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Length weight relationship and relative condition factor of goby fish, *Paracheaturichthys ocellatus* (Day 1873) from the creeks of Mumbai

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Abstract

Length Weight Relationship of *Paracheaturichthys ocellatus* (Day1873) from the creeks of Mumbai was carried out from July 2010 to September 2011. The males ranged in the length of 66-182 mm and weight 1.152-54.801g while females ranged in the length 66-153mm and weight 2.209-38.383g. The juveniles ranged in the length range of 52-65mm and weight of 1.775-3-545g. The parabolic equation was $W = -5.1742L^{3.1041}$ with high correlation of 0.9961 indicating that fish increased in body weight as it grows in total length in the total population. The coefficient of regression b was 3.1041 for all fishes combined together showing a positive allometric growth. The relative condition factor for males was 1.0126, females was 1.0375 and 1.0013 for juveniles. Sex wise analysis of relative condition values revealed that mean Kn values in females (1.0375) was higher than that of males (1.0126). In present study Kn values were higher in males during pre-spawning period while in females it was during post spawning period. In males higher Kn values was observed in the length group of 106-115mm while in females it was 66-75mm. Relative condition factor was never less than 1 through the period of study hence it was in good condition irrespective of feeding or reproductive condition.

Keywords: length weight relationship, relative condition factor, allometric growth

Introduction

Length-weight relationship for fish was originally used to provide information on the condition of fish and to determine whether somatic growth was isometric or allometric^[1, 2]. A mathematical representation of length-weight relationship derived from study of different sexes and sizes from a particular geographical area is a practical index of the condition of the fish^[3] and is a very useful tool for the study of biology, physiology, ecology, population dynamics, fisheries assessment and general conditions of the fish^[4]. According to Schneider *et al*^[5] the length –weight regressions are useful for: a) calculating total weight of fish from length-frequency data. b) measuring changes in robustness/ health of the population (relative to past or future samples at the same place and season). c) determining the relative condition of small fish compared to large fish (from the slope of regression) d) comparing condition of this population to the state wide standards.

The Condition Factor is a frequently used index for fish biology study, as it furnishes important information related to fish physiological state, based on the principle that individuals of a given length, exhibiting higher weight, are in a better condition^[6]. It is studied by the method known as Fulton's condition factor or coefficient of condition also known as Ponderal Index. Anderson and Neumann^[7] reported that the condition factor was a relative indicator of fish health and the degree of sustainable environments, where variations in the relative condition factor is linked to sexual maturity and the degree of nutrient supply within the environment.

Paracheaturichthys ocellatus is native to Western Indian Ocean and Western Central Pacific ocean at 30° E - 80° E and 45° S - 30° N. It was identified by Day^[8] in 1873 from the creeks of Mumbai. Mutsaddi and Bal^[9] reported that *P. ocellatus* occurs in the muddy creeks of Colaba, Worli, Mahim, Danda, Madh, Mahul, and Thane. The present study of goby fish *Paracheaturichthys ocellatus* from creeks of Mumbai coast was undertaken to carry out a

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comprehensive description of the length-weight relationship in male female and juvenile to establish pattern of growth in these fishes which would contribute to population dynamics of the fish. The study of relative condition factor 'Kn' of *Parachaeturichthys ocellatus* was carried to assess the general condition of the fish from the creeks of Mumbai seasonally and lengthwise to be used in fishery.

Materials and Methods

Samples for the present study were collected every fortnight at regular intervals from Vasai, Malad, Thane and Mahul creek during June 2010 to September 2011. Fresh fish samples were brought to the laboratory and thoroughly washed, cleaned and wiped.

Length Weight Relationship

Total length was measured from the tip of the snout to the tip of the caudal fin in millimetres and weight was noted to the nearest 0.001 gram. The length weight relation was estimated by exponential curve fitting as per formula $W=aL^b$. This equation can also be expressed in its logarithmic form as

$$\text{Log } W = \text{Log } a + b \cdot \text{Log } L$$

where W= total weight, L=total length, a=intercept(initial growth coefficient), b= slope(growth coefficient).

The parameters of 'a' and 'b' were estimated by linear regression analysis (least square method) on log transformed data and the association degree between variables W and L was calculated by determination of coefficient (r²).

The significance of regression was assessed by ANOVA. Variance ratio F was calculated by the following formula

$$F = \frac{\text{Mean square between groups (MS)}}{\text{Mean square within groups (Residual)}}$$

The regression coefficients of the sexes were compared by the analysis of covariance (ANCOVA) to establish the variations in the b values, if any between males and females. The significance of the difference, in the estimate of b in males, females, juveniles and pooled data of sexes from the expected value of 3 was tested by Bailey's t-test ^[10] (Snedecor and Cochran, 1967) as given by the formula,

$$t = \frac{b-3}{S_b}$$

where b= regression coefficient of log transformed data and S_b = standard error of b. The t-test on 'r' values reveals whether significant correlation exist between length and weight.

Relative condition factor

The relative condition factor Kn was calculated using the formula expressed by Le Cren ^[1] which is expressed as follows:

$$Kn = W/W'$$

where W is the observed weight of the fish W' is the calculated weight of the fish derived from the length weight relationship

Results

Length weight Relationship

In the present study length weight relationship of 685 males, 489 females and 338 juveniles was analysed. Table no. 1 shows the minimum, maximum values of total length and total weight of *Parachaeturichthys ocellatus* male, female, juvenile and combined. It also shows the values of intercept 'a' regression coefficient 'b', correlation coefficient 'r' and coefficient of determination 'r²'.

Table 1: Length weight relationship in male, female and juvenile *P. ocellatus*.

Sample	Total length in mm		Total weight in grams		Total number 'n'	Intercept 'a'	Slope 'b'	Correlation coefficient 'r'	Coefficient of determination 'r ² '
	min	max	min	max					
Male	66	182	1.152	54.801	685	-4.8341	2.9159	0.9895	0.9790
Female	66	153	2.209	38.383	489	-4.3520	2.7216	0.9699	0.9400
Juvenile	52	65	1.775	3.545	338	-4.5939	2.7745	0.8986	0.8070
Combined	66	182	1.152	54.801	1512	-5.1742	3.1041	0.9961	0.9920

The length weight relationship worked out in *P. ocellatus* was established with the formula, $W = a \cdot L^b$ which can also be expressed as $\text{Log } W = \text{Log } a + b \cdot \text{Log } L$ or $Y = a + bx$. It was as follows:
 Males : $W = -4.83416 L^{2.9159}$ Females : $W = -4.3520 L^{2.7216}$
 Juveniles : $W = -4.5939 L^{2.7745}$ Combined: $W = -5.1742 L^{3.1041}$

The correlation coefficient 'r' between log length and log weight was found to be 0.9895 in males, 0.9699 in females, 0.8986 in juveniles and 0.9961 in combined or pooled fishes. The coefficient of determination r² values indicated that 97.90% variation of weight in males, 94% variation in females and 80.70% variation of weight in juveniles (Table

no.1)
 The b values were 2.9159, 2.7216, and 2.7745 in male, females and juvenile respectively. This indicated a slight negative allometry in the growth rate of fishes. The pooled values however showed a positive allometric growth with b value 3.1041.

Table 2: Significance of variations in the estimates of regression coefficient value 'b' from '3' using t test

	b	t value		Significance
Male	2.90706	-4.57	P<0.01	significant
Female	2.7216	-13.10	P<0.01	significant
Juvenile	3.0082	2.12	p0.01	Not significant
Pooled	2.89199	-7.29	P<0.01	significant

The significance of variations in the values of regression coefficient 'b' from '3' was tested by using t test and is presented in Table no. 2. The regression values were found to be highly significant ($p < 0.001$) showing a good relationship between length and weight in these fishes. The values of regression coefficient 'b' exhibited significant difference between male and female ($F = 9.06$, $df = 1, 1173$ at 5% level of

significance). The results indicate that t value is significant in males, females and pooled observation of male and female, while in juveniles it is not significant at $p < 0.01$. Based on LWR the growth in males and females was negative allometric whereas the same in juveniles was almost isometric.

Table 3: Comparison of regression coefficients of male and female *P. ocellatus* using t- test

Between	df	t value	p
Male- Female	1170	6.401	$p < 0.01$ highly significant

df-degree of freedom

Table no.3 depicts the comparison of regression coefficients of male and female using t-test. The results indicate that there is significant difference in LWR between male and female *P. ocellatus* at $p < 0.01$.

Relative Condition factor

In the present study 1512 fish were assessed for relative condition values. It consisted of 685 males, 489 females and 338 juveniles. The males ranged in the length of 66-182mm

and weight 1.152-54.801g while females ranged in the length 66-153mm and weight 2.209-38.383g. The juveniles ranged in the length range of 52-65mm and weight of 1.775-3-545g. The data was analysed separately for both sexes in 10mm length range. Relative condition values were calculated for a period of 18 months from June 2010 to September 2011 in male, female and juveniles separately. It was analysed monthly and length wise in adults.

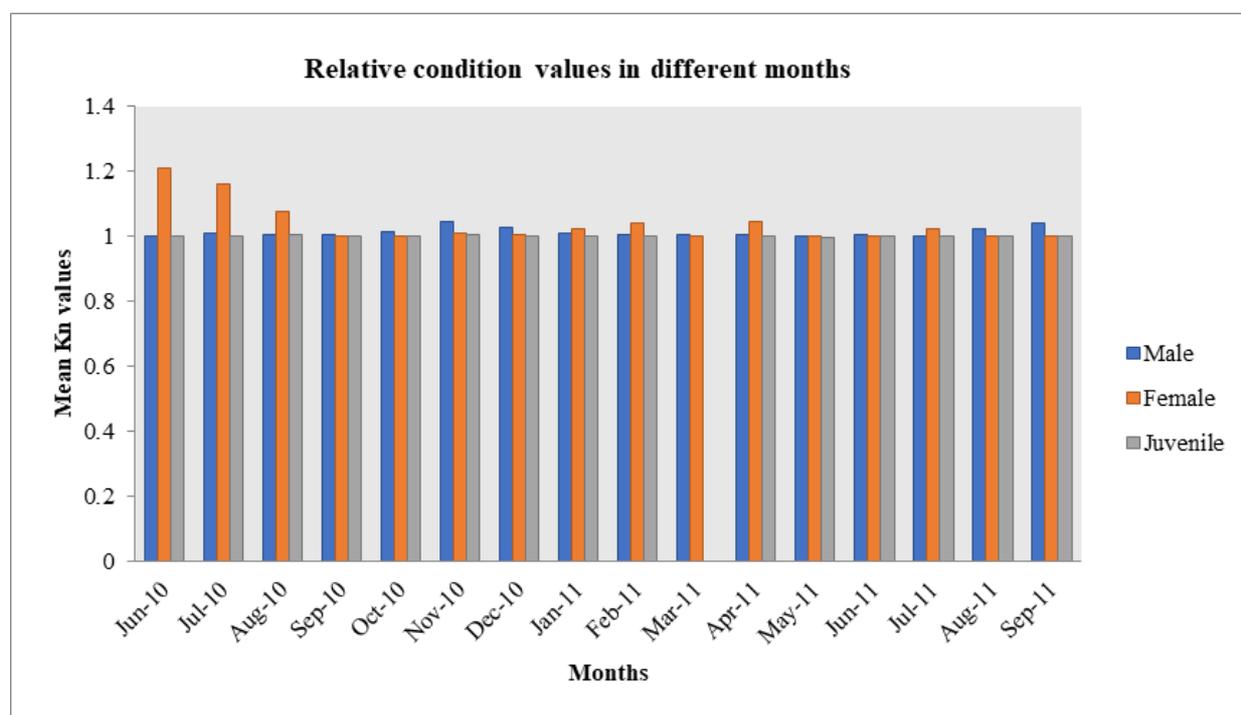


Fig 1: Fluctuation of relative condition values in different months of *Parachaeturichthys ocellatus* male female and juvenile

The relative condition factor Kn for male, female and juvenile in different months are shown in and Figure no. 1. The mean relative condition factor of male was 1.0126, female 1.0375 and juvenile 1.0013 respectively. This Kn value greater than 1

indicated good general condition of fish. The highest relative condition value of 1.0470 was observed in November 2010 in male and of 1.2118 was observed in females in June 2010. In juveniles high value of 1.0059 was observed in August 2010.

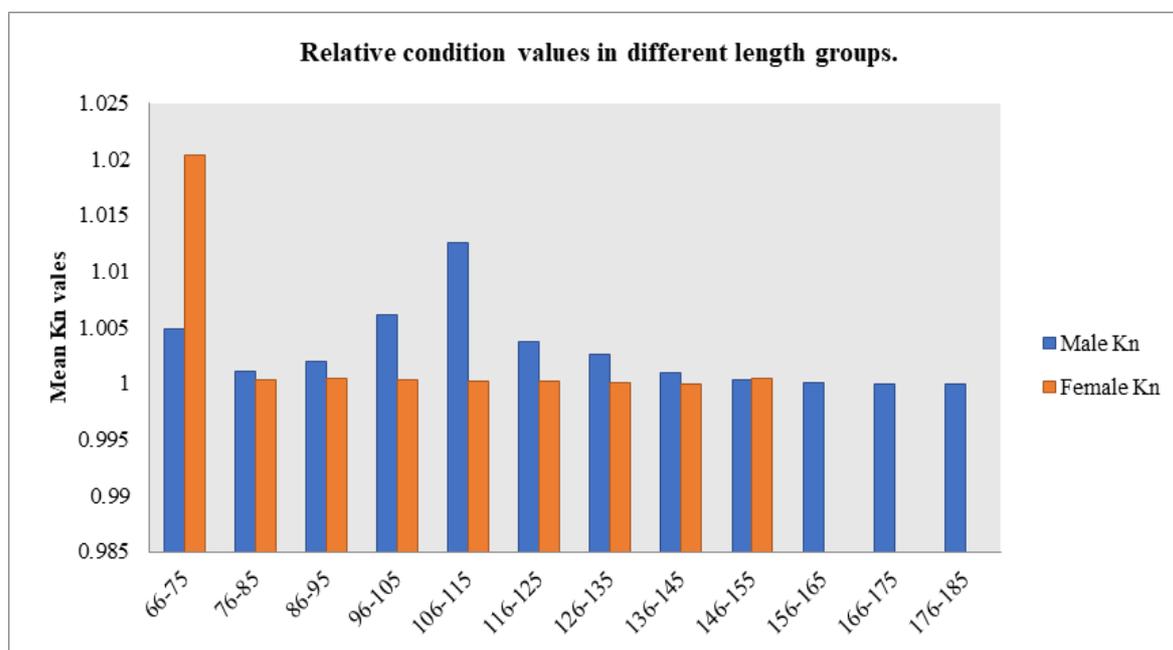


Fig 2: Fluctuation of relative condition values in different length groups of *Parachaeturichthys ocellatus* male and female

The relative condition factors in different length groups of are shown in Figure no.2 in male and female. In male's higher value was observed in the length group 106-115 mm of 1.012 while in females higher value of 1.0204 was observed in length group 66-75mm.

Discussions

Length-weight relationship of any fish is dependent upon various environmental factors besides body shape, outline and contour. [11]. The principle of the length-weight relationship is that the weight of the fish increases in relation to increase in its length. To test application of this principle to studies on LWR in *P. ocellatus* the statistical tool like correlation coefficient, regression analysis, ANOVA and ANCOVA are employed. In the present study the correlation coefficient 'r' was observed to be highly significant in male female and juvenile *P. ocellatus* indicating a strong correlation between length and weight of the fish.

Wootton [12] has observed that if fish retains the same shape and its specific gravity remains unchanged during the lifetime, it is growing isometrically and the value of exponent 'b' would be exactly 3.0 whereas a value of less than 3.0 shows that the fish becomes lighter (negative allometry) and greater than 3.0 indicate that the fish becomes heavier (positive allometric) for a particular length as it increases in size. According to Jhingran [13] and Frota *et al.* [14] the slope value 'b' indicates the rate of weight gain relative to growth in length and varies among different populations of the same species or within the same species.

In the present study the 'b' value representing LWR was 2.9071 in male and 2.7116 in female. The 't' test on b values indicated a significant deviation from cube law in both male and female *P. ocellatus* suggesting that the male and the female had negative allometric growth. The 'b' value in male which is slightly higher than that of female is suggestive of comparatively greater weight gain in male fish than that in the females for the corresponding increase in their length. Similar trend was observed in *Glossogobius guiris* from North Western Bangladesh which showed b value of 2.768 and 2.667 for males and females respectively [15] indicating negative allometry. Kalayci *et al.* [16] reported that the growth

was negative allometric for *Gobius niger*, *Engraulis encrasicolis*, *Sprattus sprattus* and *Pomatomus saltatrix*. The authors opined that functional regression 'b' value represents the body form, and it is directly related to the weight, affected by ecological factors such as sex, age, fishing time area and fishing vessels.

The analysis of covariance and comparison of slopes revealed significant differences between both the sexes of *P. ocellatus* at $p < 0.05$. The observed differences in the males and females in the present study may be attributed to factors like gonad maturity, sex and diet. Tesch [17] has stated that length weight relationship can be affected by several factors including habitat, area, seasonal effect, degree of stomach fullness, gonad maturity, sex, health, preservation techniques and differences in the observed length ranges of the specimen caught. Moyle and Cech [18] indicated that the differences in length between the sexes are the most common form of sexual dimorphism among fishes. The males being longer than the female is a distinct sexually dimorphic character in *P. ocellatus* observed during the period of study.

In the present study on LWR in *P. ocellatus* the b value for juveniles was 3.0082 which was highly significant at $p < 0.01$. The 't' test clearly indicated that b values did not deviate from 3.0 significantly showing an isometric growth i.e. increase in weight with the corresponding increase in length. The observation of LWR in juveniles and adult *P. ocellatus* are in agreement with Nikolsky [19] in terms of specific characteristics of growth in different age groups.

All allometric values observed in the present study were within the range of 2.5 to 3.5 indicating that growth of *P. ocellatus* in the creeks of Mumbai was satisfactory. Hile [20] found that the exponent 'b' usually lies between 2.5 and 4.0 with 3 as the ideal value for 'b' indicating isometric growth while deviation from 3 indicates an allometric growth. The value of coefficient of determination 'r²' was 0.9828, 0.9407 and 0.8428 for males, females and juveniles respectively. The value being closer to 1 indicates goodness of fit for regression to the observed data.

The present study provides a baseline data on the LWR of *P. ocellatus* from the four creeks of Mumbai. LWR and linear regression was highly significant in males, females and

juveniles. The males and females indicated a negative allometric growth pattern while the juveniles exhibited isometric growth pattern. The significant difference between the slopes of regression of male and female reflects a divergence in growth pattern in both the sexes.

The condition factor as a frequently used index furnishes important information related to physiological state of the fish and its determination is important for any studies on fish biology. According to Le Cren^[1] Kn greater than 1 indicated good general condition of fish. In the present study the mean 'Kn' value which is ratio of $W:W'$ where W is the recorded weight and W' is the calculated weight from LWR observed in male female and juvenile was greater than 1 indicating an overall good condition of fish in creeks of Mumbai throughout the year. Sex wise analysis revealed 'Kn' value of 1.0375 and 1.0126 in male and female fish respectively. The female fish thus seem to be heavier than male fish for a given length. LeCren^[1] reported that females are heavier than males of the same length probably because of difference in fattiness and gonadal development. The present observation of comparative value of 'Kn' in male and female *P. ocellatus* was in agreement with the observation of Le Cren^[1] and the findings of Ravi^[21] and Gore^[22] in *Boleophthalmus boddarti*.

Sebastian^[23] reported that there was a definite seasonal cycle in the 'Kn' values of both male and female *Colletteichthys dussumieri*. In the present study maximum 'Kn' value was observed in male fish in November 2010 and the value progressively decreased though slightly till February 2011. The values showed a sharp decline from March 2011 to May 2011. There is a gradual increase in 'Kn' value from June 2011 to August 2011 indicating a recovery in the general condition of male fish.

In female *P. ocellatus* maximum 'Kn' value was observed in the month of June 2010 which the decreased gradually from August 2010 to October 2010. There was an increase gradually thereafter till February 2011. The 'Kn' values declined sharply again in April 2011 and continued to decline till May 2011. The 'Kn' value was found to again increase sharply in June 2011. Thus the 'Kn' value in *P. ocellatus* also seems to follow a seasonal cycle. Similar observations were noted in *Lesuerigobius friessi* by Nash^[24] and in *Gobioides rubicundus* by Kader *et al.*^[25].

When the condition factor of a fish is determined every month of the year the suitability of the environment of the fish during each month could be better understood^[26]. Seasonal variation of 'Kn' is influenced by gonadal development, feeding activity and several other factors^[27, 28]. The period in which lower condition value is obtained is also a period in which accumulated fat is in use for spawning^[29]. Condition and feeding activity decrease in the spawning time^[30]. Relative condition factor is closely related not only to the feeding intensity but also with sexual cycle and weight of gonads before and after spawning as reported in gobiids of south east coast by Ravi^[21]. Lizama and Ambrosio^[31] reported that lowest 'Kn' values during the more developed gonadal stages suggesting resource transfer to the gonads during the reproductive period. According to Costa and Araujo^[32], relatively lower 'Kn' values are usually due to the fact that a larger part of the energy is allocated for certain activities such as growth and emptying of ovaries. Sebastian^[23] reported that higher 'Kn' values in *C. dussumieri* may be related to the increase in the feeding intensity of the spent fishes to rebuild their body reserves resulting in sharp increase of 'Kn' at the

end of spawning and during post spawning period.

In the present study of *P. ocellatus* the condition value of male was high in pre spawning phase being maximum during November 2010 and declined during the spawning period to reach minimum immediately after the peak spawning to again show a great rise. In female 'Kn' values increased gradually from the pre spawning period of November 2010 to the peak spawning period of February and March 2011 and declined sharply in the post spawning phase to reach minimum during May 2011. The female recovered immediately after spawning with sharp increase in condition value whereas the condition values in males increased gradually as compared to the female.

El-Agami, Hadi, Shalloof and Salam^[33, 34, 35] reported that the condition factor determines the period of gonad maturation, and can be attributed to sexual and active spawning sizes. Froese^[36] observed that reproduction results in lower value of Condition factor with $K < 1$ coinciding with the post spawning period when the fish tends to lose weight. However in the present study the 'Kn' was never less than 1 throughout the year and it can therefore be assumed that *P. ocellatus* tends to maintain its overall good condition irrespective of its reproductive phase probably by modulating its feeding intensity. The condition values of juvenile ranged between 0.9964-1.0059 and the juvenile fish were found to be in overall good condition throughout the year except in May 2011.

The 'Kn' also varies in different length groups and probably also depends on feeding intensity. The variation of 'Kn' values observed in different length groups seems to be due to differences in feeding intensity and reproductive cycle. Sebastian^[23] reported that in *C. dussumieri* high 'Kn' values observed in 131-140 mm TL and 151-160 mm TL size groups of male might be due to the occurrence of large number of maturing and mature individuals within that particular range. The 'Kn' values in male *P. ocellatus* gradually increases from the length group of 66-75mm through 96-105mm reaching the maximum value in the length group 106-115mm. This probably correlates with the advancing stages of maturity. The lower 'Kn' values in *P. ocellatus* were observed in the large sized individuals with a length of 166-175mm and 175-185mm probably because the male fishes have reached the post spawning stage. However the 'Kn' values in male *P. ocellatus* was never less than 1 in the sample of fish analysed. In female *P. ocellatus* maximum 'Kn' value was observed in smallest length group of 66-75mm. The value slightly decreased in the higher length groups. The lowest value was observed in the length group of 146-155mm. Thus be surmised that in male *P. ocellatus* the relative condition factor 'Kn' increased till the males attained maturity and then the 'Kn' decreased slightly while the females are in good condition at minimum body length and later undergo slight decrease in condition values in the higher length groups reaching the lowest values in the large sized females. According to Palazon *et al.*^[37] males and females of *Halobatrachus didactylus* matured at different length and the authors opined that size at maturity for males was greater than that of females, which may indicate that after first maturation females tend to allocate energy mainly for the production of gamete and then they do not exhibit further growth in terms of length while males, with a small reproductive effort, continue growing to the larger length group.

During the course of present study, the male, female and juvenile *P. ocellatus* were found to be in a healthy condition

in the creeks of Mumbai. The sex wise analysis revealed that females have higher 'Kn' values and are in a better condition than males. The condition factors may be influenced by number of factors of which feeding and reproductive activity may probably be the important factors.

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