Note

Length-weight relationship and growth parameters of moonfish *Mene maculata* (Bloch and Schneider, 1801) from Karnataka Coast, India

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ABSTRACT

The present study aimed to elucidate the length-weight relationship and growth parameters of the moonfish *Mene maculata* (Bloch and Schneider, 1801) along the Karnataka Coast. The species showed positive allometric growth with pooled 'b' value of 3.390 which is significantly greater than 3 ($p<0.05$) level. The "b" values of males (3.316) and females (3.440) showed significant difference from that of the indeterminates (2.90). The annual growth parameters estimated for moonfish off Karnataka Coast were: L_∞ = 29.1 cm and K = 1.014 yr^{-1}.

Keywords: Growth parameter, Karnataka Coast, Length-weight relationship, *Mene maculata*, Moonfish

Mene maculata (Bloch and Schneider, 1801) (Fig. 1) commonly known as moonfish forms a minor fishery along the Karnataka Coast of India. The fish is usually landed as a bycatch in the trawl fishery and is seldom used for domestic consumption due to insignificant catch which is mostly converted to fish meal. However, with increased operation of bull trawls/pair trawls and adoption of light fishing by purse seine, the catch of moonfish registered a significant increase during 2014-15. Consequent to this development of increased landings, a good domestic market emerged and the larger sized fishes fetch a good price. Though, the occurrence of moonfish was reported along the Indian Coast (Talwar and Kacker, 1984; Kapoor *et al.*, 2002; Rajan *et al.*, 2011), very little study has

been carried out on the growth of this species. Hence, a preliminary study was taken up to elucidate the length-weight relationship as well as to estimate the growth parameters of moonfish landed along the Karnataka Coast.

Fish samples were collected every month from the mechanised fishing vessels landed at Mangaluru and Malpe fishing harbours in Karnataka from December 2015 to May 2017. The total length (TL, to the nearest mm) from the tip of snout to the tip of upper caudal lobe and wet body weight (W, to the nearest 0.1 g) of the sampled fishes were recorded. A total of 339 specimens with length ranging from 6.1 to 25.5 cm were classified on the basis of sex. There were 153 females, 105 males and 81 indeterminates.

The length-weight relationship was calculated using the formula (Le Cren, 1951):

$$W = a L^b$$

where, W = body weight (g), L= total length (cm); 'a' is a coefficient allied to body and 'b' is an exponent signifying isometric growth when equal to 3 (Edwards, 1976). The same can be written in the logarithmic form as: $\ln W = \ln a + b \ln L$.

The constants 'a' and 'b' were derived by the method of linear least squares. The equations derived separately for males, females and indeterminates were compared for

Fig. 1. Moonfish *Mene maculata* (Bloch and Schneider, 1801)

significant difference between regression coefficients (b) and intercepts (a) using Analysis of covariance following Snedecor and Cochran (1967). The t-test (Snedecor and Cochran, 1967) was done to check whether the regression coefficients (b) varied significantly from the isometric value of 3.

For estimation of growth parameters, length data collected from trawlers were used. Samples from trawlers had length ranging from 61 to 255 mm (Fig. 2). Data was available for all months except June and July 2016, when a fishing ban existed along the Karnataka Coast. Further, during August 2016, severe rough weather conditions continued and only a few samples were collected from trawlers. The growth parameters of the moonfish population landed along the Karnataka Coast was estimated using the measurements of 1668 fishes collected during the study period. The length measurements were distributed into 5 mm class intervals. The size-frequencies were raised to the sampling days catch and then subsequently to the monthly catch. The preliminary estimate of growth parameter, L_∞ was estimated by the modified Wetherall plot in FiSAT software (Gayanilo *et al.*, 1996). Automatic search routine and response surface were run to obtain the best L_∞ and K values. However due to poor goodness of fit, size frequency were delineated using Bhattacharya's method and modes of each cohort were linked and growth parameters were estimated by Gulland and Holt plot (Gulland and Holt, 1959). The corrections for gear selectivity were done using the selection factor (L_{50} = 13.90 and L_{75} = 14.35 cm) and were used to re-estimate the length-frequencies (Mohamed and Rao, 1997) and finally the growth parameters were estimated using Gulland and Holt plot. The classical von Bertalanffy growth function (VBGF) (Sparre and Venema, 1998) was fitted to obtain the length of fish at different age using the following formula:

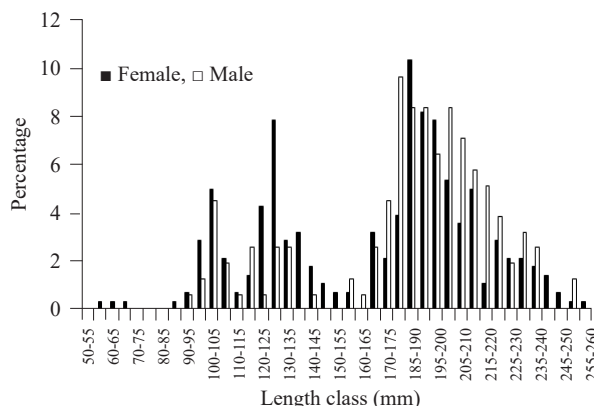$$Lt = L_\infty(1 - e^{[-K(t-t_0)]})$$

Fig. 2. Graph showing the percentage of moonfish (gender-wise) in different length classes, landed in trawl

where, L_∞ is the asymptotic length, K is the von Bertalanffy growth coefficient *i.e.,* the growth rate at which asymptotic length is attained (per year), Lt is the length of the fish at age 't' and t_0 is the age of the fish at zero length. Longevity or maximal age (t_{max}) of moonfish was estimated using the Pauly's equation (Pauly, 1983): t_{max} = t_0+2.996/K and the 't_0' was estimated using the empirical equation proposed by Pauly (1979): $Log_{10}(-t_0)$ = -0.392 - 0.275 $log_{10}L_\infty$ - 1.038K. The growth performance index (φ) was estimated as: φ = $log_{10}K+2$ $log_{10}L_\infty$ (Munro and Pauly, 1983), and compared with the results obtained for this species from other parts of the world.

The length-weight equations derived for males, females and indeterminates of *M. maculata* are given in Table 1. Analysis of covariance revealed no significant difference between male and female while there was significant difference with indeterminates. Hence the length-weight data of both sexes were pooled for further analysis.

Growth in an ideal fish is considered isometric if the weight of the fish is an exponential function of its length and the relationship could be expressed by the cube-law, *i.e.,* weight = a x length³. The regression coefficient (b) of *M. maculata* was found to be 3.390 which differed significantly from the hypothetical isometric value (3), indicating positive allometric growth. Positive allometric growth was observed in males (3.316) and females (3.440) while the sex indeterminates with the b value of 2.905 showed negative allometric growth. The male and female fishes grew faster in weight than in length while indeterminates grew faster in length than in weight (Fig 3a-c).

The comparison of length-weight studies conducted in moonfish across different seas around the world is shown in Table 2. The length-weight relationships of moonfish in the current study have shown major deviation in the 'b' values obtained from the previous studies. The present study has shown a positive allometric growth in case of adult fishes and a negative allometry in the case of indeterminates. These variations in growth among the indeterminates (mainly juveniles) and adults indicated that the fish grows more in length in the early phase and after a particular age, the increment in weight is more rapid than

Table 1. The length-weight equations derived for males, females and sex indeterminates of *Mene maculata*

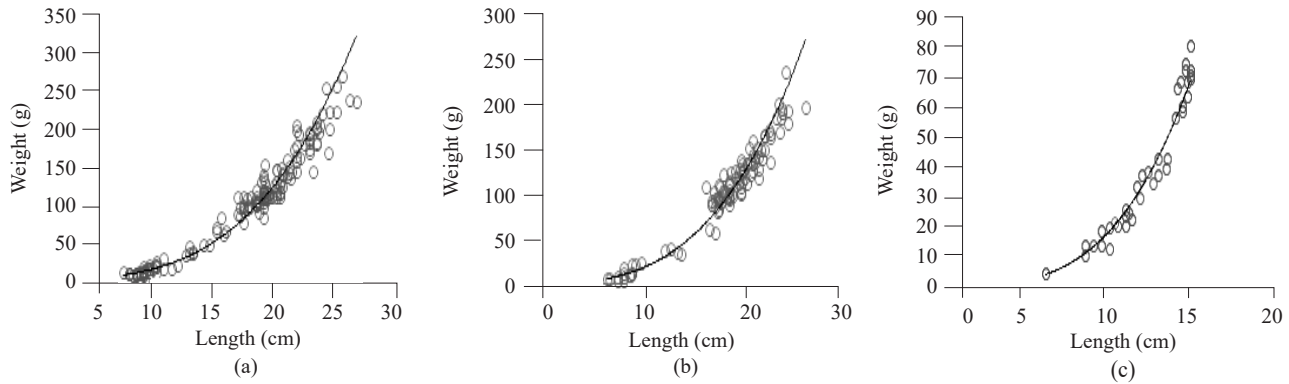| Group	L-W equation	R value	'b' value
Male	W= 0.00629L³·³¹⁶	0.98	3.316
Female	W= 0.00465L³·⁴⁴⁰	0.99	3.440
Pooled data	W= 0.00524 L³·³⁹⁰	0.97	3.390
Sex indeterminates	W=0.02330L²·⁹⁰⁵	0.98	2.905

Fig. 3. Length-weight relationship of moonfish a) Female; b) Male; c) Sex indeterminates

Table 2. Comparison of length-weight studies conducted on moonfish across different seas around the world

a	b	Sex	Sample size	Length (cm)	Length type	r^2	Locality	Reference
0.0344	2.939	Unsexed	150	10.0 - 21.0	SL	0.955	South-western waters, Taiwan, 1981-84	Hwang *et al.* (2002)
0.0153	3	Unsexed	5	10.2 - 15.5	TL	-	-	Pauly*et al.* (1998)
0.0229	3	Unsexed	5	9.0 - 13.0	SL	-	-	Pauly*et al.* (1998)
0.0219	3.147	Unsexed	154	11.0 - 20.0	SL	0.994	South-western waters, Taiwan, 1995-97	Hwang *et al.* (2002)
0.0234	3.186	unsexed	30	7.2 - 17.5	SL	0.995	Davao Gulf, Phillipines, 2009-12	Gumanao *et al.* (2016)
0.00006	2.842	unsexed	1025	8.3-25.6	FL	0.94	Beibu Gulf, South China Sea, 2011-12	DU Shi-qiang *et al.* (2012)
0.0046	3.440	Female	153	7.5-25.5	TL	0.98	Eastern Arabian Sea off Karnataka Coast	Present study
0.00629	3.316	Male	105	7-25.6	TL	0.96	Eastern Arabian Sea off Karnataka Coast	Present study
0.0233	2.905	sex indeterminates	81	6-15	TL	0.96	Eastern Arabian Sea off Karnataka Coast	Present study

SL - Standard length; TL - Total length

the increment in length resulting in a changeover from negative allometry to a positive allometry. The differences seen in the 'b' value estimated in the present study and that carried out by earlier researchers could be due to the difference in sampling techniques or due to the varying environmental and ecological parameters prevailing in different ecosystems. The regional differences in the growth and maturation of the fish could also lead to difference in the growth pattern (Ahmed *et al.*, 2011).

The growth parameter estimates for *M. maculata*, derived in the present study, employing different methods in FiSAT II are given in Table 3. In order to estimate the length of fish at different age, L_∞ value of 29.1 cm, K value of 1.014 yr^{-1} and t_0 of -0.014 were used, as the r-values (0.38) were good. The average length attained by moonfish at different age is given in Table 4. Maximum size of the fish obtained during the study was 25.5 cm. This corresponds to approximately 2 years of age and could be considered

as the maximum fishable life span of moonfish fished off Karnataka waters. The t_{max} for the fish was estimated as 2.97 years which is approximately 3 years of age. The estimated value of L_∞ in the present study falls well within the range of 21.8-33.4 cm as observed in the past studies

Table 3. Growth parameters estimated for *M. maculata*, using different methods in FiSAT II

Method used	L_∞ (cm)	K (yr^{-1})
Modified Wetherall plot	28.14	-
ELEFAN I	29.10	1
Bhattacharya and G&H plot (before gear selection)	28.24	1.14
Bhattacharya and G&H plot (After correction for gear selection)	29.10	1.014

Table 4. Age-length key for moonfish, off Karnataka waters

Age	0.5 yr	1 yr	1.5 yr	2 yr	2.5 yr
Length (cm)	11.8	18.69	22.83	25.32	26.82

(Table 5). The growth parameters estimated were found to be different from the estimates made by Hwang *et al.* (2002), while similar to those by Armada (2004). The growth performance index (φ) of the fish in the present study estimated at 2.934, is comparable with values obtained in other studies (2.13 to 2.87) indicating that the growth parameters estimated are reliable. The difference in the φ value may be due to impact of variation in the environmental parameters and geographical variation of the sampling sites.

Table 5. Comparison of growth parameter studies conducted in moonfish across different seas around the world

L_∞	Length type	K (yr^{-1})	φ	t_o	L_{max}	Country/Locality	Reference
21.8	SL	0.285	2.13	-	21	South western waters, Taiwan	Hwang *et al.* (2002)
22.5	TL	1.22	2.79	-	21.4	Manila Bay, Philippines	Ingles and Pauly (1984)
26	-	1.1	2.87	1.98	-	Davao Bay, Philippines	Armada (2004)
28	SL	0.186	2.16	-	20	South western waters, Taiwan	Hwang *et al.* (2002)
33.49	FL	0.17	2.28	-0.92	25.6	Beibu Gulf, South China Sea	DU Shi-qiang *et al.* (2012)
29.1	TL	1.014	2.934	-0.014	25.5	Eastern Arabian Sea, India	Present Study

SL - Standard length; TL - Total length

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