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Note

Length-weight, length-length relationships and condition factor of obtuse barracuda *Sphyraena obtusata* Cuvier, 1829 (Pisces: Perciformes) from Vizhinjam coast, Kerala, India

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ABSTRACT

Eleven morphometric variables including weight were recorded for 429 specimens of obtuse barracuda *Sphyraena obtusata* Cuvier, 1829 collected over a period of two years from January 2017 to December 2018, from Vizhinjam fish landing centre, Thiruvananthapuram, Kerala. Length-weight relationship and length-length relationship of the species were estimated using linear regression analysis. Different length measurements were converted to ratios with standard length as morphometric ratios and the growth rate was assessed gender-wise. Length-weight relationship for male and female population were estimated as $W_m = 13.326 \times L^{3.2409}$ and $W_f = 11.952 \times L^{2.9821}$, respectively. Linear relationships for other morphometric variables and morphometric ratios with standard length were established for the species. Principal component analysis was performed and total length, snout length and snout to pre-nostril length were identified as key morphometric variables discriminating gender. The relative condition factor was estimated as 1.04 ± 0.13 for total population and the role of morphometric ratios in sex differentiation was examined.

Keywords: Condition factor, Morphometric ratio, Morphometric sex difference, Principal component analysis, *Sphyraena obtusata*

Sea-pikes or barracudas (Sphyraenidae) are commercially important food fishes of tropical and subtropical Indo-Pacific region (Williams, 1959; Blaber, 1982). The family includes 29 valid species, out of which only 9 species have been reported from Indian region (Eschmeyer and Fong, 2020) and only 5 species are common and available year-round in the commercial marine fish landings along the south-west coast of India. Obtuse barracuda *Sphyraena obtusata* Cuvier, 1829 is the common species that contributes 45.3% of the barracuda landing along south-western coasts of India (CMFRI, 2018). Eventhough a few reports are there on the growth rate assessment through length-weight relationship (LWR) for the species, no report on the morphometric relationship of the species is available from south-west coast of India. Morphometric and meristic relationships and LWR are useful for fishery management, stock biomass assessment, population dynamics and taxonomical studies (Ricker, 1968; Froese, 1998). Ayo-Olalusi and Ayoade (2019) reported the LWR and condition factor of *Sphyraena afra* from the coastal waters of Lagos State, Nigeria. Jaiswar *et al*. (2004) reported the morphometric and length-weight relationship in *S. obtusata* from Bombay waters. Shivasanthini *et al*. (2009) highlighted the size distribution and sex-wise length-weight relationship for *S. obtusata* from the Jaffna lagoon, Sri Lanka. Somvanshi (1989) assessed the stock and length-weight relationship of *S. obtusata* from the Gulf of Mannar, India. Subodha *et al.* (2018) described the occurrence and morphometric details of *S. obtusata* from Chilka Lake, Odisha. Some reports are also available on the length-weight relationship of *S. obtusata* from various parts of the world such as Indonesia, New Caledonia (Pauly *et al*., 1996; Letourneur *et al*., 1998; Kulbicki *et al*., 2005) and Malaysia (Ahmad *et al*. 2003). None of these reports, however, provide details of morphometric variables and their application in studying sex-wise variations in the population of the species. Hence, the present study aimed at size distribution, length-weight relationships (LWRs), length-length (LLR) relationships and condition factor of obtuse barracuda from the commercial landings from the Vizhinjam coast of India.

Samples of *S. obtusata* were collected from Vizhinjam fish landing centre (8°.22'41788"N; 76.59'27937"E), Thiruvananthapuram, Kerala, India from January 2017 to December 2018. Identification of the species was confirmed following Fischer and Bianchi (1984), Smith and Heemstra (1986) and Froese and Pauly (2019). Fishes were collected mainly from the commercial landings of gears like boat seine, gillnet, *roll vala* and hooks and lines. A total of 429 fresh specimens belonging to different size groups were collected and transported to the laboratory. Fishes were dissected to identify the sex after obtaining the morphometric measurements. Eleven morphometric measurements were recorded, of which lengths (mm) were measured using a digital vernier calliper and a laboratory scale and weight (g) was measured using a precision electronic balance. Morphometric measurements included total length (TL), standard length (SL), head length (HL), snout length (SnL), pre-nostril length (Pr-Nsrl), pre-pelvic length (Pr-Plvc), pre-anal length (Pr-Anl), inter-dorsal length (IntrDrsl), caudal peduncle length (CPL) and fork length (FL). All the variables were converted to ratios with SL. Both, morphometric parameters measured (Table 1) and morphometric ratios (Table 2) were compared between sexes using Student's t-test.

Length-weight relationship (LWR) of male, female and pooled data was worked out following cube law ($W = aL^b$). Logarithmic transformation was applied to arrive at a linear relationship in the form of Log W = Log a + b Log L where, W is the weight of the fish, L is the total length of fish, 'a' and 'b' are intercept and slope of regression line, respectively. Estimated b values were compared with the isometric value of 3 using Student's t-test. The length variables (TL, SL, FL, SnL and HL) were also related to SL/FL/HL (length-length relationships, LLR) using regression analysis (Table 3), sex-wise separately to assess the growth pattern of the species. Fulton's condition factor (K) was calculated using the equation $K = (W/L^3) \times 100$, where W is body weight and L, total length (Le Cren, 1951). Relative condition factor (Kn) was also computed as Kn=W/W', where W' is the expected weight according to length-weight relationship (Le Cren, 1951; Ricker, 1975; Anderson and

Table 1. Morphometric parameters and condition factor of total population and gender comparison of *S. obtusata*

Morphometric parameters (mm)	Total population	Male	Female	t value (Comparing gender)
	Mean±SD	Mean±SD	Mean±SD	
Weight (W in g)	59.99±13.75	57.64±14.06	61.62±13.43	-1.712
Total length (TL)	212.54±28.09	208.92±28.15	215.05±27.82	-2.234*
Standard length (SL)	176.22±23.39	173.87±23.77	177.85±23.04	-1.738
Fork length (FL)	194.47±25.54	191.09±25.63	196.82±25.27	-2.297*
Head length (HL)	60.77±7.38	59.86±7.48	61.40±7.26	-2.124*
Snout length (SnL)	25.48±6.47	25.09±6.36	25.75±6.54	-1.042
Pre-nostril length (Pr-Nrsl)	19.10±2.82	18.85±2.50	19.27±3.02	-1.527
Pre-pelvic length (Pr-Plvc)	72.72±12.68	72.12±14.56	73.14±11.21	-0.822
Pre-anal length (Pr-Anl)	126.93±18.26	124.60±18.34	128.55±18.06	- 2.210*
Inter-dorsal length (IntrDrsl)	25.26±5.15	25.12±5.31	25.36±5.03	-0.471
Caudal peduncle length (CPL)	33.46±5.08	33.17±5.16	33.66±5.01	-0.984
Condition factor (*K*)	0.59±0.05	0.59±0.06	0.59±0.06	- 0.958
Relative condition factor (*Kn*)	1.04±0.13	1.03±0.11	1.05±0.13	- 1.281

*p<0.05

Table 2. Morphometric ratios and their comparison between sexes of *S. obtusata*

Morphometric ratio	Total population	Male	Female	t value (Comparing gender)
	Mean± SD	Mean±SD	Mean±SD	
TL:SL	1.21±0.03	1.20±0.03	1.21±0.02	- 2.918**
HL:SL	0.35±0.02	0.35±0.02	0.35±0.01	-0.625
SnL:SL	0.15±0.04	0.15±0.04	0.15±0.04	0.001
Pr- Plvc: SL	0.41±0.04	0.41±0.05	0.41±0.03	0.725
Pr-Anl: SL	0.72±0.04	0.72±0.06	0.72±0.03	-1.225
Intr- Drsl: SL	0.14±0.02	0.14±0.02	0.14±0.02	0.903
CPL:SL	0.19±0.02	0.19±0.02	0.19±0.02	1.13
FL:SL	1.10±0.03	1.10±0.03	1.11±0.02	- 2.711**

**p<0.01

Table 3. Length-weight and length-length relationships of total population, males and females of *S. obtusata*

Population	Relationship	Log equation	r^2
Sexes pooled	TL × W	Log W =3.0902×Log TL - 5.4408	0.903
Male		Log W =3.2409×Log TL - 5.7874	0.955
Female		Log W =2.9821×Log TL - 5.1909	0.862
Sexes pooled	SL × W	Log W =3.0574×Log SL - 5.1159	0.880
Male		Log W =3.1941×Log SL - 5.4239	0.936
Female		Log W =2.9481×Log SL - 4.8685	0.843
Sexes pooled	FL × W	Log W =3.1249×Log FL - 5.4012	0.897
Male		Log W =3.2932×Log FL - 5.7812	0.953
Female		Log W =3.0066×Log FL - 5.1326	0.853
Sexes pooled	SL × TL	Log TL =0.9886×Log SL + 0.1069	0.978
Male		Log TL =0.9821×Log SL + 0.1199	0.974
Female		Log TL =0.9905×Log SL + 0.1039	0.983
Sexes pooled	SL × HL	Log HL =0.8557×Log SL - 0.1381	0.908
Male		Log HL =0.9821×Log SL - 0.1199	0.864
Female		Log HL =0.8712×Log SL - 0.1719	0.942
Sexes pooled	SL × SnL	Log SnL =0.7600×Log SL - 0.3081	0.766
Male		Log SnL =0.7071×Log SL - 0.1916	0.657
Female		Log SnL =0.7972×Log SL - 0.3906	0.769
Sexes pooled	SL × FL	Log FL =0.9698×Log SL + 0.1107	0.969
Male		Log FL =0.9553×Log SL + 0.1411	0.953
Female		Log FL =0.9771×Log SL - 0.0955	0.981
Sexes pooled	HL × SnL	Log SnL =0.8364×Log HL - 0.0933	0.509
Male		Log SnL =0.7893×Log HL - 0.0105	0.457
Female		Log SnL =0.8703×Log HL - 0.1534	0.458

Neumann, 1996). The observed weight of an individual was compared with its expected weight in relative condition factor. K indicates whether an individual is in better (K>1) or worse (K<1) condition than an average individual of same length. Hence condition factor allows the comparison quantitatively (Rim *et al*., 2009). Principal component analysis (PCA) was used to elucidate the morphometric ratios for total population that influence the sex difference. All statistical evaluations (Zar, 1996) were performed using software 'R' (R Core Team, 2020).

Gender-wise average length and weight along with other morphometric parameters of *S. obtusata* and its condition factor (K) are given in Table 1. All size groups were represented in the sample, and weight of the species ranged between 8.20 to 156.20 g with an average of 59.99 g without much weight difference between sexes. Mean values of total, standard and fork lengths recorded in the present study for the pooled samples were 212.54±28.09, 176.22±23.39 and 194.47±25.54 mm respectively and there was no significant difference between sexes with respect to standard length, but total, head, pre-anal and fork lengths were significantly higher ($p<0.05$) in the female population. Shaila Prasad *et al*. (2020) reported significant changes in morphometry in sexes of *S. obtusata,* especially during breeding season. The present observations of difference in SL and FL between male and female can be attributed to sexual dimorphism as well as attaining bulkiness during breeding season due to gonadal development. Previous reports on the species recorded minor variations in W, TL and SL (Somvanshi, 1989; Jaiswar *et al*., 2004; Sivashanthini *et al*., 2009). Kasim and Balasubramanian (1990) estimated the fishery and growth of *S. obtusata* in which the species has been reported to attain a size of 305 mm at an age of one year but here fishes were mostly around 200 mm.

Other morphometric variables (Table 1) like HL, SnL, Pr-Nsrl, Pr-Plvc, Pr-Anl, IntrDrsl and CPL were also measured sex-wise and among these variables, only HL and Pr-Anl registered significant ($p<0.05$) difference between male and female. Shaila Prasad *et al*. (2020) also explained the difference in the morphometric variables, including HL and Pr-Anl between sexes and among breeding seasons. Jaiswar *et al*. (2004) also reported a difference in growth rate of male and female for variables like pre-anal length, snout length and pre-anal length for *S. obtusata* from Mumbai waters of India. Length-weight relationship between sexes was not significant at 5% level. However, a difference in growth rate of male and female was observed here. The present study suggests that the sexual dimorphism in obtuse barracuda is restricted to very few morphometric variables and hence it is difficult to identify the gender without gonadal inspection by dissection. However, all morphometric parameters registered lower values for males than the females whereas, females recorded slightly higher values than that of total population values even though it was not significant. Hence it can be inferred that females are

bigger or stouter. Shaila Prasad *et al.* (2020) also reported similar observations for *S. obtusata* from the same coast. Condition factor of the species is suggestive of their well-being (Le Cren, 1951). Condition factor (K) registered almost similar values for both sexes (0.59) without significant difference as well as for total population (0.59), which shows that both the sexes and total population are in good health and condition. The expected Kn value was estimated as 1.04 for total population. K and Kn of a few other sphyraenids were reported and discussed in relation to feeding ecology by Kalogirou *et al*. (2012). Wootton (1990) reported fish species with high K values are heavy for their length, while those with low K values are lighter for their length.

Comparison of morphometric ratios across male, female and pooled samples are presented in Table 2. The relative measures give a more accurate growth comparison than the absolute values. Absolute values and ratios change with respect to TL and FL emphasising that the growth rate in sexes differ significantly ($p<0.01$). TL, SnL, Pr-Nsrl, Pr-Plvc, IntrDsrl and CPL ratios to SL registered no significant difference between sexes of *S. obtusata*, which again confirms that sexual dimorphism in obtuse barracuda is limited. Even though earlier reports (Jaiswar *et al*., 2004; Subodha *et al.* 2018) describe basic morphometry, no reports hitherto have dealt with relative or morphometric ratios for the same species.

Since four absolute and two relative variables among the ten length measurements under consideration registered significant difference between sexes, principal component analysis (PCA) was performed with morphometric ratios of total population (Fig. 1) to identify the primary factors that affect the morphometric variation between the sexes. HL to SL ratio resulted as principal component 1 (PC 1) with factor loading value of 0.832 (Eigen value 2.741; 34.26% variance) followed by TL to SL ratio as principal component 2 (PC 2) with factor loading value of 0.732 (Eigen value 1.664; 20.81% variance) and SnL to SL ratio as principal component 3 (PC 3) with factor loading value of 0.921 (Eigen value 1.119; 13.991% variance). Even though TL and FL showed significant difference between sexes in relative variables, PCA extracted HL as the PC1 as combined effect of all the cephalometric variables, especially length from snout. The second and third factors, TL and SnL to SL ratios also had a significant difference with respect to male and female. Jaiswar *et al.* (2004) reported morphometric and meristic variables of *S. obtusata,* but there is no comparison across gender. Many reports on morphometric assessment using PCA for fish populations (Ihssen *et al*., 1981; Surre *et al*., 1986; Hedgecock *et al*., 1989; Melvin *et al*., 1992; Mamuris *et al*., 1998; Trapani, 2003) are available, but they

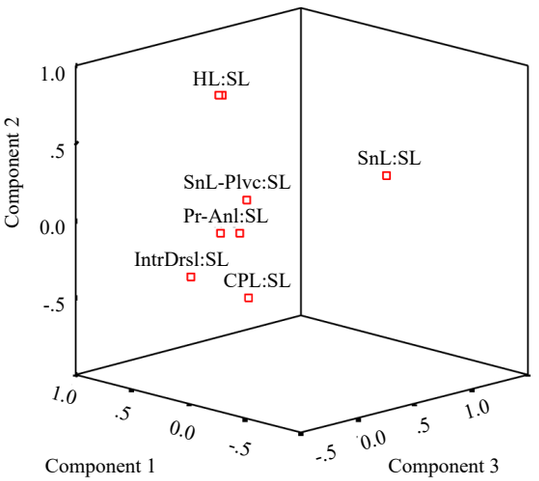

Fig. 1. Principal component analysis loading plot of morphometric ratios for gender of *S. obtusata*

mostly focus on fish population or stock identification. Bijukumar *et al*. (2008) used PCA to distinguish male and female population of sea horse. A detailed morphometric evaluation of *S. obtusata* was lacking except the works of Jaiswar *et al*. (2004), who reported the morphometric and meristic characters of *S. obtusata* from Mumbai coastal waters on the west coast of India.

Froese *et al.* (2011) highlighted the importance of studies on LWR in the field of fisheries science and management. The LWR is usually estimated for TL but some studies report it for SL/FL.The present study assessed LWR with FL, SL and TL and the results are given in Table 3. The LWR in *S obtusata* with TL was derived as:

$W= 0.000001632L^{3.2409}$ (Male)

$W= 0.000006443L^{2.9821}$ (Female)

$W= 0.000003624L^{3.0902}$ (Sexes pooled)

The LWR derived for sexes pooled showed isometric growth with b values not significantly different from isometric value of 3 ($t = 1.787$; $p>0.05$). Interestingly, male population showed positive allometric value (>3), whereas female population showed negative (<3) allometric value, indicating deviation between sexes in growth pattern.

Shaila Prasad *et al*. (2020) reported breeding season induced morphological variation for the species. This may be the reason for the difference in growth pattern with sexual development observed for obtuse barracuda. A comparison of the LWR of *S. obtusata* estimated from different parts of the world and different locations of India with that obtained in the present study is given in Table 4. Majority of the reports showed negative allometry (<3)

Table 4. Length-weight relationship of *S. obtusata* from different countries/locations

Country	Equation (Log W=b ×Log TL ± a)	Gender	Reference
Visayas, Philippines	Log W=3.000×Log TL - 0.0070	Unsexed	Federizon (1993)
Indonesia	Log W=2.868×Log TL - 0.0095	Unsexed	Pauly *et al*. (1996)
New Caledonia	Log W=2.472×Log TL - 0.0370	Unsexed	Letourneur *et al*. (1998)
Malaysia	Log W=2.870×Log TL - 0.0070	Unsexed	Ahmad *et al*. (2003)
New Caledonia	Log W=2.588×Log TL - 0.0257	Unsexed	Kulbicki *et al*. (2005)
Sri Lanka	Log W=2.898×Log TL - 1.9304	Male	Shivashanthini *et al*. (2009)
	Log W=2.843×Log TL - 1.8570	Female	
	Log W=2.857×Log TL - 1.8760	Sexes pooled	
India			
Gulf of Mannar	Log W=3.131×Log TL - 0.0041	Unsexed	Somvanshi (1989)
Gulf of Mannar	Log W=2.382×Log FL - 3.7274	Unsexed	Kasim and Balasubramanian (1990)
Cochin, Kerala	Log W=2.687×Log TL - 1.7822	Male	Premalatha and Manojkumar (1990)
	Log W=2.839×Log TL - 1.9583	Female	
Mumbai	Log W= 2.723×Log TL -0.00003	Sexes pooled	Jaiswar *et al*. (2004)
Vizhinjam, Kerala	Log W=3.241×Log TL - 5.7874	Male	Present Study
	Log W=2.982×Log TL - 5.1909	Female	
	Log W=3.091×Log TL - 5.4408	Sexes pooled	

for total population except that of Somvanshi (1989) from the Gulf of Mannar and Federizon (1993) from Philippines, who registered almost isometric value in tune with the present results. The negative allometric results may be because of the population and environmental difference, as suggested by Hossain *et al*. (2010). Some investigators reported that slight differences in b values could have been due to the variations in environmental or ecological conditions of different habitats or to the variation in the physiology of the animals or both (Bhattacharya and Acharya, 1984; Jaiswar and Kulkarni, 2002). Morphological characters can show high plasticity in response to differences in environmental conditions, such as food abundance and temperature (Allendorf and Phelps, 1988; Swain *et al*., 1991; Wimberger, 1992). The results of the present study including the slope and the intercept values were almost similar or higher than the results reported by Premalatha and Manojkumar (1990) from Cochin (Kerala) and Jaiswar *et al*. (2004), who reported b value range of 2.72-2.73 for *S. obtusata* from Mumbai waters along the west coast of India, while b value in the range of 2.84 - 2.89 was reported from the Jaffna Lagoon in Sri Lanka (Shivashanthini *et al*., 2009). Hosseini *et al*. (2009) reported b value range of 2.77-2.87 for a congeneric species, *S. jello* from the Persian Gulf.

Length-length relationships (LLRs) give more details, especially with respect to growth pattern and will be beneficial for fishery management and fish biology studies. There is not much information on the LLR for *S. obtusata* except the report by Jaiswar *et al*. (2004). In the present study, linear relationship was established between SL or HL with other length variables and presented in Table 3. SL-TL, SL-HL, SL-SnL, SL-FL and HL-SnL relationships were estimated sex-wise and for sexes pooled. SL of *S. obtusata* registered a relationship in total population with 'b' values 0.9886, 0.8557, 0.7600 and 0.9698 for TL, HL, SnL and FL respectively, all of which were <1, the isometric value. Jaiswar *et al*. (2004) reported positive linear LLRs with very low 'b' values for the relationships with respect to a few parameters considered.

The results of the present study indicate that male and female *S. obtusata* from Vizhinjam coast on the south-west coast of India have different growth pattern. Morphometric studies and morphometric ratios differ for male and female with a few variables depicting sexual dimorphism. The key variables among them are head length, total length and snout length ratios with standard length.

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