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Preliminary study on growth and mortality of *Escualosa thoracata* (Valenciennes, 1847) from Mumbai waters

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Investigation on growth and mortality of *Escualosa thoracata* reported in the present literature is based on the length frequency data collected from April 2013 to March 2014. Asymptotic length ($L\infty$), growth coefficient (K) and t_0 were estimated as 119.6 mm, 1.85 year^{-1} and -0.000095 year respectively. VBGF plot indicated that the fish reaches 72.17 and 100.79 mm at the end of 6 and 12 months respectively. The phi- prime value was obtained as 2.423. Total, natural and fishing mortality coefficient was estimated as 7.809 year^{-1}, 3.45 year^{-1} and 4.35 year^{-1} respectively. The exploitation rate (U) and exploitation ratio (E) were estimated as 0.556 and 0.557 yearr-^{1} respectively.

[**Keywords:** *E. thoracata,* Growth parameters, asymptotic length, Mumbai, Growth coefficients]

Introduction

White sardine, *Escualosa thoracata* (Valenciennes, 1847) are shoaling pelagic fishes belonging to family Clupeidae which is one of the most important marine fish family across the globe both in terms of the quantum of its production and its socioeconomic importance to coastal community. It is recorded from India, Pakistan, Ceylon (=Sri Lanka), Burma (Myanmar), Malaya, Malay Archipelago and China[1]. It forms fishery throughout its distribution off the western coasts of India from April to November. Marine fish landing of India during 2012 was estimated around 3.94 million tonnes and contribution from pelagic resources to the total landing was 21.3 lakh tonnes. Contribution of total clupeoid group production is 10.27 lakh tonnes and fishes in category other clupeids contributed 81240 tonnes to the production. The estimated marine fish landing during 2012 for Maharashtra is 3.15 lakh tonnes. Pelagic finfishes contributed around 41.3% to total landing[2]. An outstanding contribution of pelagic fishes to marine landings makes it economically very important despite its relatively lower price realization. Increase or decrease in annual fish production of the country depends on success or failure of groups like clupeoids, mackerel, Bombay duck, carangids and ribbon fishes. White sardine is reported in small quantities from most of the coastal waters of the country, it supports economically important fishery only along south west coast of India[3]. Separate catch statistics for the species is not available and is grouped under category other clupeids. When oil sardine occurred in plenty, white sardine and other sardine are almost neglected. But because of highly fluctuating nature of oil sardine fishery, importance of white sardine fishery is increasing gradually.

White sardine fishery emerged in mid 1980s along Mumbai coast. The work on its fishery, biology and related aspects are limited to that of Raje *et al.*[4] way back in early 1990s when the fishery was still young. Two decades of commercial exploitation since last work warrants reassessment of the resource. Such a reassessment require a sound knowledge of growth and mortality of the species for understanding the longevity of exploited stocks, age composition of catch and population dynamics of the species. With that in view the study on *Escualosa thoracata* was conducted from Mumbai waters.

Materials and Methods

Weekly samples of *E. thoracata* were collected from the fish landing centres in Mumbai during the period of April 2013 to March 2014. Recorded in the length range 22 to 111 mm, the length frequency data were grouped into 5 mm class interval, and raised for the day and subsequently for the month following Sekharan[5]. Initial estimate of growth parameters $L\infty$ and K was made using scatter diagram technique[6].

Progressions of modes are explained by the eye fitted lines which are extrapolated to cut the horizontal axis indicating the origin of brood. Average sizes attained in respective months obtained from traced modes are used to calculate L∞ and K using Ford-Walford plot[7-8]. This estimate of L∞ and K are used as seed value in ELEFAN developed by Gayanilo *et al.*[9] using FiSAT programme where the growth parameters are fine-tuned based on R_n value[10-13]. Growth parameters are also estimated using Bhattacharya's method[14] and Gulland and Holt plot[15] employing FiSAT. Hypothetical age at which length is zero (t_o) was estimated using von Bertalanffy's plot[16]. Total mortality coefficient was estimated by different method such as Beverton and Holt Method[17], Jones and van Zalinge's Method[18] and length-converted catch curve[19-20]. Natural mortality coefficient was estimated using methods given by Taylor, Cushing, Pauly and Alagaraja[21-24]. Growth performance index, phi prime (∅) was estimated following Munro and Pauly[25], given as: ∅ =2* *log L∞+Log K* where L∞ is in cm and K is annual. The exploitation rate (U) and exploitation ratio (E) were estimated applying formula, $U = F/Z*(1-e^{-Z})$ and $E= F/Z$ respectively.

Results

The fishery is harvested using gill nets of mesh size ranging from 16-24 mm. Percentage length composition of catch for different months shows typical pattern of gillnet fishery which accounts for almost the entire catch along Mumbai coast. A progressive increase in dominant size group in catch was observed from March to February (Fig. 1). Growth parameters obtained by various methods for the species is presented in the Table 1. Asymptotic length (L∞) for the species varied from 116.98 to 121.5 mm and 'K' from 1.80 to 1.89 year^{-1} with average value of 118.81 mm and 1.85 year^{-1} respectively. Modal progression analysis by scatter diagram technique of Devaraj[6] (Fig. 2) and Ford-Walford plot method[7-8] (Fig. 3) estimated the value of asymptotic length 'L∞' and 'K' as 121 mm and 1.8 yr^{-1} respectively. The value of 'L∞' and 'K' estimated by ELEFAN employing FiSAT programme was found to be 119.6 mm and 1.85yr^{-1} respectively having Rn value of 0.291 and a growth curve generated used restructured data is presented in Fig. 4. Linking of means was done by Bhattacharya's method[14] using FiSAT programme and L∞ and K were estimated as 117 mm and 1.89 respectively. This data was further analyzed by Gulland and Holt Plot[15] (Fig. 5) of FiSAT programme and estimated value of L∞ and K were 116.98 mm and 1.87 respectively. The variations among the value obtained from different methods were not large enough to eliminate estimates of L∞ and K by any one method. Nevertheless for the further calculations estimates obtained by ELEFAN employing FiSAT programme were used.

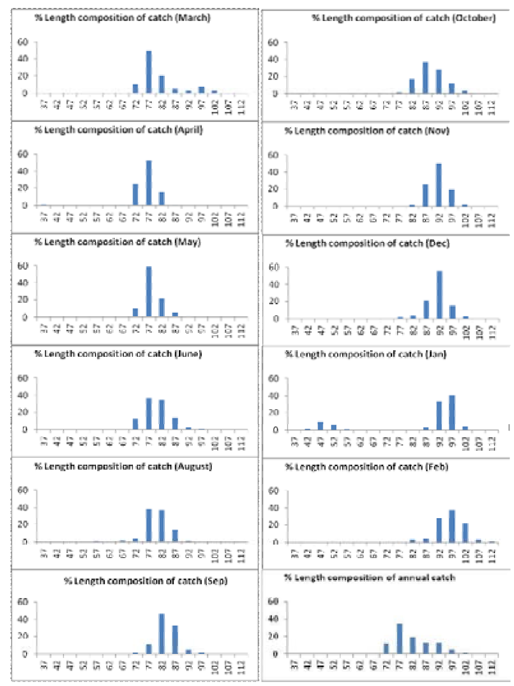

Fig.1. Percentage length composition of catch (Horizontal axis: mid class length and vertical axis: percentage contribution)

Table 1. Estimates of growth parameter using different methods

S. No.	Methods applied	L∞ (mm)	K (year^{-1})
1	Gulland and Holt plot[15]	116.98	1.87
2	Linking of means employing Model progression analysis[14]	117.15	1.89
3	Model progression analysis scattergram technique[6] and Ford - Walford plot[7-8]	121.5	1.80
4	ELEFAN using FiSAT[9]	119.6	1.85
	Average	118.81	1.85

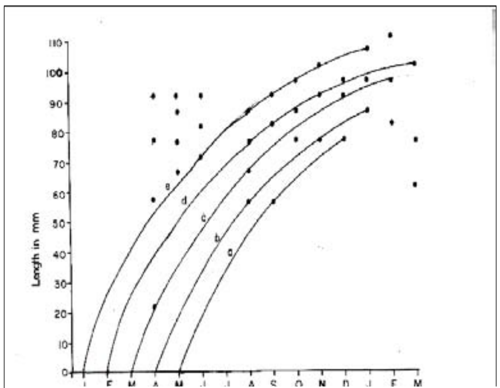

Fig.2. Modal progression Analysis (scatter diagram technique) of *E. thoracata*

Fig.3. Ford-Walford Plot for estimation of growth parameters of *E. thoracata*

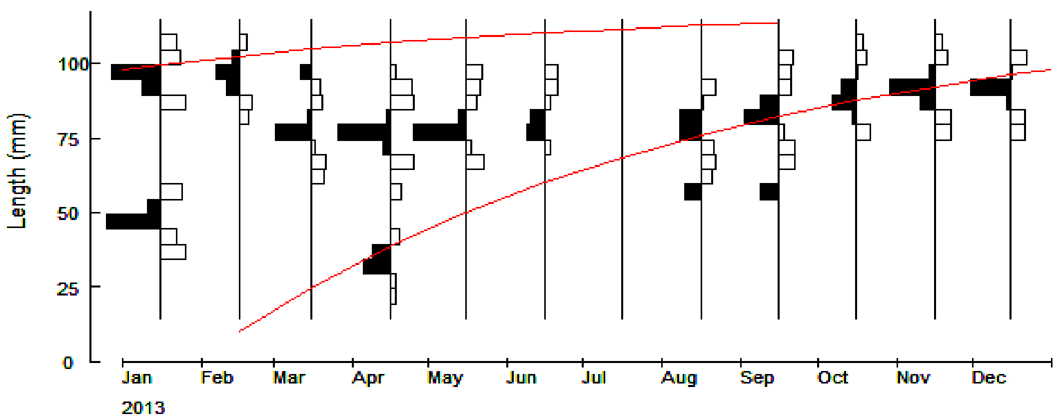

Fig.4. ELEFAN curve of *E. thoracata* employing computer based FiSAT Programme

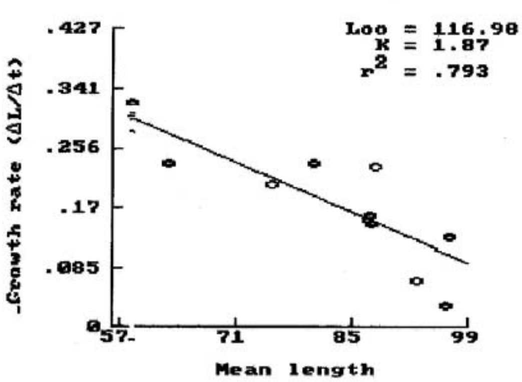

Fig.5. Gulland and Holt plot for estimation of Growth parameter of *E. thoracata*

Growth parameters obtained from ELEFAN routine was used to calculate average length obtained at quarterly interval to plot von Bertalanffy growth curve (Fig. 6). The value of t_0 was found to be -0.000095 years using von Bertalanffy's plot[16]. During the current investigation the maximum recorded size was 111mm which might have been attained in 1.42 years. From the VBGF plot it was calculated that the fish attains 72.17 mm size in first 6 months and 100.79 mm on completion of one year. The Phi prime (Ø) value for the species was calculated as 2.338.

The value of Z obtained by Beverton and Holt[17], Jones and Zalinge[18] and length converted catch curve method[20] (Fig. 7) were 8.01, 5.58 and 7.809 year^{-1} respectively with an average of 7.14 year^{-1}. Z calculated by length converted catch curve method was used in subsequent analysis as it is among the widely used method. Natural mortality was obtained as 2.11, 3.24, 3.46 and 3.24 year^{-1} using Taylor, Cushing, Pauly and Alagaraja method respectively[21-24] with an average value of 3.01 year^{-1}. M obtained from Pauly's empirical formula is used in subsequent cases. F was evaluated as 4.35 year^{-1} using equation: [F=Z–M]. The M/K and Z/K value are calculated as 1.86 and 4.22 respectively. The estimated value of exploitation rate (U) and exploitation ratio (E) were 0.556 and 0.557 year^{-1} respectively.

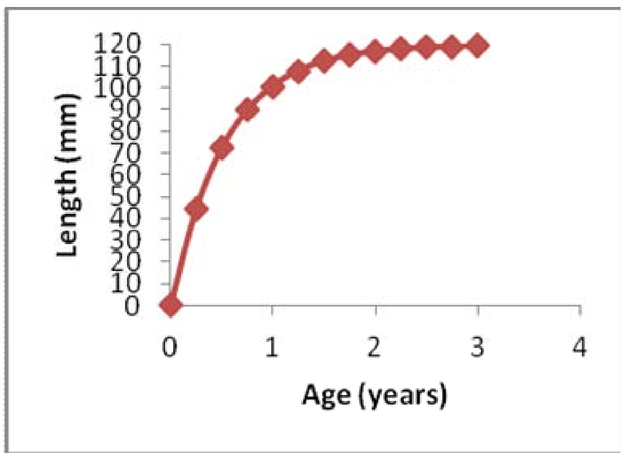

Fig.6. Estimated von Bertalanffy's growth curve for *E. thoracata*

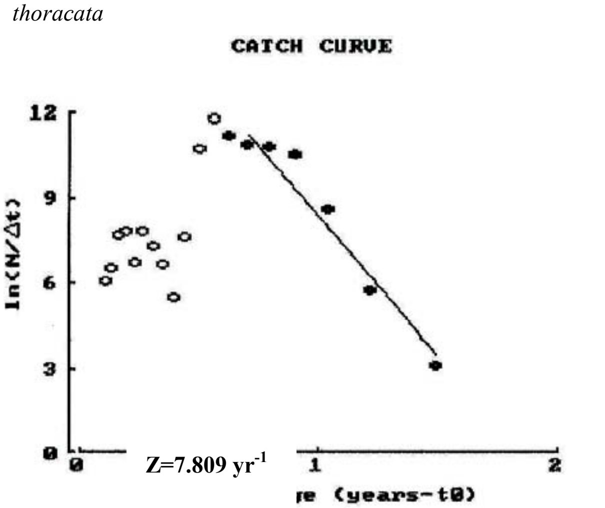

Fig.7. Length converted catch curve for estimation of total mortality coefficient (Z) for *E. thoracata*

Discussion

Investigation on age and growth of *E. thoracata* were carried out by Nair[3] from Malabar Coast and Raje *et al.*[4] from Bombay. Using Petersen's method[26], Nair reported unimodal (10.5cm) feature of length frequency distribution of fishery accounting for almost one third of the catch emphasizing the dominance of single age group in catch[3]. Similar dominance of single length group was also observed in present investigation with 77 mm (mid class length) accounting for more than one third of the total annual catch in numbers (Fig: 1). Overall dominance of 77 mm size group in annual catch give an indication of March to June being major fishing season in which 77 mm size group are dominant which is in agreement of Raje *et al.*[4] Similar finding was observed by the analysis of raised catch data for different months showing month of April to June as peak fishing season accounting for more than 65% of total catch in numbers. A second major fishing period is from October to December which accounts for nearly 25% of total catch in numbers. Monthly increase in size composition of catch from March to February could be explained by similar progressive change in mesh size of operated gill nets. Gill nets of mesh size 16 and 18 mm are operated from March to May, 18 and 20 mm from June to September, 20 and 22 mm from October to December and 22 and 24 in January and February. The changing size composition gives fishermen an indication to switch to larger mesh size. The decrease in overall catch prompts the fishers to revert back to smaller mesh size.

Raje *et al.*[4], employing ELEFAN program estimated L∞ and K for *E. thoracata* from Mumbai as 110 mm and 1.8 yr^{-1} respectively. They have estimated that fish reaches 65.3 mm size in first 6 months and 91.8 mm in one year as against current estimates of 72.17 mm and 100.79 which are slightly higher. Rashed-Un-Nabi *et al.*[27] estimated L∞ and K as 120.8 mm and 1.40 yr^{-1} from Bangladesh waters. Estimate of L∞ are very much similar whereas the K in current studies is substantially higher than their estimate. In the absence of hard parts showing definite and periodic markings, length frequency data remains the only method in tropics to estimate age. Limitations of the method employed are well known and often they are termed subjective. A very rough estimate of the L∞ can be obtained assuming that only 5 % (in some case 1%) of the fish would have survived and reached their maximum size if they were subjected to natural mortality only. Considering the maximum size obtained in the present study of 111 mm, the L∞ is 116.8 mm which is very near to the estimated L∞ of 119.6 mm. Phi prime can be used as reliability index for the estimated growth parameters as the value of Phi prime for the same species and genera are similar. Current estimate of phi prime is slightly greater than the calculated value from the growth parameters (Table 2) of Raje *et al.*[4] and Rashed-Un-Nabi *et al.*[27] affirming the accuracy of the estimates.

Table 2. Phi prime (F) of *E. thoracata* based on growth parameters calculated by various workers.

Sr. No	L∞	K	∅	Author
1	11.00	1.80	2.338	Raje *et al.*[21]
2	11.96	1.85	2.423	Present study

According to Boiko[28], Pauly[23, 29] and Jones[30] natural mortality coefficient in fish varies with age and predator abundance. In addition natural mortality is difficult to estimate in tropics as the classical method of Z against efforts does not give an accurate estimate of M as apportioning of the efforts is not possible. Thus a number of methods have to be tried and more often we have to depend on the M/K as an indicator of accuracy of M and K. The M/K ratio of 1.5 to 2.5 indicates the accuracy in the estimation of natural mortality coefficient. In present study M/K ratio were found to be 1.86 which lies in the range of 1.5 to 2.5, indicating that the estimates are fairly reasonable. A stock is considered as mortality dominated if Z/K value is equal to more than 2 and growth dominated if Z/K value is equal to 1. The stock of *E. thoracata* along Mumbai water was found to be highly mortality dominated as calculated value of Z/K was 4.22.

Gulland[31] suggested that the optimum 'E' should be 0.5 and Patterson[32] reported that the optimum value for the exploitation ratio (E) as 0.4 for the sustainable exploitation of pelagic stocks. In present study the exploitation ratio was found to be 0.56 which is slightly higher than the optimum.

Conclusion

The growth estimates obtained in the present study broadly agrees with the study done by Raje *et. al*[4.] The present study on this species is a preliminary study as it includes only one year of data. Further strengthening of the accuracy of the life history parameters estimated would be worked out by collection of data for a longer period. However, since no work on this species has been done after the work of Raje *et al.*[4] This preliminary work covering growth, mortality and population parameters would help us understand the present status of species.

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