

Length-weight Relationship and Relative Condition Factor of *Puntius carnaticus* (Jerdon, 1849)

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The length-weight relationship of *Puntius carnaticus* (Jerdon, 1849) was calculated for males, females and indeterminates. The relationship was analyzed using the formula $W = aL^b$ which was further transformed into $\log W = a + b \log L$. A total of 882 specimens comprising 262 males, 150 females and 470 indeterminates with size groups ranging from 52 to 472 mm total length (TL) were used. The equation obtained for males was: $\log W = -4.1567 + 2.7148 \log L$; for females: $\log W = -4.5089 + 2.8618 \log L$; and for indeterminates: $\log W = -0.9611 + 1.4243 \log L$. The regression coefficients between males and females did not show any significant difference while significant difference could be noticed between males and indeterminates and between females and indeterminates ($p < 0.01$). Studies on relative condition factor (Kn) of *P. carnaticus* revealed that the fluctuations in 'Kn' values can be attributed to spawning cycle as well as feeding intensity.

Key words: Length-weight relationship, Condition Factor, *Puntius carnaticus*

Growth is defined as the change in size with reference to time. Weight of a fish is expressed as a function of length. Knowledge of length-weight relationship is of paramount importance in fishery biology as it serves several practical purposes. The general length-weight relation equation provides a mathematical relationship between the two variables, length and weight, so that the unknown variable can be easily calculated from the known variable. This expression had been extensively used in the study of fish population dynamics for estimating the unknown weights from known lengths in yield assessments (Pauly, 1993), in setting up yield equation for estimating population strength (Beverton & Holt, 1957; Ricker, 1958), in estimating the number of fish landed and in comparing the populations over space and time (Sekharan, 1968; Chanchal *et al.*, 1978). It also yields information on growth, gonadal development and general condition of fish (Le Cren, 1951) and therefore, is useful for comparison of body

forms of different groups of fishes. The length-weight relationship has a biological basis also as it depicts the pattern of growth of fishes. According to the general cube law governing length-weight relationship, the weight of the fish would vary as the cube of length. However, all fish species do not strictly obey the cube law and deviations from the law are measured by condition factor (Ponderal index or K factor). Le Cren (1951) proposed relative condition factor (Kn) in preference to 'K' as the former considers all the variations like those associated with food and feeding, sexual maturity, etc., while the latter does so only if the exponent value is equal to 3. Thus 'K' factor measures the variations from an ideal fish, which holds the cube law while 'Kn' measures the individual deviations from the expected weight derived from the length-weight relationship.

The length-weight relationship of cyp-rinids from India has been studied by many.

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Some of the recent studies in this line are that of Mohan & Sankaran (1988), Kurup (1990), Reddy & Rao (1992), Biswas (1993), Pandey & Sharma (1997), Sarkar *et al.* (1999) and Sunil (2000). *Puntius carnaticus*, commonly known as carnatic carp is an endemic species to the Western ghats of India. In comparison to other members of genus *Puntius*, this species attains big size and the maximum size recorded is 12 kg (Talwar & Jhingran, 1991). Even though studies on food and feeding, maturation, spawning and age and growth of this species revealed its good aquaculture potential as a better substitute for grass carp in composite fish culture, nobody practiced its culture till now (Manojkumar, 2007). No information is available so far on the length-weight relationship and condition factor of *P. carnaticus* and therefore, the present study was undertaken to establish the pattern of growth and general condition of this fish species from the natural waters.

Materials and Methods

A total of 882 specimens of *P. carnaticus*, comprising 262 males, 150 females and 470 indeterminates were collected from Peringalkuthu region of Chalakudy river (Kerala) using nylon monofilament and multifilament gill nets of varying mesh sizes (32, 34, 64, 78, 100 and 140 mm) during March 2001 to February 2003. The specimens were preserved in 8% formalin. After removing the excess water on the specimens by pressing with blotting paper, the total length to the nearest millimeter and weight to the nearest 0.01 gram were recorded. Total length was measured from the tip of snout to tip of the longest ray in caudal fin (Jayaram, 1999). Total length of male, female and indeterminates varied from 232 to 430 mm, 270 to 472 mm and 52 to 228 mm respectively. The weight varied from 250 to 1120 g in males, 300 to 1750 g in females and 15.2 to 314 g in indeterminates. The data so generated were subjected to statistical analysis by fitting length-weight relationship following Le Cren (1951). Length-weight

relationship can be expressed as $W = aL^b$, the logarithmic transformation of which gives the linear equation:

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

where W = weight in gram, L = length in mm,

a = a constant being the initial growth index,

and b = growth coefficient.

Constant 'a' represents the point at which the regression line intercepts the y-axis and 'b' the slope of the regression line.

The relationship between length and weight was determined for males, females and indeterminates separately by transforming the values of both variables to logarithmic values and fitting a straight line by the method of least squares. The significance of regression was tested by ANOVA. The regression coefficients of the sexes and indeterminates were compared by analysis of covariance (ANACOVA) (Snedecor & Cochran, 1967) to establish the variations in the 'b' values, if any, between them. Bailey's t-test (Snedecor & Cochran, 1967) was employed to find out whether 'b' value significantly deviated from the expected cube value of 3 [$t = (b-3)/S_b$], where b = regression coefficient and S_b = Standard error of 'b'. The t-test (Snedecor & Cochran, 1967) on 'r' values reveals whether significant correlation exists between length and weight.

Relative condition factor (Kn) as per Le Cren (1951) is expressed as follows:

$$Kn = W / \hat{W}$$

where W = observed weight

$\hat{W}$ = calculated weight derived from length-weight relationship

Results and Discussion

Length-weight relationship of males, females and indeterminates of *P. carnaticus* can be expressed as follows:

Males : $\log W = - 4.1567 + 2.7148 \log L$
 Females : $\log W = - 4.5089 + 2.8618 \log L$
 Indeterminates : $\log W = - 0.9611 + 1.4243 \log L$

The 95% confidence limits of 'b' values were:

Male = 2.4705 to 2.959
 Female = 2.5386 to 3.1850
 Indeterminates = 1.3117 to 1.537

The correlation coefficient 'r' between log length and log weight was found to be 0.8705 in males, 0.8849 in females and 0.9311 in indeterminates. The 't' test on 'r' values (Table 1) showed the existence of good relationship between length and weight ($p < 0.01$). The results of ANOVA on the length-weight regressions were found to be highly significant in both the sexes as well as in indeterminates ($p < 0.001$). Based on the coefficient of determination (r^2) (Croxtan, 1953), 76% of the variation in weight in males, 75% in females and 86.5% in indeterminates were found to be associated with the change in the length of the fish.

The results of analysis of covariance (ANACOVA) revealed significant difference in the regression coefficient of males, females and indeterminates (F value = 69.04, df: 2, 1102) thereby indicating heterogeneity of the samples. Hence, pair-wise comparison between males and females, males and indeterminates, and females and indeterminates were carried out using Student's 't' test (Zar, 1974). The results revealed no significant difference between 'b' values of males and females ($t = 0.7$, df: 257). In contrast, indeterminates were found

to be significantly different from that of males ($t = 9.4$, df: 252, $p < 0.01$) and females ($t = 7.6$, df: 203, $p < 0.01$).

The comparison of elevations disclosed significant difference among the three groups ($p < 0.01$). Hence, pooling of data to provide a single equation expressing the length-weight relationship of *P. carnaticus* will not be justifiable, thus necessitating fitting up of separate equations for males, females and indeterminates.

The results of Bailey's 't' test revealed significant departure of 'b' value from the hypothetical value of '3' in males and indeterminates ($p < 0.01$) while no significant difference could be noticed in females. The 't' test arrived at, 2.3 (df: 152) in males manifested the significant departure of 'b' value from 3 ($p < 0.05$). In females, 't' value was 0.8 (df: 103) which was non-significant. In the case of indeterminates, the 't' value was 27.7 (df: 98) which was significantly different from 'b' value of 3 ($p < 0.01$).

In the present study, the highest 'b' value arrived at in females of *P. carnaticus* implies that the females gain weight at a faster rate in relation to its length whereas the low exponential value 1.4243 observed in indeterminates indicates their low growth rate. The 'b' value of males indicates negative allometry, which indicates that, the increase in length is not in accordance with increase in weight.

Reports on the length-weight relationship of cyprinid fishes showed that many of them strictly follow cube law while there are many in which the weights of fishes either tend to increase or decrease in proportion to

Table 1. Statistical details showing number of fish studied (n), intercept (log a), regression coefficient (b), standard error of b (sb) and results of Bailey's t-test on 'b' and t-test on correlation coefficient (r)

Sex	n	log a	b	sb	t	p	r	t	p
Males	262	- 4.1567	2.7148	0.1236	2.3	$p < 0.05$	0.8705	22.65	$p < 0.01$
Females	150	- 4.5089	2.8618	0.163	0.8	-	0.8849	20.1	$p < 0.01$
Indeterminates	470	- 0.9611	1.443	0.0568	27.7	$P < 0.01$	0.9311	24.35	$p < 0.01$

the cube of length. Isometric growth pattern has been reported in *Cirrhinus mrigala* and *Labeo rohita* (Jhingran, 1952), *Labeo calbasu* (Pathak, 1975), *Puntius sarana* (Sultan and Shamsi, 1981), *Puntius dorsalis* (Sivakami, 1982), *Catla catla* (Choudhury *et al.*, 1982; Kartha & Rao, 1990) and *Schizothorax plagiostomus* (Bhagat & Sunder, 1983). All these earlier reports are in compliance with the present findings on the length-weight relationship in females of *P. carnaticus* in which the 'b' value was very close to the isometric value of 3.

The slope value of regression line less than '3' has been reported in *Tor tor* (Malhotra, 1982), *Labeo dero* (Malhotra & Chauhan, 1984), *Labeo dyocheilus* (Malhotra, 1985), *Puntius ticto* and *Barilius bendelesis* (Gairola *et al.*, 1990) and *Cyprinus carpio communis* and *Ctenopharyngodon idella* (Dhanze & Dhanze, 1997) and *Rasbora daniconius* (Sunil, 2000). These reports corroborate with the present findings on the length-weight relationship in *P. carnaticus*, in which significant departure of 'b' value from the isometric value of 3 was noticed in respect of both males and indeterminates.

Females of *P. carnaticus* were found to surpass males in weight in relation to length as evidenced from the disparity in 'b' values. Similar trend has been observed in other cyprinids too viz., *Puntius kolus* (Bhatnagar, 1963) *L. fimbriatus* (Bhatnagar, 1972) *L. dero* (Malhotra & Chauhan, 1984) *R. daniconius* (Thakre & Bapat, 1984) and *L. dussumieri* (Kurup, 1990).

Le Cren (1951) reported that females are heavier than males of the same length probably because of the difference in fatness and gonadal development. While discussing the seasonal effect on length-weight relationship of *Clarias batrachus*, Mitra & Naser (1987) found that higher metabolic activity with spawning season lowered the 'b' value while less metabolic activities, accumulation of fat, weight of gonad, etc. during the pre-spawning period increased the values. The

higher regression coefficients in female *P. carnaticus* may be attributed to the higher fat accumulation and higher gonadal weight when compared to its male counterpart.

Beverton & Holt (1957) opined that since 'a' and 'b' of allometric formula might vary within a wide range for very similar data and are very sensitive to even slight variations in various factors, allometric formula worked better than cubic formula. Any indication in biological events could be recorded by allometric law. The significant departure of regression coefficients from the isometric growth value in male and indeterminates of *P. carnaticus* indicate that the general parabolic equation $W = aL^b$ expresses the length-weight relationship in these groups better than the cube law while the cube law $W = aL^3$ holds good for the females of this species.

The fluctuations noticed in 'Kn' values of males and females during 2001-02 and 2002-03 are represented in Fig. 1 and 2 respectively. In 2001-02 the 'Kn' values of

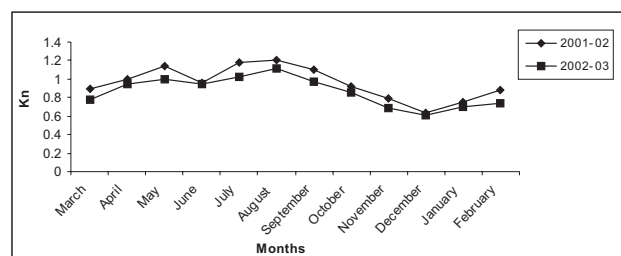


Fig. 1. Seasonal variation of relative condition factor (Kn) in males of *Puntius carnaticus*

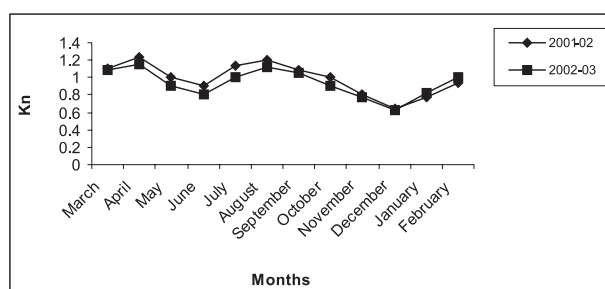


Fig. 2. Seasonal variation of relative condition factor (Kn) in females of *Puntius carnaticus*

males showed two peaks (May and August) and one trough (December). In 2002-03 also the 'Kn' of males showed the same pattern. In the case of females, during 2001-02 lowest 'Kn' value of 0.64 was observed during December. An increase in 'Kn' value was observed in April while it decreased in May-June followed by a gradual increase in the values upto August. After August the 'Kn' gradually decreased and reached the lowest level in December. In 2002-03 also females followed more or less the same trend.

Fluctuations in the condition of many fishes were observed in relation to their reproductive cycle (Neelakantan & Pai, 1985; Gairola *et al.*, 1990; Narejo *et al.*, 2002), feeding rhythms (Shrivastava & Pandey, 1981; Das gupta, 1991; Pandey & Sharma 1997) or physico-chemical factors of environment, age, physiological state of fish or some other unknown factors (Kurup and Samuel, 1987; Kurup, 1990; Kalita & Jayabalan, 1997). In *P. carnaticus*, the higher 'Kn' values recorded in March-April and July –August in females and April-May and July- August in males coincided with the occurrence of high gonadosomatic index (GSI) in both males and females (Manojkumar, 2007). The 'Kn' values in males showed a decreasing trend during June and from September to December. While in females, the relative condition factor decreased during May-June and September to December. This may be attributed to the increased spawning strain in them, as opined by Menon (1950). Thus it appears that reproductive cycle in *P. carnaticus* is related to the variations in the condition factor.

The mean values of relative condition factor worked out for different size groups of indeterminates, males and females are plotted in Fig. 3 and 4 respectively. In males, a 'Kn' value of 1.08 was worked out in 240-260 mm length group, followed by a decreasing trend in 260-280 and 280-300 mm size group. In 300-320 mm length group, the 'Kn' value increased up to 1.1 and plummeted to 0.94 in 340-360 mm length group.

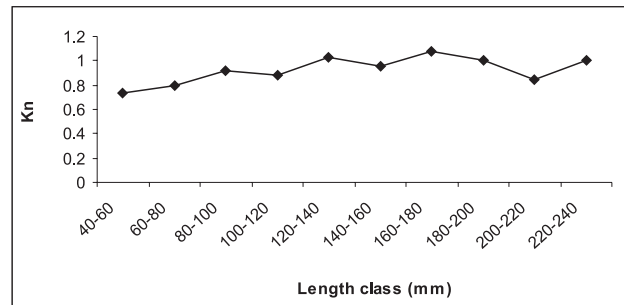


Fig. 3. Lengthwise variation in relative condition factor (Kn) of indeterminates of *Puntius carnaticus*

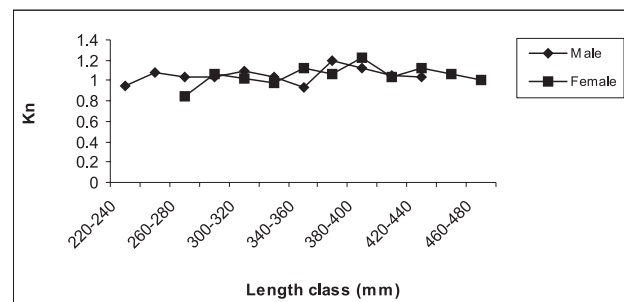


Fig. 4. Lengthwise variation in relative condition factor (Kn) of males and females of *Puntius carnaticus*

Thereafter, the 'Kn' value increased and reached the highest value of 1.2 in 360-380 mm size class followed by a diminishing trend. In females, after reaching a 'Kn' value of 1.06 in 280-300 mm size class, it gradually decreased and attained the lowest value of 0.98 in 320-340 mm size class. Thereafter, the 'Kn' increased to a peak in 380-400 mm length class followed by a gradual decline in the succeeding classes. In the case of indeterminates the 'Kn' gradually increased from 0.73 in 40-60 mm length class and showed a comparatively good condition of 1.03 in 120-140 mm length class. Thereafter the 'Kn' decreased to 0.96 in 140-160 mm length class and reached the peak of 1.08 in 160-180 mm length class. Beyond 160-180 mm length class the 'Kn' showed a declining trend and plummeted to 0.85 in 200-220 mm length group.

Sex-wise analysis of 'Kn' values revealed that the mean 'Kn' value in females (0.96) was higher than that of males (0.91). In indeterminates, the mean value was 0.77. According to Le Cren (1951), 'Kn' values

greater than 1 indicated good general condition of fish. Pandey & Sharma (1997) studied the condition of four exotic carps and only the common carp, *Cyprinus carpio communis* was found to have value above 1 (1.0109). Pandey & Sharma, (1998) reported high 'Kn' values for *Labeo rohita* (1.0129) and *C. catla* (1.0007) and low values for *Cirrhinus mrigala* (0.9967).

Influence of feeding intensity, as indicated by the gastro-somatic index, on condition factor was apparent during May, June and September (Manojkumar, 2007). In females even though the gonad was in far advanced condition during May, low 'Kn' value and comparatively low gastrosomatic index were observed (Manojkumar, 2007). Similarly in both males and females, during June, 'Kn' value was less when the gonadosomatic index was comparatively higher and gastrosomatic index was less.

It can be concluded that in *P. carnaticus*, females gain weight at a faster rate in relation to its length when compared to males and indeterminates. Females of *P. carnaticus* followed isometric pattern of growth whereas, males and indeterminates showed negative allometry. The study also revealed that in *P. carnaticus*, though the condition of fish is more related to gonadosomatic index, there exists some relationship between relative condition factor and gastrosomatic index and other environmental and physiological factors.

The authors are thankful to The Director, School of Industrial Fisheries, Cochin University of Science and Technology for providing the necessary facilities. The financial assistance from ICAR-NAT project on 'Germplasm Inventory, Evaluation and Gene Banking of Freshwater Fishes' is gratefully acknowledged.

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