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Note

Biometric analysis of white sardine *Escualosa thoracata* (Valenciennes, 1847) from Goa coast, India

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ABSTRACT

The morphometry, length-weight relationship and condition factor of *Escualosa thoracata* (Valenciennes, 1847) from Goa waters was studied from 758 specimens. Males ranged in size from 80 to 117 mm and weighed 4.16 to 14.96 g, while females were 77 to 115 mm and 3.75 to 15.03 g. Among the compared characters, coefficient of correlation *r* were highest for standard length against fork length (0.9879) and lowest against snout length (0.1799). Based on meristic counts, the fin formula for white sardine can be written as $D_{13-17}\ P_{9-13}\ V_{7-7}\ A_{11-19}\ P_{ps12-19}\ P_{ops10-12}$. Length-weight relationship was estimated as $W = 0.0128L^{3.14}$ (r^2 0.8677), $W = 0.0140L^{3.10}$ (r^2 0.9084) and $W = 0.0134L^{3.12}$ (r^2 0.8921) for males, females and combined sexes, respectively. A positive allometric growth (b>3) was observed for all samples. Condition factor was 1.31 for males, 1.43 for females and 1.37 for pooled samples, indicating that females are in better condition than males.

Keywords: Allometric growth, Condition factor, Length-weight relationship, Meristic counts, Morphometry

Morphometric dimensions and meristic counts of fishes provide valuable information on different aspects of the evolution process, taxonomic position, spatial-temporal distribution, health status, population parameters and their interaction with different environmental conditions (Park *et al.,* 2015; Vatandoust *et al.,* 2015; Muriana *et al.,* 2017). The length-weight relationship explains the changes in weight with respect to length, and *vice versa* and is estimated for a better understanding of the life dynamics, evaluation of fish populations and ontogenetic development (Froese, 2006). Similarly, the condition factor (K) based on the length-weight of fish is often used to measure degree of well-being, growth pattern and maturity of fishes (MacGregor, 1959). It can also significantly assess the health status of fish populations inhabiting a specific environment or ecosystem (Tsoumani *et al.,* 2006).

The genus *Escualosa* (Family: Clupeidae) is known to have only two valid species globally *viz,* the white sardine *Escualosa thoracata* (Valenciennes, 1847) and *Escualosa elongata* (Wongratana, 1983). *E. thoracata* is a shoaling clupeid that inhabits shallow coastal waters and supports seasonal fisheries along the coasts of India, Burma, Ceylon, China, Malaya, Pakistan and Australia (Mishra, 1947). It is highly relished among the local fisher communities and substantially contributes as a source of protein and income. Studies on its morphometry and length-weight relationship have been done by several workers from different parts of the Indian coast (Raje *et al.,* 1994; Rahangdale, 2014; Seah *et al.,* 2016; Dar *et al.,* 2017; Gurjar *et al.,* 2017; Abdussamad *et al.,* 2018; Srihari *et al.,* 2018). However, there is no information available on morphometric traits, length-weight relationship and condition factor of this species from the Goa coast. Therefore, the present study was undertaken to generate baseline data on the biometric characteristics of *E. thoracata* from Goa waters.

A total of 758 specimens of *E. thoracata* ranging from 77 to 117 mm in total length and 3.75 to 15.03 g in weight were collected fortnightly from the local gillnet landing centres (Fig. 1) during the period, October 2014-April 2015. All the measurements of morphological traits (mm), meristic counts and weight (g) were recorded in fresh condition following standard methods (Lagler *et al.,* 1962). Morphometric characters, total length (TL), standard length (SL), fork length (FL), pre-dorsal length (PDL), pre-anal length (PAL), pre-pectoral length (PPL), pre-pelvic length (PVL), head length (HL), snout length (SNL), Inter-orbital length (IOL), post-orbital length (POL), eye diameter (ED), body depth (BD), caudal depth (CD), length between anal and pelvic (LBAP), depth at anal opening (DAO), anal fin base length (ABL) and dorsal fin base length (DBL) were measured using digital calipers to the nearest 0.1 mm.

Meristic counts including the number of rays in dorsal, pectoral, pelvic and anal fins were also recorded. A linear regression equation: Y=a+b X was fitted for the compared characters using the least square method (Snedecor and Cochran, 1967) and the values of intercept 'a', regression coefficient 'b' and the correlation coefficient 'r' were calculated using simple regression. The length-weight relationship was established separately for males and females using the equation $W = aL^b$ (Le Cren, 1951) after log transformation to the form Log W = Log a + b Log L, where 'W' is total body weight (g) and 'L' is the total length (mm). ANCOVA was performed to determine significance of variation ($p<0.05$) in the value of regression coefficients for both sexes. The t-test was applied to determine whether regression coefficients differ significantly from the isometric value of 3 ($p<0.05$). The condition factor (K) was estimated from length and weight using Fulton's index $K = W \times 10^5/L^3$ (Fulton, 1904). Measurements of various morphological characters, their range, mean, standard error and co-efficient of correlation revealed that the maximum value of coefficient of variation was for snout length (14.52%) while minimum (9.16%) was for fork length (Table 1).

Regression of the TL, FL, PDL, PPL, PVL, PAL, HD, BD, CD, SNL, IOL, POL, ED, LBAP, DAO, ABL and DBL against the standard length were also established and coefficient of correlation 'r' showed the maximum degree

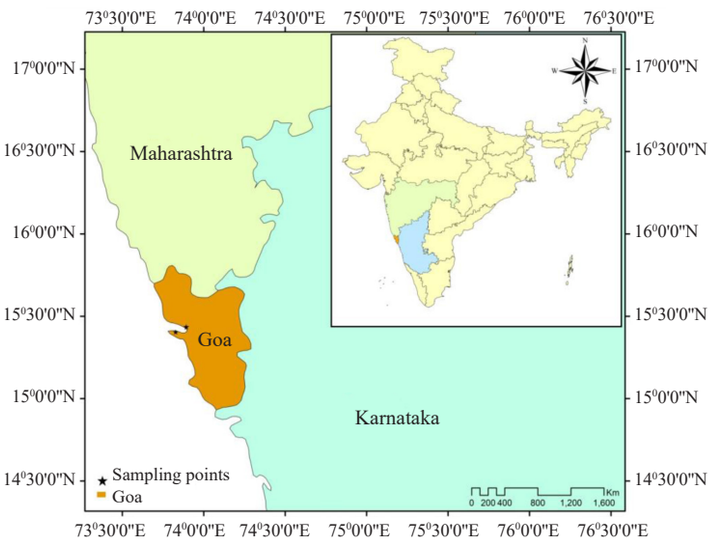

Fig. 1. Map of sampling sites along the coast of Goa

Table 1. Statistical estimates of various morphometric characters in *E. thoracata*

Morphometric characters	N	Min. (mm)	Max. (mm)	Mean±SE	CV (%)
Total length	305	7.7	11.7	9.06±0.05	9.32
Fork length	305	6.1	10.2	7.75±0.04	9.16
Standard length	305	5.6	9.7	7.21±0.04	9.42
Pre-dorsal length	305	2.42	4.45	3.42±0.02	10.33
Pre-pectoral length	305	1.26	2.19	1.66±0.01	10.17
Pre-pelvic length	305	2.49	4.66	3.49±0.02	10.29
Pre-anal length	305	3.96	6.79	5.29±0.03	9.98
Head length	305	1.15	2.18	1.64±0.01	10.31
Body depth	305	1.58	3.06	2.15±0.02	12.80
Caudal depth	305	0.4	1.05	0.78±0.00	10.51
Snout depth	305	0.31	0.68	0.52±0.00	14.52
Inter-orbital length	305	0.31	0.57	0.42±0.00	9.95
Post-orbital length	305	0.50	1.08	0.77±0.01	13.54
Eye diameter	305	0.35	0.62	0.49±0.00	10.01
Length between anal and pelvic	305	1.38	2.52	1.90±0.01	11.13
Depth at anal opening	305	1.03	2.05	1.48±0.01	12.59
Anal fin base length	305	0.90	1.56	1.18±0.01	9.70
Dorsal fin base length	305	0.59	1.21	0.91±0.01	11.15

of correlation between standard length with fork length (0.9879) and minimum (0.1799) with snout length (Table 2).

In meristic analysis, the species was found to possess 13-17, 9-13, 7-7 and 11-19 rays on dorsal, pectoral, pelvic and anal fins, respectively. The number of pre-pelvic and post-pelvic scutes ranged between 12-19 and 10-12. Based on the results, the fin formula for *E. thoracata* could be written as D_{13-17} P_{9-13} V_{7-7} A_{11-19} $P_{ps12-19}$ $P_{ops10-12}$. The results revealed no significant variation in the morphological characters and meristic counts of *E. thoracata* within the population, indicating that homogenous stock of this species occurred along the Goa coast.

Length-weight equations were established as: $W=0.0128L^{3.14}$ for male and $W=0.0140L^{3.10}$ for female. Analysis of covariance indicated that, there is no significant difference in the regression coefficients for both sexes ($p>0.05$); hence a common equation was derived as $W=0.0134L^{3.12}$. Student's t-test indicated that the slope 'b' deviated significantly from the isometric value of 3 ($p<0.05$) and thus, the species shows positive allometric growth. Month-wise condition factor 'K' was studied separately for male and female (Table 3). The highest value of 'K' was obtained in February for male (1.39) and female (1.54). Similarly, lowest value of 'K' was observed for male (1.24) and female (1.35) in November.

In the present study, a symmetrical growth pattern was observed for various body parts relative to the size of the fish. Analysis of morphometric characters showed that the regression coefficient has a varying strength relationship between total lengths against other characters. The comparative growth of morphometric characters in relation to the standard length was observed to be highest for total length and least for inter-orbital length. In meristic counts, the number of rays for dorsal, pectoral and anal fin and the number of scutes for pre-pelvic and post-pelvic vary within the size range of the fish (77-117 mm), confirming that the meristic counts are dependent on body size and vary with the growth of fish. Rahangdale (2014) also observed similar results in the same species from Mumbai waters. Hart and Reynolds (2002) specified that environmental factors, particularly temperature, influence the meristic characteristics during fish growth. Fishes show phenotypic characteristics that enable them to respond adaptively against environmental changes and to obtain physiology and behaviour modification, which helps change their morphology, survival and reproductive potentiality to adapt to environmental changes (Stearns, 1983; Meyer, 1987). Body proportions and meristic variables are not species-specific and overlap between species due to changes in ecological locations (Perez-Cuesta *et al.,* 2017). A positive allometric relationship was found when the growth of males, females and the combined sexes was evaluated in length ($b>3$, $p<0.05$). The exponential value of 3.14 implies that males gained weight faster than females (3.10). The regression coefficient value obtained for pooled data is comparable with the previous reports from Mumbai, Kerala and Goa coasts of India, respectively (Dar *et al.,* 2017; Abdussamad *et al.,* 2018; Srihari *et al.,* 2018) (Table 4).

Table 3. Month-wise condition factor of male and female *E. thoracata*

	October	November	December	January	February	March	April
Males	1.29	1.24	1.31	1.29	1.39	1.37	1.34
Females	1.46	1.35	1.41	1.39	1.54	1.47	1.38

Table 2. Regression values for various morphometric characteristics of *E. thoracata* as function of standard length

Parameters	a	b	Y=a+b X	r^2
Total length	0.2221	0.2252	Y=0.22216+1.22524X	0.9740
Fork length	0.2668	0.0378	Y=0.26684+1.03784X	0.9879
Pre-dorsal length	-0.0344	0.4783	Y=-0.0343+0.47834X	0.8496
Pre-pelvic length	0.0082	0.2292	Y=0.00817+0.22919X	0.8497
Pre-ventral length	-0.1471	0.5049	Y= -0.1471+0.5049X	0.9111
Pre-anal length	-0.0746	0.7438	Y= -07455+0.74377X	0.9163
Head length	-0.0345	0.2321	Y= 0.03448+0.2321X	0.8712
Body depth	-0.5673	0.3768	Y= -0.56730+0.376X	0.8658
Caudal depth	0.0624	0.0991	Y= 0.06242+0.0991X	0.6807
Snout length	0.1790	0.0468	Y = 0.179+ 0.0467X	0.1799
Inter-orbital length	0.1104	0.0423	Y = 0.1104+ 0.0423X	0.4831
Post-orbital length	-0.2026	0.1342	Y= -0.2026+ 0.1342X	0.7746
Eye diameter	0.0777	0.0576	Y = 0.0777+ 0.0575X	0.6294
Length between anal and pelvic	-0.0138	0.2657	Y =-0.0137+ 0.2657X	0.7277
Depth at anal opening	-0.3024	0.2465	Y = -0.3024+0.2464X	0.8136
Anal fin base length	0.2144	0.1334	Y = 0.2144+ 0.1334X	0.6312
Dorsal fin base length	0.0548	0.1190	Y = 0.0548+ 0.1190X	0.6309

Table 4. Comparison of length-weight relationship of *E. thoracata* with earlier studies

Authors	Sex	Samples	a	b	r^2
Raje *et al.* (1994)	Males	471	0.000001508	3.3946	
	Females	639	0.000002561	3.2706	
Dar *et al.* (2017)	Combined	1027	0.0048	3.2360	0.9002
Seah *et al.* (2016)	Combined	48	0.0132	2.9218	0.951
Gurjar *et al.* (2017)	Males	241	-1.7590	2.7521	0.8719
	Females	287	-1.8744	2.8567	0.9057
	Combined	528	-1.7902	2.8537	0.9012
Abdussamad *et al.* (2018)	Combined	293	0.00459132	3.2952	
Srihari *et al.* (2018)	Combined	344	0.0055	3.0900	0.98

The variation of exponential value depends on the number of specimens considered for analysis and their respective lengths. Apart from that, it could be influenced by the adjacent coastal water pollution, availability of plankton and their life span characteristics. It seems to vary within the species due to changes in sampling places, seasons and feeding intensity within the diverse length groups (Gokce *et al.,* 2007; Ahirwal *et al.,* 2018). The condition factor of a fish reflects physical and biological circumstances that depend upon the feeding intensity, parasitic infection and other physiological factors (Le Cren, 1951). Condition factor also depends upon the prevailing ecological conditions, spawning stress and feeding intensity (Edah *et al.,* 2010; Ighwela *et al.,* 2011; Ahirwal *et al.,* 2017). Fulton's condition factor values for all the specimens ranged between 1.24 to 1.54 with an average of 1.37 and a maximum 'K' value was obtained for females (1.43), followed by males (1.31) and for combined sex (1.37), which indicates that females had better condition than males. The month-wise condition factor varied for both sexes which could be attributed to variation in water temperature, water quality, food accessibility and energy conversion from somatic development to gonad ripeness.

The present evaluation of morphometrics, meristics, length-weight relationship and condition factor is perhaps the first detailed report for *E. thoracata* from the Goa coast. The results of this study therefore, will be helpful in studying the population dynamics and stock status of the species in the region and to compare the white sardine population over time and between regions.

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