

Study of age and growth of Indian sand whiting, *Sillago sihama* (Forsskal) from Zuari estuary, Goa

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Present study consists age and growth of *Sillago sihama*. Total 1465 fish were collected from Zuari estuary during January 2004-April 2005 as a part of the above study. To evaluate the age at corresponding length, length frequency distribution (LFD) analysis was applied. Growth check on otolith was also used. Number of annual rings on otolith indicated the presence of four age groups namely, 0+, 1, 2 and 3 year classes. The mean lengths of each age group was 88 mm, 130.9 mm, 168.3 mm and 199.8 mm, respectively. Von Bertalanffy growth equation (VBGE) was used to estimate the growth parameters as: $L_t = 388 [1 - e^{-0.1526(t-t_0)}]$. Length weight relationship (LWR) revealed that only male of *S. sihama* follows the cube law. Relative condition factor (Kn) is influenced by several factors. Feeding activity and reproduction cycle are the main factors influence the condition in the species.

[Keywords: *Sillago sihama*, age, growth, condition, Zuari estuary, Goa]

Introduction

Growth has been one of the most intensively studied aspects of fish biology. It is a good indicator of the health of individuals and populations. It is expressed in relation to time, thus it is useful to determine the age of the candidate species. The knowledge of age and growth of an economically important fish is essential for understanding the age composition of the stocks and the role of various class-years in the fisheries. It is also essential to determine the mortality and survival rate of various year-classes and success of the yearly broods after recruitment. Accordingly, knowledge of age and growth is of vital importance in the fisheries management. It is proposed to study age, growth and condition of *Sillago sihama* (Family Sillaginidae) from Zuari estuary, Goa, India.

Materials and Methods

Monthly samples were collected from Zuari estuary at Dona Paula point during January 2004-April 2005. A total of 1465 specimens, comprising of 676 males and 789 females were collected. The total length and weight of the fishes were recorded to the nearest 1.0 mm and 1.0 g, respectively. Estimation of age and growth rate in *S. sihama* was carried out using various methods to evaluate the age at corresponding length¹. The Length Frequency Distribution (LFD) following Petersen's method and growth check on otolith of 81

specimens following the procedure given by Qasim², (1957) were used. Otoliths were obtained by cutting across the dorsal sides of the head with a sharp scalpel behind the eyes. The largest otolith (sagitta) was removed from the otic capsule, washed in water, and cleaned from all extraneous tissue. The length and weight of each otolith were measured to the nearest 0.01 mm and 0.001 mg, respectively. Otoliths were then ground, immersed in 50% glycerol and observed under binocular microscope to see the annual rings.

The growth parameters were estimated using the Von Bertalanffy growth equation (VBGE), which can be written as:

$$L_t = L_\infty (1 - e^{-k(t-t_0)})$$

where L_t = length at age t , L_∞ = asymptotic length (the length of the fish would reach at an infinity age), K = the growth coefficient (constant), t = age of fish and t_0 is the theoretical age the fish would have at length zero. The condition or well being of fish was determined by Length Weight Relationship (LWR) using the parabolic formula and its logarithmic transformation, respectively

$$W = a + L^b \text{ (Le Cren, 1951)}$$

and

$$\text{Log } W = \text{Log } a + b \text{ log } L$$

where W is the weight of fish (g), L denoted the length of fish (mm), 'a' is the intercept and 'b' is the

slope, 'a' and 'b' are constants. Significance of difference between the regression coefficients of sexes at 0.05 level was tested using ANCOVA³. The 't' test was employed to test whether the regression coefficients depart significantly from expected cubic value '3' in both the sexes. Relative Condition Factor (Kn) was also calculated.

Results

Length frequency distribution (LFD)

The frequency distribution of different size groups in different months showed that no single mode of size groups could be traced over a period of one year. Hence, attempt was made to condense the data to find the major modes. For this purpose, data was pooled and the results depicted in Fig. 1. Presence of young fishes throughout the year made it difficult to get a clear picture of mode of different size groups. Hence, age and growth of these main length groups could not be known directly. Therefore, the mean length of different size groups has been assigned to different age groups based on otolith studies. The result is given in Table 1.

Growth check on Otolith

The mean length at various age groups is shown in Table 2 and Fig. 2. It was inferred that fishes with average length of 88 mm had no rings on their otoliths, while the fishes with an average total length of 130.9 mm had one clear ring on the otolith. The fishes showing two rings were found to have an average length of 168.3 mm. The mean length of fishes with three growth rings was 199.8 mm. The

regression analysis based on least square method revealed that there was a highly significant association between total length of fish and length and weight of the otolith ($r = 0.94$ and 0.93 , respectively, $P < 0.001$).

Growth parameters

The various growth parameters attained by the fish, as calculated by Ford Walford growth equation were found to be $L_{\infty} = 388$ mm, $t_0 = -1.60$ and $k = 0.1526/\text{year}$. By substituting these values, the VBGE for *S. sihama* can be expressed as:

$$L_t = 388 [1 - e^{-0.1526(t - (-1.6))}]$$

Based on the VBGE the length was calculated as 84 mm, 127.1 mm, 164 mm and 195.7 mm at 0+,

Table 1—Mean length at different age groups (Model progression analysis) during 2004

Month	Mean length/Age (Year)			
	0+	1	2	3
Jan	65			
Feb		119.8		
Mar	100	118.2		
Apr	100.9	118.0		
May	109.7	130.1		
Jun	91	139.7	160.7	
Jul		140.0		
Aug		138.9	178.4	
Sep		129.9	160.6	194
Oct		128.5	183	210.3
Nov		149.8		
Dec	55		169	
Mean	86.93	131.28	170.34	202.15
Growth rate		44.35	39.06	31.81

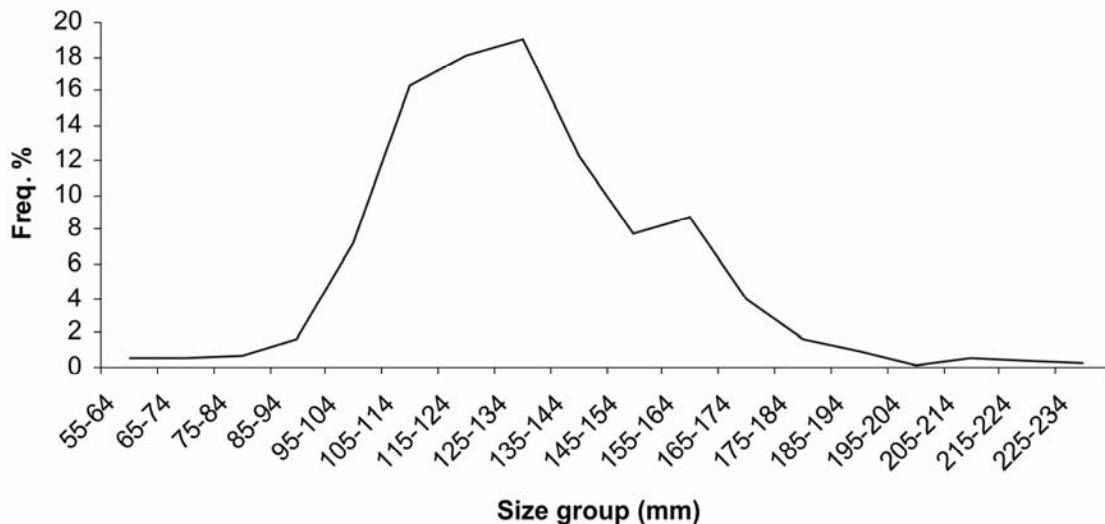


Fig. 1—The length frequency distribution (pooled data) during January - December 2004

Table 2—Mean length (mm) of *S. sihama* at various age groups based on otolith rings count

No of annuli on Otolith	Size Group (Mean)	Estimates Age	Designation of age group	Growth Rate
None	68-102 (88.0)	Less than one year old	0+	
One	108-145 (130.9)	One year old	1	42.9
Two	145-187 (168.3)	Two years old	2	37.4
Three	190-224 (199.8)	Three years old	3	31.5

1, 2 and 3 year classes, respectively Fig. 3. These results showed a very close agreement with those estimated by otolith method.

The mathematical relationship between total length and weight of male and female obtained by logarithmic regression equations and their corresponding parabolic equations can be expressed as follows:

$$\text{Log } W = - 5.1691 + 3.0045 \text{ Log } L \text{ \& } W = 0.00000678 L^{3.0045} \text{ for male}$$

$$\text{Log } W = - 5.2898 + 3.0633 \text{ Log } L \text{ \& } W = 0.00000513 L^{3.0633} \text{ for female}$$

Such relationship was depicted in Figs 4 and 5. The correlation coefficients 'r' were obtained from the statistical analysis as $r = 0.96$ ($P < 0.001$) in case of male and $r = 0.98$ ($P < 0.001$) in female. The results of the analysis of covariance revealed that there was no significant difference ($F = 3.31$, $P > 0.05$) in the regression coefficients between male and female. The 't' test showed a significant departure of 'b' value from 3 in case of female only. The values of 't' test for both the sexes were as:

$$t = 0.18 (0.01, 2, 675 \text{ df}) \text{ for Male } P < 0.01$$

$$t = 3.1 (0.01, 2, 788 \text{ df}) \text{ for Female } P > 0.01$$

Relative condition factor (Kn)

The monthly variation of Kn showed similar trends in both sexes (Figs 5 and 6). The minimum values were reported in September in both the sexes. However, the maximum values were observed in December in female and April in male. Generally, Kn values were high during pre-monsoon (February-May) and post-monsoon (November-January) and low during monsoon season (July-September) and during

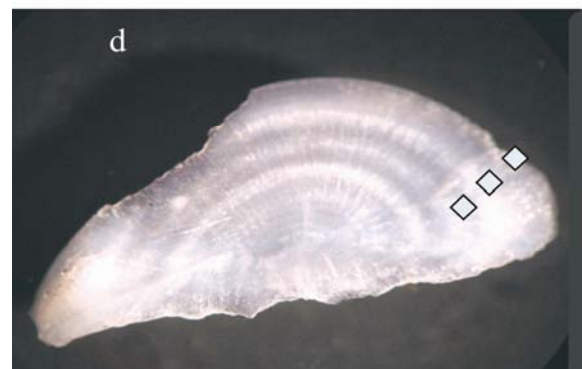
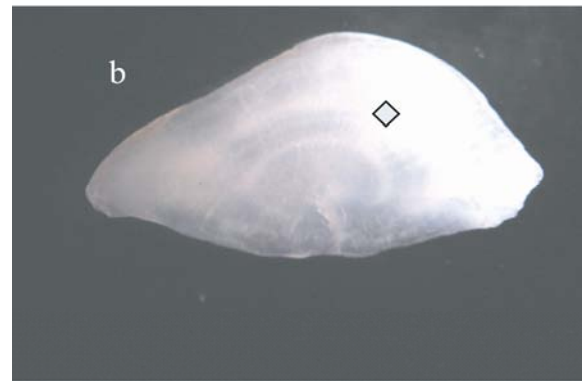
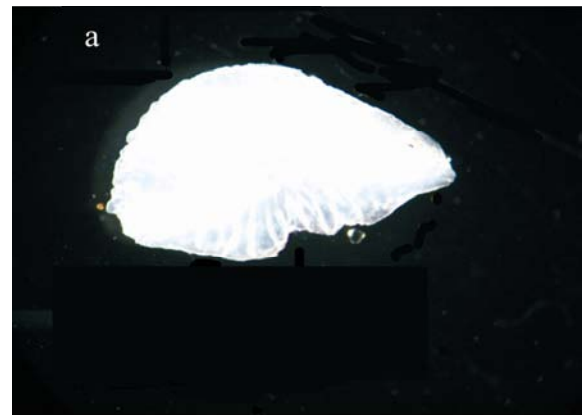
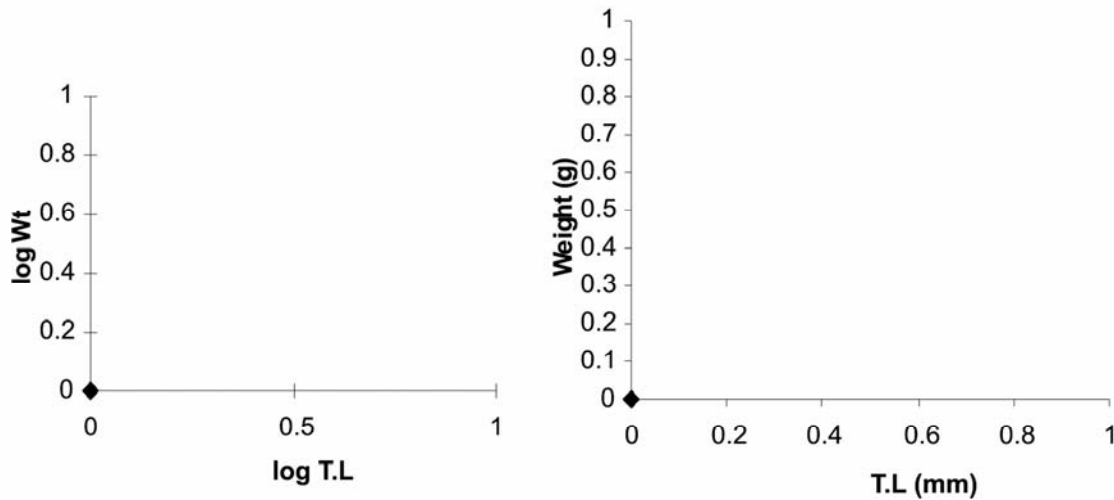
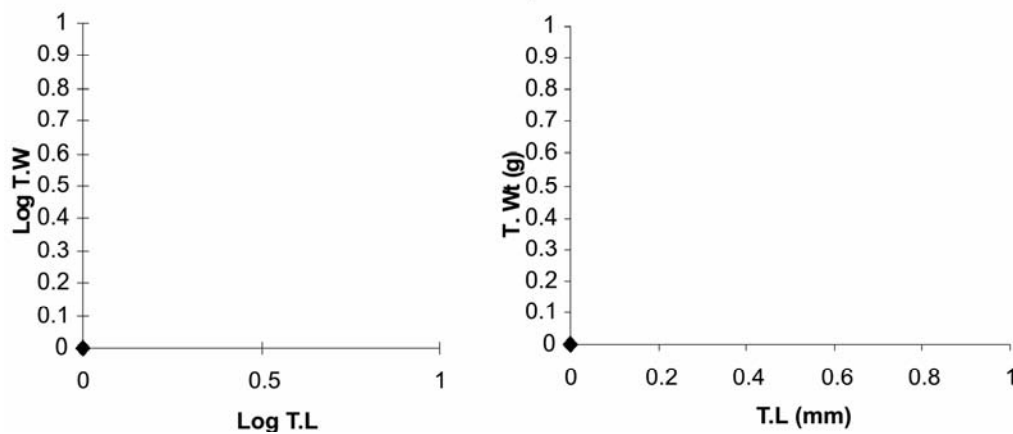


Fig. 2—Plates showing otoliths with (a) zero ring, (b) 1 ring, (c) 2 rings and (d) 3 rings

Fig. 3—Length – weight relationship in male *S. sihama*Fig. 4—Length – weight relationship in female *S. sihama*

October. Comparing the Kn values with gonado somatic index (G.S.I) and gastro somatic indices (Ga.S.I) showed that there was no direct correlation between Kn and G.S.I, while the correlation between Kn values and Ga.S.I. was significant in both sexes ($r = 0.58$, $P = 0.025$ in male and $r = 0.62$, $P < 0.025$ in female)

Discussion

In the tropical environment fishes which breed at short intervals over a prolonged period, a study of the LFD will not give a proper indication of year classes, because of the entry of broods into the population several times in a year⁴. This was clear in the present study also. From LFD data it is clear that the modal progression could not be traced during a period of one year, so the age at length could not directly be

predicted. This difficulty in calculating the age and growth from monthly LFD of fish may be because *S. sihama* has a prolonged spawning period wherein the LFD get super-imposed and may not easily indicate the yearly broods⁵.

Fish at 0-year group was not clearly indicated because they were caught in few numbers and that was probably due to the fishing gear selectivity in which small fishes could not be picked up.

The present study indicated the presence of fish in four age groups in the population namely 0+, 1, 2 and 3 year groups based on otolith observations. The mean length for the age groups 0+, 1, 2 and 3 was arranged as 88, 130.9, 168.3 and 199.8 mm, respectively. The modal progression of different size groups based on the counts of the rings on otolith, was 86.9, 129.2, 166.9 and 202.2 mm, for 0+, 1, 2, and

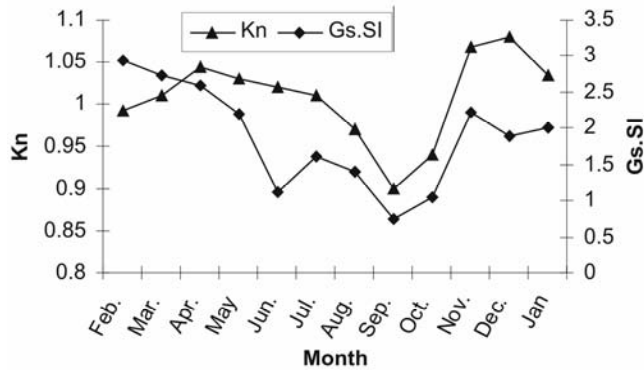


Fig. 5—Relative condition factor (Kn) in male *S. sihama*

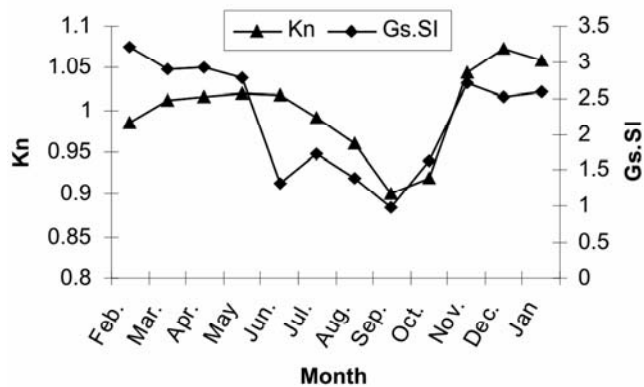


Fig. 6—Relative condition factor (Kn) in female *S. sihama*

3 years, respectively (Table 1). These results were more satisfying than those obtained from direct LFD method. Radhakrishnan⁶ reported the mean length at one to four year age groups as 148, 190, 224 and 240 mm. However, Krishnamurthy and Kaliyamurthy⁷ estimated mean length at ages one to five were 60.2, 131.1, 185.4, 227.1 and 265.7 mm, respectively. The variation in size of age groups observed by other authors could be related to geographical variation and prevailing hydrographical conditions.

In the most recent study, David and Pancharatna⁸ reported one to four translucent zones and one to five opaque zones on the otolith of *S. indica*. From Japanese waters, the longevity of specie *S. japonica* is reported to be up to four years⁹, while the study of age and growth of *S. aeolus* by Rahman and Tachihara¹⁰ suggested that the majority of this species die before reaching three years old. From Australian waters, sand whiting species e.g. *S. vittata* and *S. burrus* rarely exceeded two years of age, though a small number of *S. vittata* were caught between four to seven years old¹¹⁻¹². However, the present study

suggests that *S. sihama* reach three years old in Zuari estuary.

There are two categories of growth pattern suggested in *Sillago sp.* from south Western Australia¹²; the first category included fishes characterized by relatively small asymptotic length (<190 mm) and high growth coefficient 'K' (≥ 1) whereas those in the second category attain relatively large size ($L_{\infty} > 300$ mm) and have growth coefficient 'K' (≤ 0.5). Accordingly, *S. sihama* from Zuari estuary fall into the second category. Fishes belonging to this category attain their sexual maturity at approximately 200 mm, a length reached at the end of the second year. This is in close agreement with the present study. In *S. sihama*, as in most tropical fishes which have protracted breeding season, almost throughout the year, the entire growth is confined to the pre-maturity phase and has little growth after they become sexually mature.

From the trend of 'b' value in the LWR, it may be presumed that female gained more weight with the increase in length and subsequently age than male; this difference was not significant as it was revealed from the analysis of covariance. Gowda *et al.*¹³ reported that the regression coefficient 'b' does not differ significantly between sexes in *S. sihama* from Mangalore waters, while Jayasankar¹⁴ and Annappaswamy *et al.*¹⁵ reported significant differences in 'b' values of male and female ($P < 0.05$). Although, the difference between the slopes of the regression of male and female was not significant, it reflects a difference in growth pattern in both the sexes. This difference may be attributed to gonadal development where weights of gonads of females are higher than those of males leading to gaining more weight by female. Dulcic and Karaljevic¹⁶ stated that the estimated parameters of length weight relationship might differ among seasons and years primarily due to physicochemical characteristics of the environment, sex and maturity stages of a given species. Radhakrishnan⁶ reported that 'b' value followed the cube law in *S. sihama* from Mandapam and Rameswaram waters. It has been reported that the regression coefficient were not significantly different from cube law in *S. sihama* from Pulicat lake, Netravati-Gurupur Estuary and Gulf of Mannar and Palk Bay^{7,13-14}, respectively. Annappaswamy *et al.*¹⁵ also observed that only female is following the cube law in *S. sihama* from Mulki Estuary. In the present study also it is concluded that

the LWR followed cube law only in male of *S. sihama*. However, variation in departure of 'b' value from cube law as reported by different authors may be due to difference in the number of samples used for 't' test and also the environmental conditions of the study area.

The study showed that there was a definite seasonal cycle in the Kn of both sexes of *S. sihama*. The high values of Kn during February-May may be attributed directly to feeding activity during the summer months (Just prior to the major spawning season in *S. sihama*). Baragi and James¹⁷ found it difficult to explain the changes in condition of the Sciaenid *Johneops osseus* based on the intake of food and sexual cycle. They suggested that this could depend on several other unknown factors. Seasonal variation of Kn is influenced by the gonadal development, feeding activity and several other factors¹⁸.

Conclusion

Above observations suggest presence of four year groups namely, 0+, 1, 2, and 3 year of *S. sihama* in this area. Study of otolith of *S. sihama* in age determination indicates its validity in tropical fishes. Feeding activity and reproduction cycle are the main factors influence the condition of the species.

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