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Note

Length-weight relationship and condition factor of *Sphyraena putnamae* Jordan and Seale, 1905 and *Sphyraena obtusata* Cuvier, 1829 from Pamban Island waters, Gulf of Mannar, south-east coast of India

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ABSTRACT

Length-weight relationships (LWRs), Fulton's condition factor (K) and relative condition factor (Kn) of two barracuda species, *Sphyraena putnamae* Jordan & Seale, 1905 and *Sphyraena obtusata* Cuvier, 1829 were studied from the Gulf of Mannar. The length and weight range for *S. putnamae* was 23.6 to 55.3 cm and 70.89 to 702.50 g, respectively, whereas for *S. obtusata* it was 17.7 to 40.9 cm and 34.68 to 299.01 g, respectively. The estimated 'b' value for *S. putnamae* ranged from 2.632 to 2.743, whereas for *S. obtusata* it ranged from 2.621 to 2.722. The results indicated a negative allometric growth pattern (b<3) in both the species. For *S. putnamae,* the coefficient of determination (r^2) was from 0.928 to 0.969, whereas for *S. obtusata,* it was 0.904 to 0.930. The regression slopes (b) of both sexes of *S. putnamae* and *S. obtusata* showed no significant difference (p>0.05) in the analysis of covariance (ANCOVA). Condition factor (K) was estimated to be higher for *S. obtusata* (0.70±0.10; Mean±SE) than *S. putnamae* (0.49±0.04) for the total population. The relative condition factor (Kn) was estimated as 1.05±0.07 for *S. putnamae* and 1.00±0.12 for *S. obtusata* populations.

Keywords: Allometric growth, Biomass, Fishery management, Morphology, Sphyraenidae

The barracudas are acanthomorph teleosts belonging to the family Sphyraenidae and are commonly called spikes, which are important food and sport fishes (Williams, 1959). Barracudas are active predatory fish with entirely marine life, but some species during the juvenile stage inhabit tropical mangrove or shallow estuarine regions (Senou, 2001). In 2018, the overall barracuda landing was 46,370 t along the Indian waters and Tamil Nadu contributed the maximum of 16,678 t (CMFRI, 2018). In 2019, it was 34,010 t and Tamil Nadu contributed around 13,715 t (CMFRI, 2019). The length-weight relationship is an important tool for measuring fish species' weight and biomass (Froese, 2006) and these studies are required to evaluate morphological characteristics of different species within the same taxon and populations from different geographical locations (Roul *et al.,* 2017). Fulton's condition factor (K) is commonly used in fish biology studies which state the relative fatness of fish. It is an index that represents the interplay between biotic and abiotic elements in the physiological condition of fish (Lizama and Ambrosio, 2002). It is derived from the relationship between a fish's weight and length to represent a fish's "condition" or well-being (Froese, 2006). The relative condition factor (Kn) determines the 'condition' of a fish based on the concept that a fish that is heavier for a given length is in better condition (Bagenal and Tesch, 1978). When comparing an individual's observed weight to the mean weight for that length, the relative condition factor (Kn) can be employed (Froese, 2006). The 'condition' determined by relative condition factor (Kn) is based on the hypothesis that heavier fish for a given length is in the better condition (Bagenal and Tesch, 1978). The relative condition factor (Kn) can be used for comparing the observed weight of an individual with the mean weight for that length (Froese, 2006).

The Gulf of Mannar (GOM) is one of the most biologically diverse region in India and exhibits tropical weather conditions throughout the year. The north-east monsoon brings more rain to the GOM than the south-west monsoon (Jyothibabu *et al.,* 2021). The GOM ecosystem is very productive, sustaining many species and eco-sensitive habitats. Around 4,223 species of flora and fauna are reported from this region (UNESCO, 2019). The barracudas, inhabiting the 20-40 m depth range, are found to prefer warmer low saline waters of the Gulf of Mannar (Sivakami *et al*., 1996). Only a few attempts have been made to understand the biology of *S. obtusata* from the Thoothukudi waters of the Gulf of Mannar (Kasim and Balasubramanian, 1990; Kasim, 2000; Roul

et al., 2020) except Srilankan waters of the Gulf of Mannar (Somavanshi, 1989). LWR and condition factor is essential to understand the life cycle of any fish species, which helps in framing proper management measures and to know their equilibrium in the ecosystem. Hence, the present study was aimed at estimating the length-weight relationship (LWR), Fulton's condition factor (K) and Relative condition factor (Kn) for *S. putnamae* and *S. obtusata,* which are commercially exploited along the Pamban waters of Tamil Nadu, India.

Two species of barracudas, namely *Sphyraena putnamae* Jordan & Seale, 1905 and *Sphyraena obtusata* Cuvier, 1829 were studied, which are locally known as 'Maoola' and 'Karaooli', respectively. Weekly, fish specimens were collected from March 2019 to February 2020 from the Pamban Therkuvadi Fish landing centre (lat 9°16'45.681"N and long 79°12'19.29" E) (Fig. 1). A total of 226 nos. of *S. putnamae* and 684 nos. of *S. obtusata* specimens were collected without physical damage, iced and brought to the laboratory for detailed analysis. They were identified based on the standard key given by Fisher and Whitehead (1974). Fish specimens were measured to the nearest cm (TL-total length) with an accuracy of 1 mm and weighed to the nearest g (TW-total weight) using an electronic balance with an accuracy of 0.01 g (Model-Ishtaa ITA-610J - Ishtaa Scales Inc. India). The fish specimens were dissected to identify the sex for further analysis. The length-weight relationship was estimated separately for males, females and pooled individuals using Le Cren's (1951) equation, $TW = aTL^b$, where TW is total body weight (g) and TL is total length (cm) and 'a' is the body form intercept and 'b' is the coefficient indicating allometric growth.

The coefficient of determination (r^2) and the 95% confidence limits (CL) of parameters 'a' and 'b' were calculated. At 1 and 5% levels of significance, the analysis of covariance (ANCOVA) was used to examine the difference in mean log-weight adjusted for a covariate (log length) and the homogeneity (equality) of regression slopes between male and female participants. At 1 and 5% significance levels, the Student's 't' test was used to assess the 'b' value against the null hypothesis of isometric growth (H0: b = 3). The equation K = (W L-3) 100 was used to compute Fulton's condition factor (K), where W represents body weight and L is total length (Le Cren, 1951).

The relative condition factor (Kn) is calculated as Wo/Wc, where Wo is the observed weight and Wc is the predicted weight (Le Cren, 1951). When Kn=1, the organism is in good growth condition and when Kn<1, the organism is in poor growth condition, compared to an average individual of the same length. It is worth noting that the stomachs of the fishes were not removed prior to weighing. MS-Excel 2016 and PAST 3.0 were used for all statistical analyses.

The barracudas are exploited mainly by trawl nets operated from boats of 24 m overall length (OAL) fitted with 240 HP along the Pamban waters (Northern Gulf of Mannar). These two species are commercially important and are landed throughout the year along this coast. Both

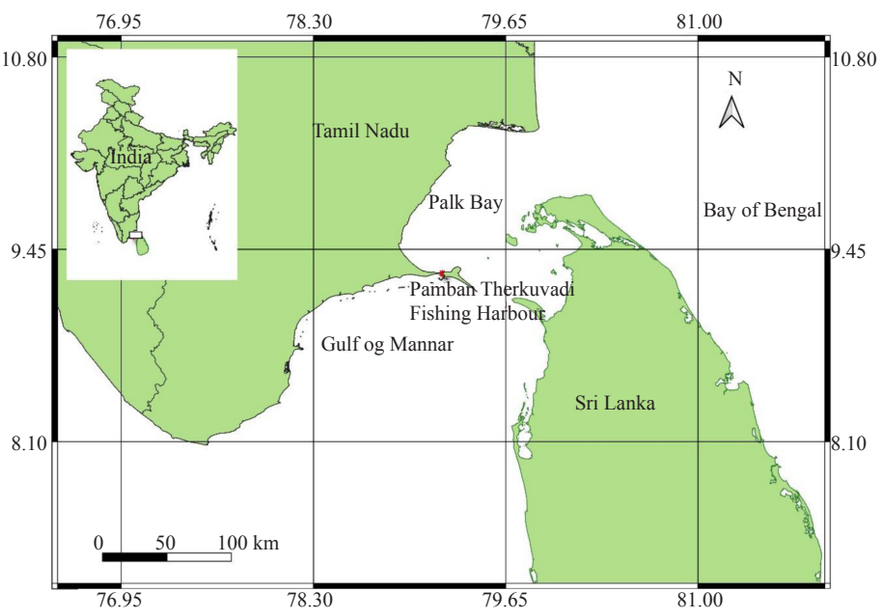

Fig. 1. Sampling location of Barracudas at Pamban Therkuvadi, Gulf of Mannar

the species have good demand in local markets due to their high preference among the consumers. Descriptive statistics such as sample size, minimum length, maximum length, intercept (a) and slope of regression (b) and the coefficient of determination (r^2), were estimated using the formula based on total length (TL) of S. *putnamae* and *S. obtusata* (Table 1). The length and weight range for *S. putnamae* was 23.6 to 55.3 cm and 70.89 to 702.50 g, respectively. The recorded size ranges of this species showed that it is smaller than earlier reported studies (Table 2). The estimated co-efficient 'b' value based on total length (TL) and fork length (FL) for *S. putnamae* ranged from 2.632 to 2.743 and the results indicated negative allometric growth in the species. Limited studies have been carried out on the length-weight relationship of *S. putnamae* which specifies the negative allometric growth for this species (Table 3). The length and weight range for *S. obtusata* ranged from 17.7 to 40.9 cm and 34.68 to 299.01 g, respectively. The estimated co-efficient 'b' value based on total length (TL) and fork length (FL) for *S. obtusata* ranged from 2.621 to 2.722. The result specifies negative allometric growth of the species. The calculated 'b' value for *S. obtusata* based on total length ranged from 2.621 to 2.722, which illustrates negative allometric growth in the species. Froese (2006) stated that 'b' values for fishes usually range from 2.5 to 3.5. In the present study, the estimated 'b' values of *S. putnamae* and *S. obtusata* were less than 3, indicating a negative

Table 1. Descriptive statistics and LWR (based on TL-total length) of *S. putnamae* and *S. obtusata* from Pamban waters of Gulf of Mannar

Species	Sex	N	Length (cm)		Weight (g)		Relationship parameters			95% CI of a	95% CI of b	Type of growth	LWR
			Min.	Max.	Min.	Max.	a	b	r^2				
S. putnamae	M	110	23.6	55.3	70.8	695.0	0.016	2.659	0.953	0.011-0.025	2.546-2.772	-A	$W=0.016*L^{2.659}$
	F	119	27.5	54.5	101.0	702.5	0.012	2.743	0.928	0.010-0.018	2.639-2.783	-A	$W=0.018*L^{2.780}$
	P	226	23.6	55.3	70.8	702.5	0.018	2.632	0.969	0.009-0.017	2.653-2.833	-A	$W=0.022*L^{2.723}$
S. obtusata	M	371	17.7	35.7	34.6	299.0	0.013	2.722	0.904	0.009-0.017	2.639-2.822	-A	$W=0.016*L^{2.758}$
	F	313	20.0	40.9	40.5	297.5	0.018	2.621	0.930	0.014-0.024	2.541-2.703	-A	$W=0.016*L^{2.700}$
	P	684	17.7	40.9	34.6	297.5	0.015	2.667	0.926	0.013-0.018	2.610-2.725	-A	$W=0.016*L^{2.755}$

M: Male; F: Female; C: Combined; N: Sample size; Min: Minimum; Max: Maximum; a and b: Intercept and Slope of regression; r^2: Coefficient of determination; -A: Negative allometric; LWR: Length-weight relationship

Table 2. Length-weight relationship of *S. putnamae* and *S. obtusata* reported from different regions of the world

Locality/Country	Sex	Size (cm)	a	b	Reference
S. putnamae					
New Caledonia waters	Unsexed	20.0 -104.0 (FL)	0.00834	2.903	Letourneur *et al.* (1998)
New Caledonia waters	Mixed	19.5-104.0 (FL)	0.00754	2.931	Kulbicki *et al.* (2005)
North of Persian Gulf	Sexed	10.6- 96.5 (FL)	0.0071	2.9995	Mohammadizadeh *et al*. (2010)
Karnataka waters, India	Sexed	18.5-100.0 (FL)	0.0140	2.690	Rajesh *et al.* (2020)
Kerala Waters, India	Unsexed	11.0- 88.0 (TL)	0.008	2.858	Roul *et al.* (2020)
Bay of Bengal, India	Sexed	14.7 -123.0 (FL)	0.0129	2.9945	Gosh *et al.* (2021)
Gulf of Mannar, India	Sexed	23.6 -55.3 (FL)	0.0127	2.7217	Present study
S. obtusata					
Gulf of Mannar, India	Unsexed	16.0-40.0	0.0041	3.131	Somavanshi (1989)
Kochi, India	Sexed	11.5-37.0	-	-	Premalatha and Manojkumar (1990)
Gulf of Mannar, India	Unsexed	11.0-43.5 (FL)	0.00001	2.381	Kasim and Balasubramanian (1990)
Visayas, Philippines	-	-	0.0070	3.000	Federizon (1993)
Western Region Indonesia	Unsexed	12.0-50.0 (FL)	0.0095	2.868	Pauly and Martosubroto (1996)
New Caledonia	Unsexed	19.0-26.5 (FL)	0.0370	2.472	Letourneur *et al.* (1998)
Malaysia	Unsexed	-	0.0070	2.870	Ahmad *et al.* (2003)
Bombay, India	Sexed	18.1-43.5	0.000024	2.722	Jaiswar *et al.* (2004)
New Caledonia	Unsexed	19.0-26.5 (FL)	0.0257	2.588	Kulbicki *et al.* (2005)
Jaffna Lagoon	Sexed	14-33.4	0.0133	2.857	Shivasanthini *et al.* (2009)
Gulf of Mannar, India	Unsexed	18.2-39.0 (TL)	0.005	3.017	Roul *et al.* 2020
Vizhinjam, India	Sexed	20.8-21.5 (TL)	-5.1909	3.090	Shaila Prasad *et al.* (2021)
Mangaluru, India	Sexed	16.5-30.1 (TL)	0.01945	2.654	Meshram *et al.* (2021)
Gulf of Mannar, India	Sexed	17.7-40.9 (TL)	0.013	2.722	Present study

L- Fork length, TL-Total length, a-Intercept, b-Slope

Table 3. Differences in the mean condition factor (K) and Relative condition factor (Kn) of male and female *S. putnamae* and *S. obtusata* in different length groups

Size group (cm)	Male			Female		
	No. of fish	K (Mean±SD)	Kn (Mean±SD)	No. of fish	K (Mean±SD)	Kn (Mean±SD)
S. putnamae						
23.6-28.6	1	0.54±0.00	0.99±0.00	1	0.49±0.00	0.95±0.00
28.6-33.6	1	0.56±0.00	1.15±0.00	13	1.30±0.24	1.07±0.46
33.6-38.6	23	0.47±0.04	1.01±0.09	14	0.59±0.05	1.06±0.10
38.6-43.6	34	0.46±0.05	1.03±0.12	34	0.79±0.06	1.03±0.13
43.6-48.6	30	0.45±0.03	1.04±0.07	34	0.52±0.03	1.01±0.06
48.6-53.6	16	0.41±0.02	0.98±0.05	11	0.45±0.02	0.96±0.05
53.6-58.6	2	0.43±0.02	1.04±0.05	3	0.43±0.02	0.98±0.04
58.6-63.6	-	-	-	1	0.20±0.00	0.48±0.00
S. obtusata						
11.8-16.8	-	-	-	2	0.85±0.08	1.28±0.14
16.8-21.8	19	0.79±0.42	1.43±0.76	11	0.70±0.15	1.25±0.26
21.8-26.8	140	0.53±0.14	1.01±0.25	96	0.58±0.14	1.10±0.25
26.8-31.8	197	0.49±0.07	0.99±0.13	125	0.51±0.11	1.04±0.21
31.8-36.8	19	0.47±0.08	0.99±0.17	80	0.49±0.13	1.05±0.13
36.8-41.8	-	-	-	9	0.44±0.09	0.98±0.19

allometric relationship inferring that weight increase will be slower than increase in body length of both barracuda species. This might be due to the unique morphology of *Sphyraena* spp.

In the present study, the size range, 'a' and 'b' values of *S. obtusata* were found comparable with those already reported from different parts of the world (Table 2). The 'b' value of *S. obtusata* was on par with other reported researchers, except with Somavanshi (1989) and Roul *et al*. (2020), who reported positive allometric and Federizon (1993) who observed isometric growth respectively. The difference in 'b' values can be attributed to different factors like geographical, ecological, physiological, environmental factors (temperature, salinity), biological factors (season, food availability, habitats, gonad development, health) as well as due to variations (number and length range) in the specimen analyses (Wootton, 1998; Froese, 2006). The length-weight showed significant correlation between them, as evidenced through the high value of the coefficient of determination for both *S. putnamae* and *S. obtusata.*

The relationship between total length and weight of the fish were plotted separately for males, females and pooled as shown in Fig. 2 and 3. There was no significant difference between the 'b' values between sexes for both the species, which indicated the non-existence of differential growth rate for length and weight between sexes ($p>0.01$, $r^2> 0.90$). Both males and females of both species showed negative allometric growth (Table 1).

Table 3 depicts the differences in the lowest, maximum, mean, and relative condition factor (Kn) of males and females of *S. putnamae* and *S. obtusata* in different length groups. In the present study, females

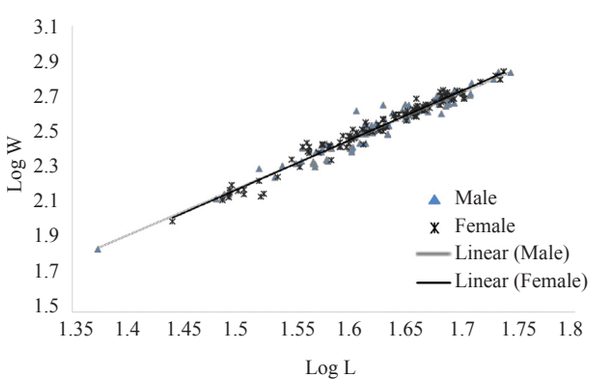

Fig. 2. Log transformed LWR for female (**x**), male (▲) of *S. putnamae*

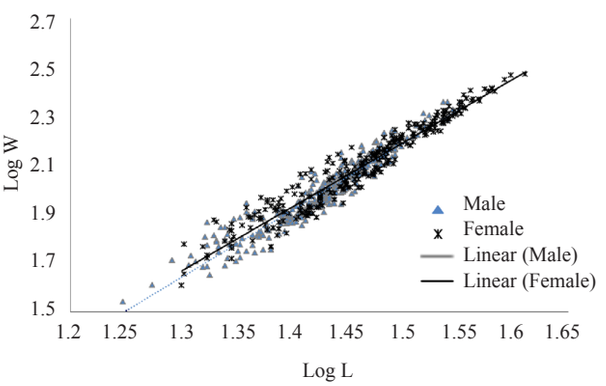

Fig. 3. Log transformed LWR for female (**x**), male (▲) of *S. obtusata*

had higher K values than males and smaller size groups had higher K values than larger size groups for both *S. putnamae* and *S. obtusata.*

The present study supported the general observation that higher values of condition factor are observed in the smaller size groups of fish. In the present study, the mean (K) 0.49 value of *S. putnamae* was similar to that reported by Hassan *et al*. (2020) (K= 0.5085) along Pakistan waters. Aggrey-Fynn and Hotor (2021) also reported that *S. sphyraena* has higher K values in smaller groups in Ghanaian waters. Gonzalez-Acosta *et al*. (2015) reported K value of 0.574 for *Sphyraena idiastes* from Gulf of California coast. Ayo-Olalusi and Ayoade (2019) reported similar observations of higher K values (1.19) in females of *S. afra* from Lagos waters. Shaila Prasad *et al*. (2021) reported that *S. obtusata* had similar K values (0.59) for both sexes in Vizhinjam waters.

High condition factor values suggested suitable environmental conditions, while low values indicated less favourable environmental conditions (Blackwell *et al.,* 2000). *S. obtusata* recorded higher K values than *S. putnamae* in the current study, indicating that *S. obtusata* thriving in Pamban island waters had a favourable habitat with plenty of food and favourable environmental circumstances. Nash *et al*. (2006) recommended that the variance in the K value may be attributed to ecological conditions, nutrition and reproductive state in different size groups. Furthermore, the differences in the overall mean Fulton's condition factor could be due to sampling size and size groups.

The analysis of relative condition factor also indicated similar results as that of mean condition factor with females and smaller size groups having higher values of Kn. Between the two species studied, *S. obtusata* showed slightly higher Kn value. Both females and males of both the barracuda species showed Kn values around 1.0, which specifies a nearly identical condition for both the sexes. The present study reported highest Kn values in the size group of 28.6-33.6 cm seen in female *S. putnamae*, while in *S. obtusata* the highest value was observed in 26.8-31.8 cm size group, which may be ascribed to the maturation and spawning activity (Meshram *et al*., 2021).

Kalogirou *et al*. (2012) estimated Kn values for *S. chrysotaenia* (1·00), *S. sphyraena* (1·00) and for *S. viridensis* (1·02) from the eastern Mediterranean Sea. Gonzalez-Acosta *et al*. (2015) reported Kn values (Males=0.989 and Females=0.984) for *S. idiastes* from Gulf of California coast. Shaila Prasad *et al*. (2021) estimated the Kn value (1.04) for *S. obtusata* in Vizhinjam waters. Meshram *et al.* (2021) reported Kn values in the bigger size groups of *S. obtusata* from Mangaluru waters. Kn is influenced by characteristics like reproductive period and fat accumulation, and it is thought to be a good predictor of a fish species' physiological health as it is linked to fitness.

The findings of this study on the length-weight relationship, Fulton's condition factor (K) and relative condition factor (Kn) for the species *S. putnamae* are the first to be published from Gulf of Mannar. It would serve as baseline information for further studies in delineating its growth in spatial and temporal scales. Studies on food and feeding habits, reproductive biology and studies on age growth are much required for this species along this region. Any information so generated can be suitable inputs to formulate management measures and aid in optimum utilisation of these resources.

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