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Length-weight relationship and condition factor of grey mullet, *Mugil cephalus* Linnaeus, 1758 from pulicat lake, Tiruvallur (dt), Tamil Nadu

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Abstract
Study on Length Weight relationship and Condition factor of grey mullet *Mugil cephalus* Linnaeus, 1758 was conducted by collecting data from commercial landings of Pulicat Lake, Tamil Nadu during 2016. In total 415 specimens including 174 females and 241 males were collected and measured standard length and bodyweight in mm and gm, respectively. Standard length for males ranged from 70 to 165 mm and females from 100 to 200 mm. Slope value 'b' was estimated as 2.7638 for male and 2.7624 for female and 2.7653 for combined sexes. Established $W = 0.00038\ L^{2.7638}$ and $W = 0.00040\ L^{2.7624}$ for male and female respectively. The value 'b' was considerably close to 3 indicates that rotund, strongly streamlined body. Regression Coefficient for combined sexes was estimated as 0.9068. Average condition factor value for combined sexes was found as 1.0155 with a range from 0.5249 to 1.5854 revealed wellbeing of fish was in good condition.

Keywords: Length-weight relationship, condition factor, grey mullet, Pulicat Lake

Introduction
Fishes of the family Mugilidae are commonly known as "mullets" or "grey mullets". This family includes 18 genera and 81 species (Vaitheeswarn *et al.*, 2016) [1]. Mullet fishes contribution at 0.25-0.30% in the total marine fish production of India and caught throughout the year. Way back to 1980s and 90s the average mullet fish production from Tamil Nadu was reported to the tune of 1221, 394 and 2700 tonnes respectively during the period from 1975 to 1980 (BoBP 1983) [2], from 1985 to 1989 (Mahadevanpillai *et al.*, 1994) [3] and from 2007 to 2012 (HOFS, DAHD&F 2014) [4]. Mullet fishes are valuable source of food-fish during off season of the other fishery. The estimate of marine fish landings in India for the year 2019 was 3.56 million tonnes compared to 3.49 million tonnes in 2018, showing a marginal increase of about 73,770 tonnes (2.1%). Tamil Nadu moved to the first position replacing Gujarat, which was holding the first position for the past few years, with 7.75 lakh tonnes compared to 7.02 lakh tonnes in 2018 (10.4% increase) accounting for 21.8% of the total landings in the country. As the Global Nature Fund has also declared the Pulicat Lake as threatened Lake of the year 2010 (Vaithiyanathan and Jeganathan 2010) [5] and fishery resources management need of the hour. In this perspective, there is a need to conserve the ecosystem with potential biodiversity resources as well as fisher community for their livelihood (Luther, special publication CMFRI. 1973) [6]. At a glance, mullet fish production in India was about 43956 tonnes of the total marine fish production during 2012 particularly in Tamil Nadu; it contributes about 6.25 % (2750 tonnes). Mullet fish contribution about 1.31 % towards total marine fish production of India (3344819 tonnes) during 2012, where as in Tamil Nadu it's about 0.08% (2750 tonnes) (HOFS 2014) [4]. Mullet fish contribution was estimated 14437 (tonnes) during the year 2019 in India. Thus grey mullet fish species is one of the important aquaculture candidate fish in the years to come. The overall share of Aquaculture was 2.6% in the total production of Marine fishes and it was contributed substantially by striped/flathead grey mullet as one of the species (Kurma Rao and Ramesh Babu, 2013) [7]. About 1,760 and 2,260 tonnes of mullet are caught annually from the sea and the coastal brackish-water areas respectively. However, the significance of mullet resources of our waters lies not so much in its existing capture fisheries as in its potential as culture fishes for extensive fish farming (CMFRI. 1973) [6]. Even long ago the Estuarine Biological Laboratory (EBL) [8] was founded at the Pulicat town, on the Pulicat Lake, for the Madras Christian College in 1968 by Dr. P.J. Sanjeeva Raj, the then

Professor and Head of the Zoology Department to study the wealth of the biodiversity and fisheries in this lake and to manage the resources and fisher folk of this lake, sustainably, and to promote cultural exchange between the college and the fishing communities on Pulicat Lake. For instance, the CIBA has been involved in induced breeding of Grey mullet, very recently during 2019 - 20 induced breeding of trial using east coast stock resulted in grey mullet fingerling production in captivity

LWR studies of any fish species is a pre requisite for the study of its population. Ponderal index or condition factor or the 'fatness (K) was worked out to assess the well-being of the population with the assumption that the growth of fish in ideal conditions maintain an equilibrium in length and weight (Renjini and Bijoy Nadan, 2011) [9]. Data on LWR and the associated condition factor also enables to compare the population of the same species from different environments (Vaitheeswaran *et al.*, 2016) [1]. Fishes growth is said to be an isometric (i.e. a constant specific gravity) when the length exponent is 3 and said to be an allometric (i.e. growth with changing specific gravity) when the length exponent is greater or less than 3 (Vaitheeswarn *et al*., 2016) [1]. So far, there was no study on LWR of *Mugil cephalus* has been reported from the second largest Pulicat Lake, Tiruvallur district of Tamil Nadu. According to Martin (1949) [10] the value of the exponent 'b' in the parabolic equations usually lies between 2.5 and 4. Depending upon the deviation of 'b' values from '3' fishes can be classified into three groups (i) b= 3 where the body form of fish remains constant at different lengths (isometric) (ii) b<3 when fish becomes more slender as the length increases and (iii) b>3 (allometric) when fish grows more stouter with increase of length (Vaitheeswarn *et al*., 2016) [1].

Dineshbabu *et al.*, 2014 [11] stated in his book that every animal in its life grows both in length and weight and the relationship between these two has both theoretical and practical importance. It has been mathematically proved that there is a fairly constant relationship between total length and weight of the individuals of the species. It helps to establish a direct mathematical relationship between the two variables namely length and weight, so that if one is known the other could be easily computed. Length- Weight relationship is also needed for studies on maturity and yield estimates by analytical models.

The data on length and weight could be used for the estimation of yield per recruit in prediction models, and in the estimation of biomass from length observations and limited studies has been made on population dynamics. In this perspective, the present study establishes the mathematical relationship of LWR of *Mugil cephalus* following two variables such as Length and weight. So that the unknown variable can be estimated from the known variable and condition factor the value K.

Materials and Methods

Fresh fish samples were collected weekly during January – December 2016 from the commercial landings of Pulicat Lake (Latitude 13° 33′ 57″ N, Longitude 80° 10′ 29″ E). A total of 415 specimens including 174 females and 241 males were collected and their standard length and weight measurements were taken in mm and gm respectively were used for the LWR and condition factor. Fishes were divided into different sexes by observing their gonads after dissecting the abdomen.

The variables length and weight of the individual fish when plotted on arithmetic co-ordinates showed a curvilinear relationship. The relationship between length and weight is calculated by using the formula (Le Cren, 1951) [12].

$W = aL^b$

Where,

W = weight of the fish in grams,

L = length of fish in cm,

'b' is the exponent and 'a' is a constant

The variables length and weight are converted in to the corresponding logarithmic values and when plotted yielded a straight line (linear) relation. The length-weight relationship can be calculated by using the following equation:

$$\log W = \log a + b \log L$$

The condition factor was estimated from this experiment from the relationship

$$K = \frac{W}{W}$$

Where:

K = Condition factor

W = Observed Weight (g)

W = Calculated weight (g)

$\bar{L}$ = Length of fish (cm)

Fig 1: Mullet specimen collected from Pulicat Lake, Tamil Nadu

Fig 2: Weight mesurement of *Mugil cephalus*

Fig 1: Length mesurement of *Mugil cephalus*

Results

In this present study, the standard length of males ranged from 70 to 165 mm and females from 100 to 200 mm and. for male, the slope value (b) was estimated to be 2.7638 (Fig. 1.)

and the same was 2.7624 for female (Fig. 2.) and 2.7653 (Fig. 3.) for combined sexes. The equation of W = 0.00038 $L^{2.7638}$ and W = 0.00040 $L^{2.7624}$ were established for male and female respectively. The relationship revealed that the value of ''b'' was considerably close to 3, which might be due to the rotund, strongly streamlined body. The Regression Coefficient for combined sexes was estimated to be 0.9068. The average condition factor value for combined sexes was found to be 1.0155 with a range from 0.5249 to 1.5854. This *M. cephalus* exhibited negative allometric growth as the regression value below than 3 or close to 3. There was strong association between length and weight of *M. cephalus.* The correlations coefficient was found to be significant (P<0.01). There was no significant difference in regression values between sexes of the species and 'F' value were found to be significant at 1% level.

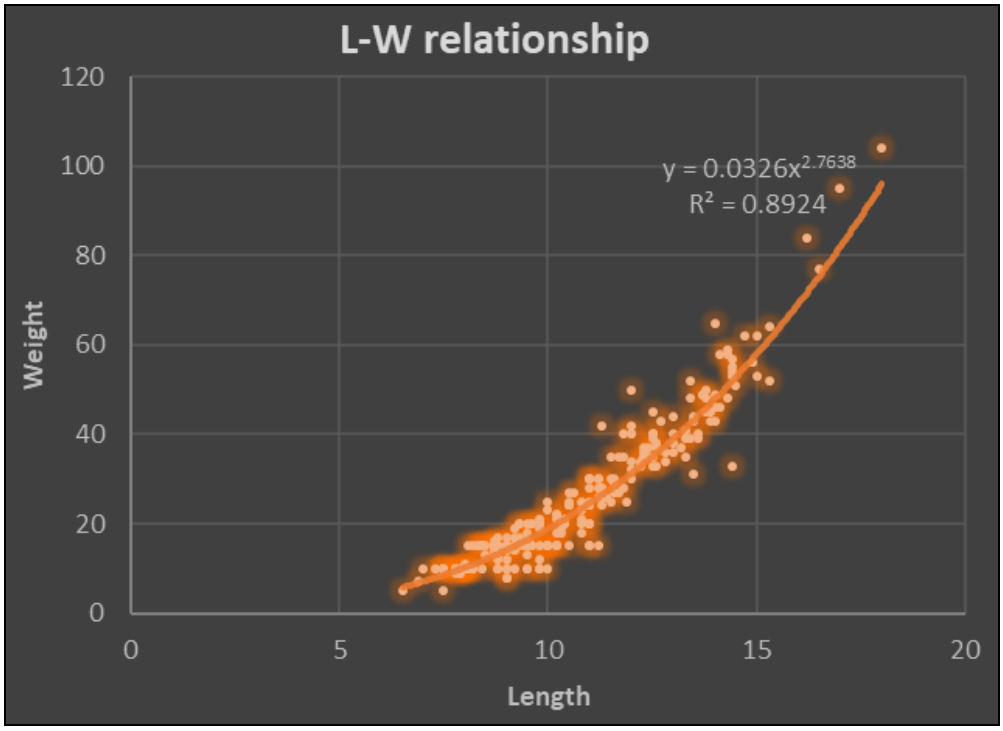

Fig 1: LWR established for male - W=0.00038$L^{2.7638}$;

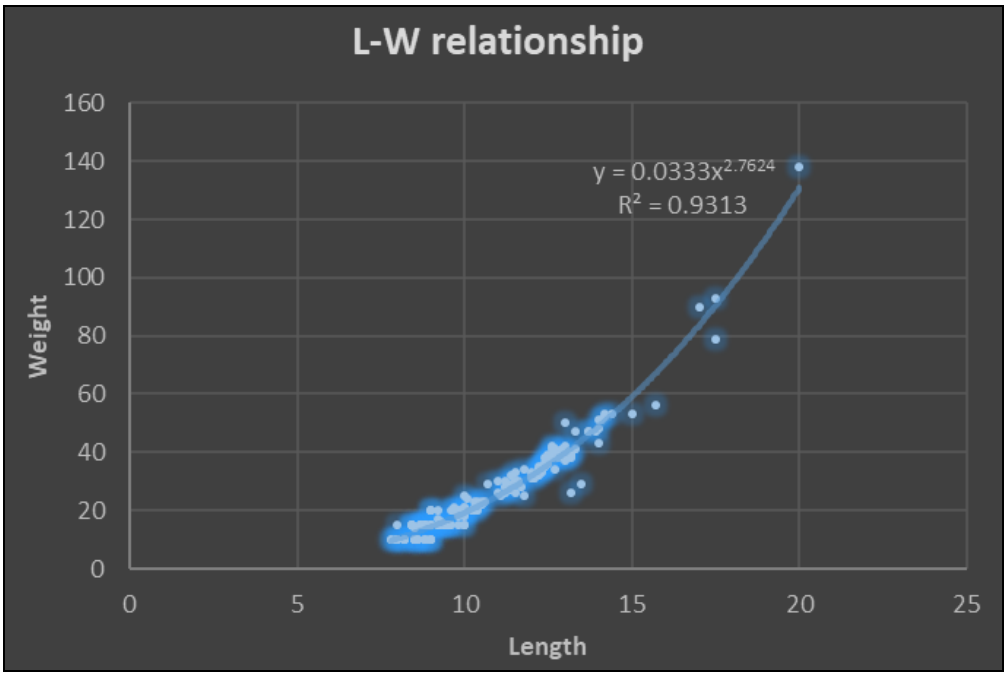

Fig 2: LWR established for Female - W=0.00040$L^{2.7624}$

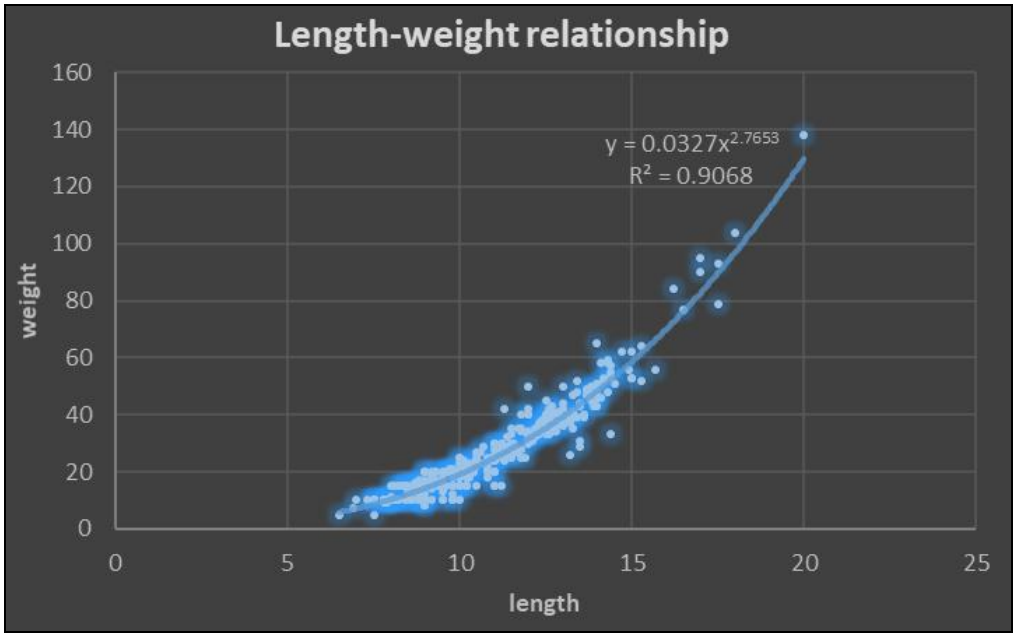

Fig 3: LWR established for Combined sexes $W=0.00038L^{2.7653}$;

Table 1: Summary Out Put For Combined Sexes

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.952274442							
R Square	0.906826614							
Adjusted R Square	0.906601012							
Standard Error	0.176134542							
Observations	415							
ANOVA								
	df	SS	MS	F	Significance F			
Regression	1	124.7014475	124.7014	4019.596	5.9375E-215			
Residual	413	12.81265458	0.031023					
Total	414	137.5141021						
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-3.419687456	0.103434423	-33.0614	4.3E-118	-3.623011041	-3.21636387	-3.623011041	-3.21636387
X Variable 1	2.765312662	0.043616722	63.40029	5.9E-215	2.679574199	2.851051125	2.679574199	2.851051125

Note: It is computed in Excel Data spread sheet (Data analysis)

Statistical analysis

t-Test: Two-Sample Assuming Equal Variances		
	Variable 1	*Variable 2*
Mean	10.83759036	26.64819277
Variance	4.851965194	276.2189279
Observations	415	415
Pooled Variance	140.5354465	
Hypothesized Mean Difference	0	
df	828	
t Stat	-19.21164394	
P(T<=t) one-tail	1.30789E-68	
t Critical one-tail	1.646696002	

P(T<=t) two-tail	2.61577E-68	
t Critical two-tail	1.962833125	

Here summary output for combined sexes of *M cephalus* is provided in Table 1, which has been computed in Excel Data Spread Sheet and provided statistical analysis above that the p-value of (Variable 1 & Variable 2) is less than the alpha level selected (alpha = 0.05). This means that groups Variable 1 & Variable 2 have less than 5% chance of belonging to the same population.

ANOVA: Single Factor						
Summary						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Column 1	415	4497.6	10.83759	4.851965		
Column 2	415	11059	26.64819	276.2189		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	51869.84	1	51869.84	369.0873	2.62E-68	3.852714
Within Groups	116363.3	828	140.5354			
Total	168233.2	829				

Here summary of ANOVA single factor is provided above that the F-value is greater than the F-critical value for the alpha level selected (0.05). Therefore, we have evidence to reject the null hypothesis and say that at least one of the two samples have significantly different means and thus belong to an entirely different population.

Discussion

In this present study, it was found that the slope value (b) was estimated to be 2.7638 for male and the same was 2.7624 for female and 2.7653 for combined sexes. This study compared favourably with other reports from Kurma and Ramesh babu (2013) [7] the study on LWR of *M. cephalus* at Krishna estuary region. The regression values obtained for Juveniles 2.61, adults 2.81, males 2.66 and females 2.74. It was found that significant difference in regression value for Juveniles and adults and there was no significant difference between males and females.

Gondal *et al*., (2014) [13] found from studies that Length-weight relationship of *Liza subviridis* and *Sillago sihama* in sub adults sampled from Somiani Bay Balochistan, Pakistan during 2002, 2003 and 2006 was analyzed. *Liza subviridis* showed positive allometry (3.23) in 2002, and negative allometry during 2003 (2.95) and 2006 (1.95). Sub adults of *Sillago sihama* showed positive allometry during 2002 (3.10) and 2003 (3.13). An isometric condition (3.02) was observed in the samples of *Sillago sihama* collected from Bhaira in 2006.

The present study states that the *M. cephalus* exhibited negative allometric growth as the regression value below than 3 or close to 3. For example a report by Murugan *et al.*, (2012) [14] from velar estuary that the negative allometric growth pattern in *M. cephalus*. It ws observed that a strong association between length and weight of *M. cephalus.* See Levent *et al.*, 2007 [15] found in his study on Weight-Length Relationships for 39 Fish Species from the North-Eastern Mediterranean Coast of Turkey that In terms of growth type, the results showed that 14 species had negative allometric (b<3), 16 species isometries (b=3) and 9 species positive allometric (b>3).

Venkatesah moorthy *et al.*, (2003) [16] reported from his study that Length-weight relationship, condition, age and growth and mortality rates of *Valamugil seheli* from Mangalore region were studied during April 1998 and March 1999. The combined length-weight relationship derived was log W = -1.4257+2.6207 log L and the growth was found to be allometric. Seasonal variation in condition factor showed higher values from September to December, while the mean values of Kn showed an increasing trend with size.

The present study revealed that the value of "b'' was considerably close to 3, which might be due to the rotund, strongly streamlined body. According to Martin (1949)[10] the value of the exponent 'b' in the parabolic equations usually lies between 2.5 and 4. Depending upon the deviation of 'b' values from '3' fishes can be classified into three groups (i) b= 3 where the body form of fish remains constant at different lengths (isometric), (ii) b<3 when fish becomes more slender as the length increases (Negative allometric) and (iii) b>3 when fish grows more stouter with increase of length (Positive allometric) (Vaitheeswaran *et al.*, 2016) [1].

In this study, the Regression Coefficient for combined sexes was estimated to be 0.9068. The average condition factor value for combined sexes was found to be 1.0155 with a range from 0.5249 to 1.5854 revealed that overall wellbeing of the grey mullets in the study area was quite good condition. Vinoth and Ramachandra (2014) [17] reported from his study in *Hirunchichtys coromandelensis* (Flying fish) in Bay of Bengal near Pulicat Lake in that there was no temporal variation in the conditions of fish with condition index value 0.83 – 1.00 and condition factor value of 0.94 was an indication of the fish species good condition.

Sandhya and Shameem (2003) [18] indicated from his study that a high regression coefficient value (b) for mullets collected from unpolluted waters as compared to those from polluted waters, the regression equations being Log W = -17.551 + 3.6811 Log L (r = 0.7804) and Log W = -5.8171 + 2.0656 Log L (r = 0.80609) respectively and growth and condition of the fish was affected by the prevailing environmental conditions of the polluted waters.

It was found in this present study that the correlations coefficient was found to be significant (P<0.01). There was no significant difference in regression values of 'b' between sexes of the species and 'F' value were found to be significant at 1% level suggesting that *M. cephalus* fish was in good condition in this study area As Vaitheeswarn *et al.*, (2016) [1] reported from his study that LWR of grey mullet *M. cephalus* from kovalm backwater, Chennai coast and gave the regression value as 1.04 for both the sexes and the slope value was less than 3 for the both sexes. The correlations coefficient was found to be significant (P<0.01). There was no significant difference in regression values between sexes of the species and 'F' value were found to be significant at 1%

level. A similar study was carried out on grey mullet *M. cephalus* from Hooghly Matlah estuary and reported the regression value as 2.8779 by Pillay (1951) [19]. A similar results was obtained for *Scatophagus argus* as brackish water fishes by Hashim *et al.*, (2017) [20] found from his study that the population growth pattern of scats was allometric negative (b < 3) indicated that the weight increment was lesser than length increment. The highest and lowest condition factor values were observed in December and June, which may indicate the spawning and recovery season of *S. argus*. Report from Musarrat-ul-Ain *el al*., (2018) [21] found that the b-value of regression equation shows the positive allometric growth in juveniles and adults of *S. argus* while, the negative allometric growth was obtained for combined fishes. The coefficient of correlation (r) was found as 0.992, 0.985 and 0.996 showing strong correlation between length and weight of juvenile, adult and combined fishes, respectively.

For example Rufus *et al.*, (2015) [22] reported 'b' values in the range of 2.7 to 3.5 for *Wallago attu* (Schneider, 1801). See Ali *et al.*, (2013) [23] that *Channa marulius* showed a definite change in LWR with size, with smaller fish growing with positive allometric exponents (b > 3) and larger individuals having negative allometric relationship (b < 3), indicating a possible age-related change in growth pattern. In the case of LLR, all three snakehead species showed non-isometric growth patterns.

Conclusion

This *M. cephalus* exhibited negative allometric growth as the regression value of 'b' was below than 3. The correlations coefficient was found to be significant (P<0.01). There was no significant difference in regression values of 'b' between sexes of the species and 'F' value was found to be significant at 1% level indicates that *Mugil cephalus* condition was in good condition. Thus, compared the slope of *M. cephalus* with other regions backwater like Kovalam, Vellar backwater etc., it could be concluded that the slope value was less than 3 for the both sexes of *M. cephalus* exhibits negative allometric growth pattern. This study paves the way to estimate VBGF growth parameters, estimation of potential yield per recruit in the study of their population dynamics and conversion between different length measurements. In general, the values of the relationship between length and weight obtained in the present study are very similar to those found by other investigators who was carried out studies in coastal estuaries.

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