



Length-weight relationship and condition factor of *Otolithoides pama* (Hamilton, 1822) from Hooghly-Matlah estuarine system of West Bengal, India

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ABSTRACT

The length-weight relationships (LWRs) of *Otolithoides pama* (Hamilton, 1822) from the Hooghly-Matlah estuarine system of West Bengal were estimated. The study is based on 618 samples (298 male and 320 female) collected at monthly intervals for a period of 18 months (November 2016 to April 2018) from artisanal catch. No significant difference ($p>0.01$) was observed in growth rate for both the sexes. The 'b' values were estimated at 2.88, 2.84 and 2.86 with 'r²' values as 0.96, 0.95 and 0.95 for male, female and pooled samples respectively. The growth pattern was found to be negatively allometric. The month-wise mean 'K' value ranged from 0.70 ± 0.07 to 0.78 ± 0.07 for male and 0.71 ± 0.05 to 0.89 ± 0.11 for female. The length-wise estimated mean 'Kn' value varied from 0.92 to 1.17 for male and 0.76 to 1.29 for female indicating the moderately good condition of the fish in the study area. The results can be used for sustainable management and conservation of this commercially important species in this estuary.

Keywords: Condition factor, Hooghly-Matlah Estuary, Length-weight relationship, *Otolithoides pama*

Introduction

The fishes of the family Sciaenidae, known as drums or croakers due to the sound produced using their swimbladders, are dominant members of continental shelf fauna in tropical and subtropical seas of the Atlantic, Pacific and Indian oceans. Nelson (1994) reported about 270, mostly marine species in about 70 genera with a few entering freshwaters. Mohanraj *et al.* (2003) reported that the family Sciaenidae is widely distributed throughout the world with approximately 70 genera and 300 species including about 30 species from Indian waters. Sciaenids are one of the most important commercial fishery resources of India and contributed 30% of the demersal fish catch during the year 2016-17 (CMFRI, 2016). The total marine fish catch of West Bengal during the year 2015-16 was estimated at 1,73,77 t and sciaenids contributed 11.45% (Anon., 2016). *Otolithoides pama* earlier known as *Pama pama* (*Sciaenoides pama*) locally called as 'Bhola' or Poa Bhola forms an important fishery in Hooghly-Matlah estuarine system. They are mainly caught by bag nets and drift gillnets in the Hooghly-Matlah estuarine system.

The knowledge of length-weight relationships (LWRs) has important implications in fishery biology and population dynamics. The length-weight relationship

(LWR) has considerable importance in fishery research especially for the study of fish population dynamics and growth (Mathur and Bhatara, 2007), taxonomic differences, events in life history like metamorphosis, maturity (Le Cren, 1951) and to the fisheries officials in evolving effective policies for management and conservation of the resource. The ratio of the length to the weight is known to be a useful index to indicate the condition of the fish. The LWR in fishes serves many important purposes like estimation of weight from length for individual fish and for length classes of fish, estimations of standing crop biomass when the length frequency distribution is known, to convert growth in length to growth in weight for estimation of weight at age and for use in stock assessment models.

The mathematical relationship between length and weight of fishes is a practical index suitable for understanding their survival, growth, maturity, reproduction and general well-being (Le Cren, 1951) and LWRs are also useful for fishery biologists for monitoring the state of health of a population (Cone, 1989). The asymptotic length (L_{∞}) based on the LWR forms an important parameter for the Beverton and Holt (1956) dynamic pool model.

In general, the expectations are that the weight of the fish is a function of cube ($b=3$) of the length of fish.

According to Carlander (1969), the value of 'b' fluctuates between 2.2 to 4.5, but Pauly and Gayanilo (1997) mentioned that the values may vary from 2.5 to 3.5. The fishes which follow the cube law in growth *i.e.*, unchanged body form and specific gravity have isometric growth. While fishes which do not follow the cube law in growth rate have allometric growth (positive or negative). The 'b' values less than 3 indicates that the fish become slender as growth increases and more than 3 indicates fish becomes heavier as size increases (Pauly, 1984). In recent years, several attempts were taken to study the LWRs of finfishes in freshwater and estuarine habitats of West Bengal (Dey *et al.*, 2016; Khongngain *et al.*, 2016; Chakraborty *et al.*, 2017; Pramanick *et al.*, 2017; Sarkar *et al.*, 2017a, b).

The estimation of K and relative condition factor (Kn) gives information on general well-being of the fish and its development process. In general, the heavier fishes of a given length are in better condition (Bagenal and Tesch, 1978). The condition factor (K) value gives information on the physiological state of the fish in relation to its well-being. The knowledge of fish condition indices provides comparative measures of fish freshness and plumpness. The study of fish condition parameter is a useful, inexpensive and easy measurement tool to know the fecundity, reproduction, growth and mortality rates of fishes (Chakraborty *et al.*, 2017; Pramanick *et al.*, 2017). The condition factor of a fish indicates accumulation of fat in the body and gonadal development (Le Cren, 1951) and also the reproductive status of the fish (Thakur, 1975).

Several researchers have worked on the LWRs and 'K' of sciaenids *viz.*, Rao (1971) on *Protonibea diacanthus*, Basu (1975) on *Otolithes argenteus*, Hussain and Abdullah (1977) on six sciaenid fishes from Kuwaiti waters, Murty (1979) and Apparao (1983) on *Pennahia macrophthalmus* and *Johnius carutta*, Muthiah (1982) on *Johnieops vogleri*, Murty and Ramalingam (1986) on *P. macrophthalmus* and *J. vogleri*, Gulati (1987) on *Otolithes cuvieri*, Kamat (1989) on *Johnius glaucus*, Mandal *et al.* (2008) on *Johnius gangeticus*, Bhuyan (2003) on *Otolithes ruber*, *J. carutta*, Kumar *et al.* (2014) on *O. cuvieri*, Sandhya *et al.* (2015) on *O. cuvieri* and Das *et al.* (2017) on *Nibea maculata*.

Nath *et al.* (2004) were the first to estimate the LWR of *P. pama* from Hooghly Estuary. Hossain *et al.* (2015) described the LWRs of *Otolithoides biauritus* and *O. pama* from the Tetulia River, southern Bangladesh. Recently Baitha *et al.* (2018) reported the LWR of *O. pama* from Ganga River, India. All these studies were based on pooled samples. Hence, the present study was conducted for estimation of LWRs and 'K' separately for both male and female of *O. pama* occurring in the Hooghly-Matlah Estuary of West Bengal.

Materials and methods

The study on the LWR of *O. pama* was based on fish samples comprising both males and females collected from three landing centers namely Godhakhali, Diamond Harbour and Frasergunj under Hooghly-Matlah estuarine system during November 2016 to April 2018. A total of 618 specimens comprising 298 males and 320 females ranging from 100-384 mm in total length and 7.29-470.71 g in total weight were collected. The freshly collected fish samples were transported to the laboratory in a plastic insulated box after preserving in ice for further studies. At the laboratory, the total length (TL) of the fish specimen was measured from the tip of the anterior-most part of the body to the tip of the caudal fin to the nearest 0.1 mm using measuring board; weight was noted to the nearest 0.01 g accuracy using an electronic balance. The LWR for both male and female specimens was calculated separately following the formula (Ricker, 1975): $W = aL^b$. This equation can also be expressed logarithmically as suggested by Le Cren (1951): $\text{Log } W = \text{Log } a + b \text{ Log } L$, where W = weight of fish in g, L = length of fish in mm, "a" and "b" are the intercept and regression coefficient respectively, which were estimated using the following formulae:

$$a = y - b x \text{ and } b = \frac{[n(\sum xy) - \sum x \sum y]}{[n\sum x^2 - (\sum x)^2]}$$

The coefficient of correlation "r" was determined in order to know the relationship between the two variables:

$$r = \frac{n \sum xy - \sum x \sum y}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$$

The linear equation was fitted separately for males and females. Analysis of covariance (Snedecor and Cochran, 1967) was used to determine variation in the 'b' values between the sexes at 5% level of significance.

Index of well being or condition of fish is measured by condition factor "K" following Fulton (1902) as: $K = \frac{W \times 10^3}{L^3}$, where K is the condition factor, W is weight of fish in g and L is total length in mm. Condition factor calculated for individual fish was pooled month-wise and sex-wise and the mode in the 'K' values can be taken to be an index of gonadal maturity and spawning season or better feeding conditions (Anderson and Gutreuter, 1983).

The relative condition factor can also be used to compare the general well-being, fatness or the state of development of gonad (Froese, 2006). The relative condition factor (Kn) was calculated using the formula: $Kn = W_0 / W_c$, where W_0 = observed weight and W_c = calculated weight. Monthly mean values of Kn

were calculated for individual samples and the average of the K_n was estimated accordingly.

Results and discussion

Length-weight relationships

The LWR was established for 618 individuals of *O. pama* within the range of 100-384 mm in total length and 7.29-470.71 g total weight. A total of 298 males with the size ranging from 100-327 mm (189.59 ± 27.37 mm) and 7.29-270.00 g (53.43 ± 26.79 g) were used for the study. In females, 320 fishes within the size ranged from 107-384 mm (195.65 ± 38.35 mm) and 10.20-470.71 g (65.57 ± 47.55 g) were used for the study. The LWR for both the sexes is presented through the scatter diagram (Fig. 1) and the logarithmic equation is as follows:

$$\text{Male : } \log W = -3.656 + 2.87581 \log L \quad (r^2 = 0.956)$$

$$\text{Female : } \log W = -3.552 + 2.83553 \log L \quad (r^2 = 0.945)$$

$$\text{Pooled : } \log W = -3.609 + 2.85848 \log L \quad (r^2 = 0.946)$$

The results of LWRs along with the descriptive statistics are presented in Table 1. The logarithmic form of the LWR for both the sexes and pooled samples are presented in Fig. 1.

Generally, the regression coefficient (b) = 3 for LWR indicates that the fish grows symmetrically or isometrically. Values other than 3 indicate allometric growth (positive or negative allometric). Fish having 'b' value as 3 maintain their specific body shape throughout their life (Bal and Rao, 1984; Day, 2007). Variation in the relative growth (b) of the species reported from different places suggests an inter-regional difference in the LWR of the fish. Three reports on length-weight of *O. pama* are available, one from Bangladesh and two are from Hooghly Estuary and Ganga River, West Bengal, India.

According to Nath *et al.* (2004), the 'b' value for pooled samples of *O. pama* was found to be 3.17, with value of correlation coefficient (r) 0.998 from Hooghly Estuary, which showed a highly significant relationship between length and weight. Hossain *et al.* (2015) reported LWR of *O. pama* and *O. biauritus* from Tetulia River of Bangladesh and 'b' values were mentioned as 3.02 ($n=135$) and 2.55 ($n=168$) respectively for combined sexes. For both the species, the LWRs were highly significant ($p < 0.01$) and the coefficient of determination (r^2) values were 0.954 and 0.974 for *O. pama* and *O. biauritus* respectively. Baitha *et al.* (2018) reported pooled 'b' value of 2.86 with 'r' value as 0.98 from the lower Ganga River of West Bengal.

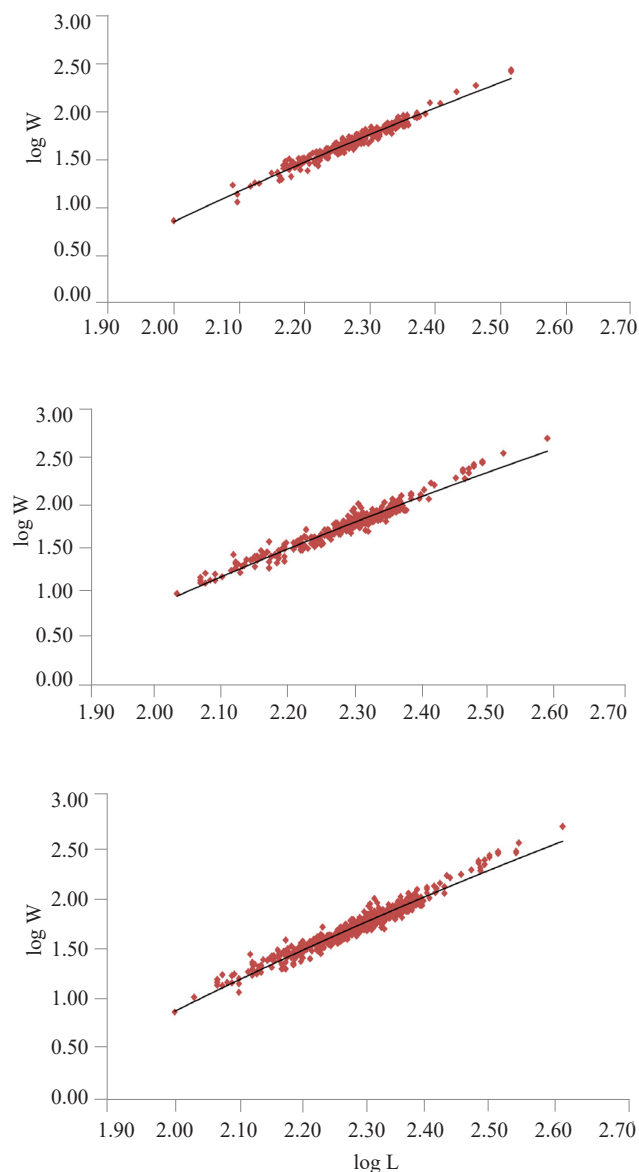


Fig. 1. Logarithmic length-weight relationship of *O. pama*. (a) Male, (b) Female and (c) Sexes pooled

Manojkumar and Acharya (1990) in their study reported 'b' and 'r' values as 2.646 and 0.991 for combined sexes of *O. biauritus* collected from Mumbai waters. Ghosh *et al.* (2009) reported a 'b' value of 2.539 for *O. biauritus* from Diu. The 'b' value obtained from the present study is similar with the study of Baitha *et al.* (2018) but differ from Nath *et al.* (2004) and Hossain *et al.* (2015). The observed differences in 'b' values may be due to the combination of one or more factors like habitat, area, seasonal effects, the degree of stomach fullness, gonad maturity, sex ratio, health condition, preservation techniques and length groups of studied specimens (Tesch, 1971). A comparative LWR from genus *Otolithoides* is presented in Table 2.

Table 1. Descriptive statistics and estimated length-weight distribution of *O. pama* collected from Hooghly-Matlah Estuary

Group	N	Regression parameters		95% CL of a	95% CL of b	R ²
		a	b			
Male	298	0.0078	2.8758	0.0067-0.0091	2.8067-2.9449	0.9577
Female	320	0.0088	2.8355	0.0074-0.0103	2.7645-2.9066	0.9510
Pooled	618	0.0082	2.8585	0.0073-0.0092	2.8072-2.9098	0.9510

Table 2. Comparative length-weight relationship of *O. pama* and *O. biauritus* by other researchers

Author	Sex	Intercept (a)	Slope (b)	Correlation coefficient (r)	Sample size	Area of study
<i>O. pama</i>						
Nath <i>et al.</i> (2004)	Pooled	0.004071	3.17	0.998	-	Hooghly Estuary, India
Hossain <i>et al.</i> (2015)	Pooled	0.0075	3.02	0.954 (r ²)	135	Tetulia River, Bangladesh
Baitha <i>et al.</i> (2018)	Pooled	0.012	2.86	0.98	92	Ganga River, India
Present study	Male	0.0000140	2.875806	0.957742 (r ²)	298	Hooghly-Matlah Estuary
	Female	0.0000183	2.835533	0.950964 (r ²)	320	
	Combined	0.0000158	2.858481	0.951047 (r ²)	618	
<i>O. biauritus</i>						
Hossain <i>et al.</i> (2015)	Pooled	0.0347	2.55	0.974 (r ²)	168	Tetulia River, Bangladesh
Manojkumar and Acharya (1990)	Pooled	0.026	2.646	0.991	-	Mumbai waters, India
Ghosh <i>et al.</i> (2009)	Pooled	0.154	2.539	-	-	Diu, India
Purushottama <i>et al.</i> (2017)	Male	0.005969	3.0	0.991	289	North eastern Arabian Sea, India
	Female	0.008416	2.9	0.996	273	
	Combined	0.009158	2.9	0.994	562	
Kumar <i>et al.</i> (2015)	Pooled	1.423	2.539	0.758	485	Mumbai waters, India

Condition factor (K) and relative condition factor (Kn)

The month-wise mean estimated condition factor for both male and female specimens is given in Fig. 2. For the male, the higher monthly mean values of ‘K’ was found during March (0.78±0.07) and September (0.78±0.04) and lowest during July (0.70±0.07) and December (0.70±0.05). In the case of female, the highest monthly mean ‘K’ values were recorded during March (0.89±0.11) and lowest during April (0.71±0.05). For both the sexes, the maximum ‘K’ value was observed during the month of March which is supposed to be one of the peaks of spawning for the fish. For both the sexes there was an irregular trend in ‘K’ values and in most of the months, female specimens were in better condition compared to the males.

The length-wise estimated condition factor for both male and female is given in Fig. 3. For male, length-wise mean ‘K’ values varied from 0.70±0.06 to 0.81±0.00 mm with lowest in the 220-239 mm length group and the highest in the 260-279 mm length group. For female, the mean lowest value (0.72±0.08) was recorded from 220-239 mm length group and highest (0.90±0.09, 0.90±0.02 and 0.90) from 100-119, 300-320 and 320-339 mm length groups respectively. Females were found in better condition in all length groups compared to male specimens. In all the length groups, the ‘K’ values were found to be slightly less

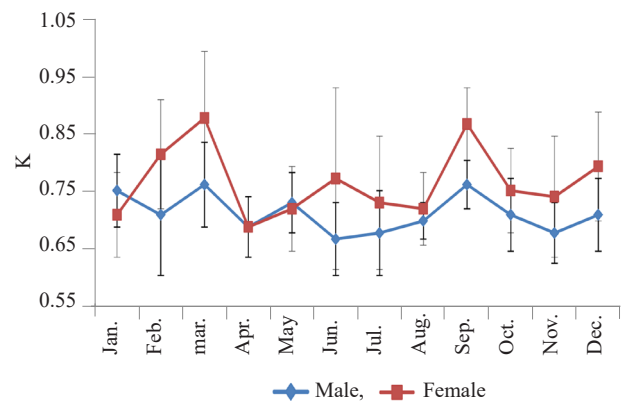
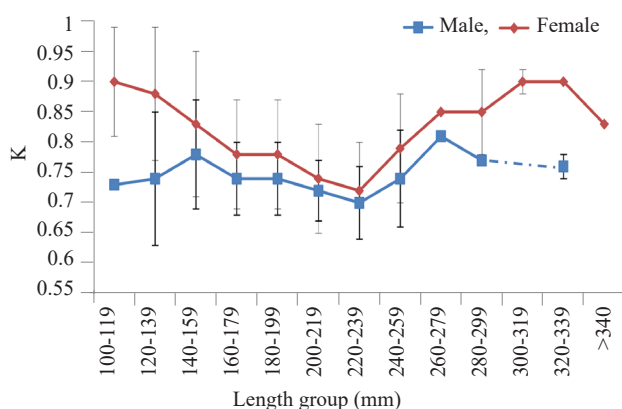
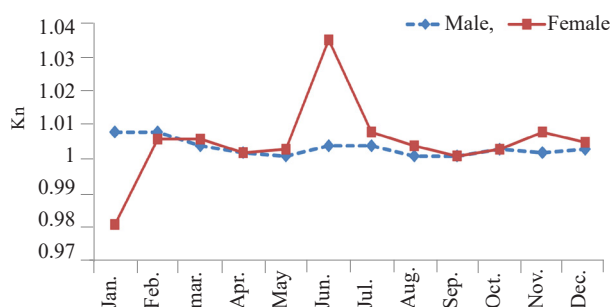


Fig. 2. Month-wise condition factor (K) of *O. pama*

than 1 which indicated that *O. pama* occurring in Hooghly-Matlah Estuary were in marginal stressed condition.

In the present study, there was little variation in month-wise ‘Kn’ values for both the sexes (Fig. 4). For the male specimens, the highest monthly mean ‘Kn’ values were recorded during the month of February (1.01±0.13) and for the female during June (1.03±0.22).

The length-wise estimated ‘Kn’ values are presented in Fig. 5. For male specimens, the highest mean ‘Kn’ value (1.17±0.11) was observed in the 240-259 mm length group and lowest (0.92±0.00) in the 100-119 mm length group. It was observed that in male specimens, the

Fig. 3. Length-wise condition factor (K) of *O. pama*Fig. 4. Month-wise relative condition factor (Kn) of *O. pama*

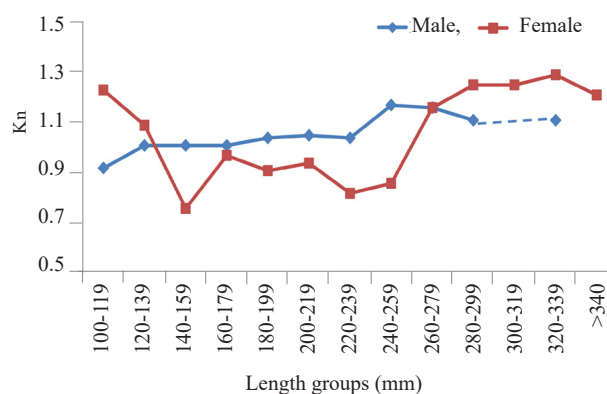
mean 'Kn' values gradually increased from lower length (100-119 mm) group to 220-239 mm length group and highest at 240-259 mm length group. After that, there was a gradual decline of mean 'Kn' values. In the case of female specimens, the lowest mean Kn (0.76 ± 0.15) value was noticed in the 140-159 mm length groups and highest (1.29 ± 0.00) in the 320-339 mm length group. For females, at initial length groups, the mean 'Kn' value was higher and then decreased upto 240-259 mm length group and again it increased in 320-339 mm length group.

The data on length-weight relationships are used for estimating condition factor and these values are used for comparing the general well-being of fishes (Le Cren, 1951; Froese, 2006). The condition factor reflects the physiological state of a fish, which is influenced by both intrinsic (gonadal development, organic reserves, presence or absence of food in the gut) and extrinsic (food availability, environmental variability) factors (Nikolsky, 1969).

In the present study, there was less variation in 'K' values for both the sexes and the values were relatively low which may correlate with several factors. For both

the sexes, the maximum 'K' value was observed during the month of March which is supposed to be one of the peaks of spawning season of the fish. For males, the lowest monthly mean 'K' value was observed during July and December and for females during April with females exhibiting better condition than males.

There are many factors which regulate the variation in condition factor in fishes. Hickling and Rutengberg (1936), Thompson (1943) and several other Indian investigators have correlated the lower level of condition with the approach of sexual maturity and spawning in fishes. But Narsimham (1970) mentioned that condition

Fig. 5. Length-wise relative condition factor (Kn) of *O. pama*

factor does not necessarily depend on the sexual cycle but is highly related to feeding activity. Significant seasonal and annual differences in condition factors were found for two sciaenids species of *Micropogonias furnieri* and *Cynoscion guatucupa* from the Rio de la Plata and Uruguay, south-western Atlantic (Galli and Norbis, 2016). King (1995) mentioned that there are multiple factors which regulate the condition factor in fishes, which include food availability, environmental stress and gonadal development. In the present study, the highest value of condition factors was observed during the spawning season of the species which differs from the other studies related to sciaenids in Indian waters (Nair, 1977; Jayasankar, 1994).

Rangarajan (1971) could not correlate the changes of condition factor either to sexual cycle or intake of food. Baragi and James (1980) reported no difference in the condition of both the sexes of *Johnnieops osseus* from South Kanara coast, but smaller specimens' showed lower condition than larger specimens. As per Baragi and James (1980), maturity and spawning may not be the factors responsible for monthly variation in condition factor in *J. osseus*. The availability of food items in the environment

and rate of feeding and several other environmental factors also may be responsible for variation in metabolic activity of the fish which in turn result in raising or lowering the condition during the sexual cycle (Rao, 1963). The variations of 'K' in the fish may be indicative of food abundance, adaptation to the environment and gonadal development (King, 1995).

The size of fishes was found to be influential in regulating the condition factor in fishes. Telveker *et al.* (2006) observed the highest condition factor of *O. cuvieri* in 300-319 mm length group for female and 240-259 mm length group for male with female specimen showing higher condition compared to male. Month-wise higher 'K' value was reported during April and December, which was associated with the breeding periods of the species from Mumbai waters.

Length group-wise condition factor revealed that in lower and higher length groups, the 'K' values were higher while in middle length groups the values were less which coincides with the study of Sandhya (2012) in *O. cuvieri* from Ratnagiri waters. Kumar *et al.* (2014) found the similar trend of monthly 'K' values between male and female and parallel trend in different size groups of *J. carutta* from Visakhapatnam coast. The values of 'K' showed an increasing trend with an increase in the size of fish except in one or two length groups and the value was influenced by gonadal maturity, spawning season and feeding rate of fish.

There are some studies which reported that the value of condition factor decreased as the size of the fish increased. Hart (1946) also stated that, as the size of the fishes increased, the value of condition factors decreased which is attributed to spawning strains. The highest value of 'K' was found in lower length classes,

then reduced to medium length classes and again increased in higher length classes of *O. cuvieri* from Ratnagiri coast (Sandhya, 2012). According to Das *et al.* (2017), the month-wise 'Kn' values of *N. maculata* off Gopalpur coast of Odisha varied from 0.8 (April) to 1.18 (February) and in different length class varied from 0.95 to 1.00. They also mentioned that the ponderal index (K) decreases with increase in length classes. The decrease of 'K' value with increase in length classes may be due to higher feeding intensity of smaller fishes compared to the larger fishes which was supported by the work of Das *et al.* (2017) in *N. maculata*.

The Kn values could not be correlated with other biological parameters in the present study. Researchers like Baragi and James (1980) also found similar difficulties in correlating the changes in condition factor of the sciaenid *J. osseus (dussumieri)* based on the intake of food and sexual maturity. Rangarajan (1971) also could not correlate these changes either to the sexual cycle or intake of food. Comparative condition factors and relative condition factors of some sciaenids by other researchers are presented in Table 3.

Several other factors like gonadal development and feeding activity also influence 'Kn' values in fishes (Doddamani *et al.*, 2001). Changes in the relative condition factor among seasons for *M. furnieri* and *C. guatucupa* could be related to reproduction, feeding habits and/or water temperature (Galli and Norbis, 2016).

The fluctuation in the ponderal index throughout the year can be correlated with sexual maturity cycle and feeding intensity of the species. The results of 'Kn' which was found around one, indicates favourable environment for the growth of the fish along Hooghly-Matlah estuarine system.

Table 3. Comparative condition factors and relative condition factors of selected sciaenid species by other researchers from the east coast of India

Species	Author	Sample size	'K'/'Kn'	Location
<i>Johnius gangeticus</i>	Mandal <i>et al.</i> (2008)	489	1.65-2.05	Hooghly-Estuary
<i>Johnius carutta</i>	Kumar <i>et al.</i> (2014)	3406	M =1.290 - 1.374 F =1.294 - 1.474	Visakhapatnam coast
<i>Pama pama</i>	Mitra <i>et al.</i> (2016)	-	1.009 0.595	Hooghly Estuary Matlah Estuary
<i>Otolithoides biauritus</i>		-	1.009 0.918	Hooghly Estuary Matlah Estuary
<i>Sciaena biauritus</i>		-	1.099 0.992	Hooghly Estuary Matlah Estuary
<i>Nibeia maulata</i>	Das <i>et al.</i> (2017)	680	0.8-1.18 (Kn)	Gopalpur coast, Odisha
<i>Otolothoides pama</i>	Present study	298 320	M = 0.70 ± 0.05 - 0.78 ± 0.07 F = 0.71 ± 0.05 - 0.89 ± 0.11	Hooghly-Matlah Estuary

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