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Archives of Applied Science Research, 2011, 3 (6):166-172
(http://scholarsresearchlibrary.com/archive.html)

ISSN 0975-508X
CODEN (USA) AASRC9

A Report on the length and weight relationship of Grouper *Epinephelus malabaricus* (Bloch and Scheneider, 1801) from Mandapam coastal waters (Southeast Coast of India)

M.A.Badhul Haq*[1], R.Vignesh[1], M.Srinivasan[1], and K.H. Brajamani Meetei[2]

[1]Centre of Advanced Study in Marine Biology, Faculty of Marine Sciences, Annamalai University, Parangipettai, Tamilnadu, India
[2]Krishi Vigyan Kendra (KVK), (ICAR), Utlou, Bishnupur District, Manipur, India

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ABSTRACT

The length-weight also helps in predicting the condition, reproductive history and life history of fish species. In the present study, the length - weight relationship in E.malabaricus has been studied with the objectives of provides a set of estimating equations and to determine whether any differences exists in their relationship between males, females and juveniles. The regression parameters of the length - weight relationship of E.malabaricus and the details of sums of squares and products of length - weight data of males, females and juveniles were analyzed. While analyzing of length - weight data of E.malabaricus separately for males, females, and juveniles for the year 2009 and 2010 the regression lines indicated a close relationship without any inflection. Slope values (b value) of males, females and juveniles are centered around 2.05, 2.78 and 2.01 for 2009 and 2.66, 2.80 and 2.35 for 2010 respectively. The correlation coefficients (r) were greater than 0.9. The study observed significant variations in the 'b' value of the grouper (male female and juvenile) collected from Mandapam Palk Bay and Gulf of Mannar coastal waters during the study period.

Keywords: length, weight, grouper, relationship, correlation significant.

INTRODUCTION

A knowledge on the length - weight relationship of fish has a vital importance in fishery, as it not only helps in establishing a mathematical relationship between the two and also in converting one variable into the other of the two length is easier to measure and can be converted into weight in which the catch is invariably expressed [1].

Length-weight relationship and condition factor are extremely useful tools for understanding the biological changes in fish stocks [2-4] was the first to propose the allometric growth formula to describe the relationship between length and weight. The application of length-weight relationships in fishery biology includes estimation of average weight of fish of given length group [5] conversion of length-growth equivalents (*i.e.*, length-atage to weight-at-age) in yield per recruit and related models [6, 7] interspecific and inter-populational morphometric comparison of fish species and in assessing the relative well-being of fish populations [8]. The length-weight also helps in predicting the condition, reproductive history and life history of fish species [9, 10] and in morphological comparison of species and populations [11].

It is known that with increase in length of fish, the weight also increases but in a more rapid way, thereby showing that the weight of fish is a function of length [12]. Since, length is a linear measure and the weight a measure of volume, it was generally found that, for fishes, the relationship between length and weight could be expressed by the hypothetical cute law, $W=CL^3$, where, 'w' represents the weight of fish 'L" its length and 'C' a constant. If the form and specific gravity remains constant, the formula could be used to calculate the weight of fish of known length or vice versa. But Le Cren (1951) pointed out that it is better to fit a general parabolic equation of the form $w=al^b$ which expresses the relation between the two factors better than the cubic formula, where 'w' and 'l' represents weight and length of fish respectively 'a' a constant equivalent to 'c' and 'b' a constant to be determined empirically i.e., from the data.

The applicability of the simple cubic relationship of weight and length of fishes has been much discussed. If, as a fish grows, it does not change form or density, the weight will be proportional to the cube of any linear dimension change in morphology with increasing age, however, often cause the coefficient of regression of logarithm of weight on logarithm of length to depart substantially from 3.0. The value of the exponent 'b' in the parabolic equation usually lies between 2.5 and 4.0 [13, 14] and for an ideal fish which maintains constant shape, b=3 [16]. Though the length - weight relationship of *Epinephelus malabaricus* been studied previously from Indian waters (Cochin) it has not been studied based on material obtained from Mandapam waters. Notable contributions on the length - weight relationship of *E.malabaricus* are of Moe (1969) Tan and Tan (1974) Thompson and Munro (1978), Baddar (1982), Hussian and Abdullah (1988) Premalatha, (1989), Tessy (1994) and Pramod (1997) from Indian and other waters. In the present study, the length - weight relationship in *E.malabaricus* has been studied with the objectives of provides a set of estimating equations and to determine whether any differences exists in their relationship between males, females and juveniles.

MATERIALS AND METHODS

Total length of each fish was measured from the anterior most edge of the lower lip (tip of snout) to the posterior most edge of caudal fin to the nearest mm. The weight was recorded to the nearest mg after blotting the fish with paper towels to remove moisture. Fishes were rejected if the caudal fin was damaged. Thrice a week specimens of *E.malabaricus* from trap and trawl net catches were collected from Mandapam fish landing centre from January 2009 to December 2010. 995 specimens collected for the year 2009 (149 males, 287 females, 559 juveniles) and 1106 specimens obtained for the year 2010 (198 males, 272 females, 636 juveniles) were employed for this analysis. The average log values of the observed weights and lengths in each 10 mm group when plotted in millimetre graph paper for males, females and juveniles for each year separately showed a linear correlation, since it has been found to adequately describe the length - weight relationship of most species the formula.

The LWR was derived for male and female following Le Cren (1951):

$$W = a*Lb$$

where, W = body weight (g), L= total length (cm), 'a' is a coefficient related to body form and 'b' is an exponent indicating isometric growth [6].

The same in logarithmic form can be written as:

$$Ln\ W = Ln\ a + b* Ln\ L.$$

The analysis of covariance was performed to determine variation in 'b' values between the sexes at 1% and 5% level of significance, following Snedecor and Cochran (1967).

RESULTS AND DISCUSSION

The regression parameters of the length - weight relationship of *E.malabaricus* for the year 2009 and 2010, and the details of sums of squares and products of length - weight data of males, females and juveniles for the year 2009 and 2010 are given in (Tables.1 - 8).

Table: 1. Sum of squares and products of length weight data of males, females & juveniles of *Epinepelus malabaricus* -2009.

Sex	No of Fish	Sx	Sy	Sx^2	Sy^2	Sxy
Male	149	279.6638	576.2072	547.1752	2322.46	1127.207
Female	287	523.8523	1053.4745	956.5486	3870.7022	1923.9250
Juveniles	559	760.2264	1443.3184	1168.8247	4303.5460	2234.2279

Table: 2. Corrected sum of squares and products of length weight data, regression co-efficient from the regression 2009

Sex	D.F	SUM OF SQUARES AND PRODUCTS			'B'	ERRORS OF ESTIMATE	
		X^2	XY	Y^2		D.F	S.S
Male	148	22.2635	45.7017	94.1732	2.0528	147	0.3584
Female	286	0.3771	1.0503	3.7736	2.7852	285	0.8483
Juveniles	558	134.9353	271.3500	576.9485	2.0110	557	31.2735

D.F Degrees of freedom XY, X^2, Y^2 - corrected sum of products and squares B-Regression co-efficient, S.S-sum of squares

$$S.SY^2 - \frac{(xy)^2}{x^2}$$

Table: 3. Sum of squares and products of length weight data of males, females & juveniles of *Epinepelus malabaricus* -2010

Sex	No of Fish	Sx	Sy	Sx^2	Sy^2	Sxy
Male	198	384.3073	789.0855	746.0987	3146.2811	1532.05
Female	272	495.9845	990.2480	904.7527	3608.3627	1806.641
Juveniles	636	973.9577	1844.1272	1525.8146	5547.6702	2904.705

Table: 4. Corrected sum of squares and products of length weight data, regression co-efficient from the regression

Sex		SUM OF SQUARES AND PRODUCTS				ERRORS OF ESTIMATE	
	D.F	X^2	XY	Y^2	'B'	D.F	S.S
Male	197	0.1790	0.4777	1.5542	2.6687	196	0.2794
Female	271	0.3386	0.9511	3.2484	2.8089	270	0.5768
Juveniles	635	34.3152	80.6454	200.4923	2.3501	634	10.9646

Table: 5. Sum of squares and products of length weight data of males, females & juveniles of *Epinepelus malabaricus* for 2009 and 2010

Year	Sex	No of Fish	Sx	Sy	Sx^2	Sy^2	Sxy
2009	Male	149	279.6638	576.2072	547.1752	2322.46	1127.207
2010	Female	198	384.3073	789.0855	746.0987	3146.2811	1532.05

Table: 6. Corrected sum of squares and products of length weight data, regression co-efficient from the regression

Year	Sex	D.F	SUM OF SQUARES AND PRODUCTS				ERRORS OF ESTIMATE	
			X^2	XY	Y^2	'B'	D.F	S.S
2009	Male	148	22.2635	45.7017	94.1732	2.0528	147	0.3584
2010	Female	197	0.1790	0.4777	1.5542	2.6687	196	0.2794
			22.4425	461794	95.7274			

D.F Degrees of freedom XY, X^2, Y^2 - corrected sum of products and squares B-Regression co-efficient, S.S-sum of squares

Table: 7. Corrected sum of squares and products of length weight data, regression co-efficient from the regression (males)

Year	Sex	D.F	SUM OF SQUARES AND PRODUCTS				ERRORS OF ESTIMATE	
			X^2	XY	Y^2	'B'	D.F	S.S
2009	Male	558	134.9353	271.3500	576.9485	2.0110	557	31.2735
2010	Male	635	34.3152	80.6454	200.4923	2.3501	634	10.9646
		1193	169.2505	351.9954	777.4408		1191	42.2381

D.F Degrees of freedom XY, X^2, Y^2 - corrected sum of products and squares B-Regression co-efficient, S.S-sum of squares

Table: 8. Corrected sum of squares and products of length weight data, regression co-efficient from the regression (females)

Year	Sex	D.F	SUM OF SQUARES AND PRODUCTS				ERRORS OF ESTIMATE	
			X^2	XY	Y^2	'B'	D.F	S.S
2009	Female	286	0.3771	1.0503	3.7736	2.7852	285	0.8483
2010	Female	271	0.3386	0.9511	3.2484	2.8089	270	0.5768
			0.7157	2.0014	7.022		555	1.4251

D.F Degrees of freedom XY, X^2, Y^2 - corrected sum of products and squares B-Regression co-efficient, S.S-sum of squares

Males

To understand the length - weight relationship of males as a whole the data for the monthly samples of the year 2009 and 2010 were pooled separately, and the equation obtained were:

$$\text{Log } w = 0.0142 + 2.0528 \log L$$
$$\text{Log } w = -1.1945 + 2.6687 \log L$$

Females

The data for the monthly samples of the years 2009 and 2010 were. Pooled separately, to understand the relationship for the entire samples of females and the equation obtained were:

$$\text{Log } w = -1.4131 + 2.7852 \log L.$$
$$\text{Log } w = -1.4814 + 2.8089 \log L$$

Juveniles

The data for the monthly samples of the years 2009 and 2010 were pooled separately, to understand the relationship for the entire sample of juveniles and the equation obtained were:

Log w = -0.1529 + 2.0110 log L
Log w = -0.6993 + 2.3501 log L

Comparison of males, females and juveniles

Analysis of covariance for the regression of log weight on log length in (i) males, females and juveniles, (ii) males and females (iii) males and juveniles and (iv) Females and juveniles showed that the difference between the regression coefficients of the (i) males, females and juveniles, (ii) males and females, (iii) males and juveniles and (iv) females and juveniles are significant for the samples of *E.malabaricus* collected for the year 2009. The details are given in (Tables.9-11) since significant difference could be noticed in the 'f' test at 5% while comparing the (i) males, females and juveniles, (ii) males and females, (iii) males and juveniles (iv) females and juveniles a common formula was not derived for the samples collected in 2009. Slope values (b value) of males, females and juveniles are centered around 2.05, 2.78 and 2.01 respectively for the year 2009 and 2.66, 2.80 and 2.35 respectively for the year 2010. Analysis of covariance for the regression of log weight on log length in (i) males, females and juveniles, (ii) males and females (iii) males and juveniles (iv) females and juveniles showed that the difference between the regression coefficients of the (i) males, females and juveniles (ii) males and juveniles and (iii) females and juveniles are significant excepting the males and females of 2010 samples. The details are given in (Tables.12-13). Since significant difference was evident based on the 'f' test at 5% while comparing (i) males, females and juveniles, (ii) males and juveniles (iii) females and juveniles (iii) females and juveniles, the common formula was not derived for the year 2010 samples.

Table: 9. Analysis of covariance (f' test) 2009

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Observed 'F'	5% F
Deviation from individual regression within sexes	989	32.4802	0.0328	-	-
Difference between regression	2	0.2555	0.1278	3.8963*	3.84
Deviation from overage regression	991	32.7357	-	-	-

Table: 10. Analysis of covariance (f' test) 2010

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Observed 'F'	5% F
Deviation from individual regression within sexes	1100	11.8208	0.0108	-	-
Difference between regression	2	0.0881	0.0441	4.1274	3.92.3.84
Deviation from overage regression	1102	11.9089	-	-	-

Table: 11. Analysis of covariance (f' test), for 2009-2010

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Observed 'F'	5% F
Deviation from individual regression within sexes	343	0.6378	0.0019	-	-
Difference between regression	1	0.0673	0.0673	35.4210*	3.84
Deviation from overage regression	344	0.7051	-	-	-

** Significance*

Table: 12. Analysis of covariance (f' test), males

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Observed 'F'	5% F
Deviation from individual regression within sexes	1191	42.2381	0.0354	-	-
Difference between regression	1	3.1472	3.1472	88.90*	3.84
Deviation from overage regression	1192	45.3853	-	-	-

Table: 13. Analysis of covariance (f' test), females

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Observed 'F'	5% F
Deviation from individual regression within sexes	555	1.4251	0.0026	-	-
Difference between regression	1	0.0001	0.0001	26.0000*	253-254
Deviation from overage regression	556	1.4252	-	-	-

* *Insignificance*

However, while comparing the males and females of *E.malabaricus* for the year 2009 samples no significant difference, could be noticed in the 'f test at 5% and hence a common formula was desired for males and females based on the pooled data.

$$\text{Log } w = -1.0258 + 2.3789 \log L$$

The weight of a fish increases logarithmically with an increase in length. The relationship between length and weight can be expressed by an equation $W=aL^b$ where 'W' is the weight of fish, 'L' is the length; 'a' is a constant and 'b' is an exponent, with a value lying between 2.5 and 3.5 but usually close 3.0 (Carlander, 1969). In many cases, 'b' values are found to be very close to 3. Hence, the length - weight relationship of a fish is often expressed by a "cube law", which establishes the length - weight relationship in fish. In this hypothesis, it is assumed that for an ideal fish if the specific gravity of the tissue remains constant throughout its life the relationship between lengths - a cube law could express weight. However, fish normally do not retain the shape of the body configuration throughout their life and the relationship may depart from the cube law (Bal and Rao, 1984). While analyzing of length - weight data of *E.malabaricus* separately for males, females, and juveniles for the year 2009 and 2010 the regression lines indicated a close relationship without any inflection. The correlation coefficients (r) were greater than 0.9 Few workers have also indicated that the 'a' and 'b' values differ not only in different species but also in the same species depending on sex, stage of maturity and food habits, etc. As there is observed significant variation in the 'b' value of the grouper (male female and juvenile) collected from Mandapam Palk Bay and Gulf of Mannar coastal waters for a period of two years, the cubic formula $W=a\ L^3$ may be a proper representation of the length - weight relationship of the grouper *E.malabaricus*. This is in quite agreement with the observation made by earlier authors.

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