, NA: Negative Allometric

3.3. Prediction of the maximum length from Extreme values

The observed extreme length and predicted extreme length of male *Terapon puta* are 21 cm and 21.70 cm respectively. The range of this species is varied from 20.23 cm - 23.26 cm at 95% confidence level. The observed and predicted extreme lengths of female *Terapon puta* are 21 cm and 22.8 cm respectively. The range of this is from 21.30 cm - 24.31 cm at 95% confidence level (Table-3, Fig. 07 & Fig. 08)

Table 3. Maximum length estimation of *Terapon puta*

Species	Category	Observed Extreme length	Predicted Extreme length	Range at 95% Confidence interval
Terapon puta	Male	21	21.70	20.23 cm - 23.26 cm
	Female	21	22.80	21.30 cm - 24.31 cm

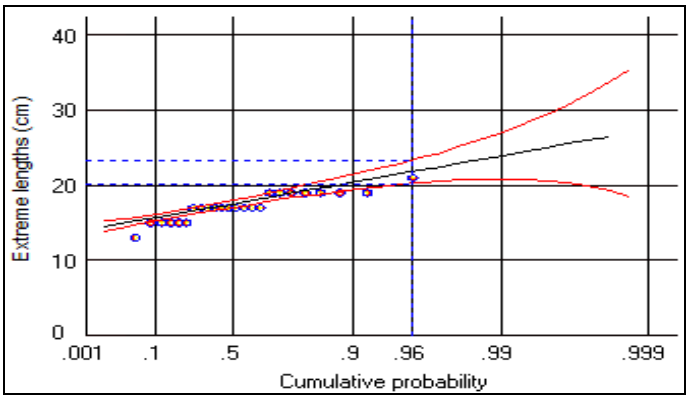

Fig 7: Facsimile representation of the resulting analysis of extreme values of male *Terapon puta*

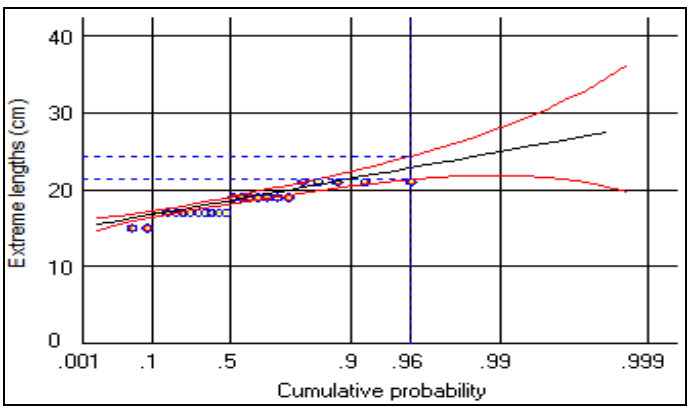

Fig 8: Facsimile representation of the resulting analysis of extreme values of female *Terapon puta*

4. Discussion

The present study on the length-weight relationship of *Terapon puta* from Puducherry coast has been studied. Length-weight relationship parameter of fishes is an important fishery management tool and it is very much useful for cultivators and fisheries managers to ascertain the growth of the species. In this study, an efficient sampling protocol was followed to include the widest possible ranges of length and weight, which were generally obtained with large samples and non-selective fishing techniques. The variation in fish sizes indicated that the fish populations ranged from immature specimens to fully mature once. Several works have been carried out on estimation of length-weight relationship in different fish species. Exponent of the arithmetic form and slope of the regression line in logarithmic form, 'b' is the most important parameter in LWR [25].

The reported exponent values of 'b' for different fishes ranged between 2.5 to 4.0 [26, 27] and 2.0 to 4.0 [28, 29]. If 'b = 3', then small specimens in the samples under consideration have the same form and condition as large specimens. If b > 3, then large specimens have increased in height or width more than in length, either as the result of a notable ontogenetic change in body shape with size, which is rare, or because most large specimens in the sample were thicker than small specimens, which is common. Conversely, if b < 3, then large specimens have changed the body shape to become more elongated or small specimens were in better nutritional condition at the time of sampling [25]. The allometric model seems to be the most appropriate for describing the LWR in fishes and applies to the vast majority of relationship and morphological characteristics with body length [30, 31, 32, 33, 34]. Though allometric calculations should not be considered optimally applicable to all metric comparisons, one must always examine its validity [35]. Based on the results of the present study, as well as of previous once [31, 32, 33, 34], it is also apparent that such relationship might reflect the effect of different factors such as habitat type and feeding habits.

In the present study, the calculated values of 'b' for length and weight of *Terapon puta* were lesser than 3. It was 1.989 for immature male, 1.5078 for immature female, 1.4752 for matured male, 2.0543 for matured female, 2.0246 for total male and 2.2074 for total female. The correlation coefficient was close to one suggesting a good adjustment between length and weight of *Terapon puta* which were of expected range and indicated that the growth is negative allometric (b < 3).

The significant differences of regression coefficient (b) from the negative allometric growth value in male and female *Terapon puta* indicate the general parabolic equation $W = a\ L^b$ express the length-weight relationship of this species. In consequence, current parameters can be used to derive weight

estimates from a given value of length or vice versa.

The earlier reports are in compliance with the present findings on the length-weight relationship of *Terapon puta*. The difference in slope (b) values have been reported by negative allometric growth in *Channa maurulius* [36, 37]. The negative allometric growth pattern have also been reported in *Channa punctatus* by Haniffa *et al.*, [38] and also Khan *et al*., [39] for the negative allometric growth in *Channa Striatus.* The inverse total length and body weight relationship showing the negative allometric patterns of growth are also reported *Channa linguatula* [16, 14, 40, 41]. The results are also comparable with the findings of Mossad [42] and Ibrahim *et al*., [43] for *Tilapia zillii* in brackish water with 'b' values of 2.9 and 2.92 respectively. The negative allometric growth was also reported by Bala *et al*., [44] for *Tilapia zillii* in fresh water with 'b' value of 2.91. As reported by Nikolsky [45] adequate feeding and gonad development increases body weight and 'b' values. Mitra and Naser [46] have found that higher metabolic activity with spawning season lowered the 'b' value while less metabolic activities, accumulation of fat and weight of gonads during the pre-spawning period increased the values.

5. Conclusion

This is the maiden and foremost report on the length-weight analysis of *Terapon puta* from India. The present study indicates the negative allometric growth of the fish. This is due to the food habit of the species. The correlation coefficient is close to one suggesting a good adjustment between length and weight of *Terapon puta.* This study is also supportive for the fishery managers to implement adequate adaptation-centric regulation for sustainable fisheries management of the species *Terapon puta*. The result of the study will be serviceable to the researchers and policy planners.

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