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Population parameters of Indian sand whiting *Sillago sihama* (Forsskal) from estuaries of southern Karnataka.

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Abstract

The Indian sand whiting, *Sillago sihama,* occurring in the estuaries of Karnataka along the southwest coast of India was found to attain a mean length of 17.1, 25.2, 29.2 and 31.1 cm at the end of 1-4 years respectively. From the length-converted catch curve, the total fishing mortality Z was estimated as 3.79 $year^{-1}$ whereas from Jones and van Zalinge method Z was estimated to be 3.28. The natural mortality M was estimated to be 1.41 which gave F = 2.38. The exploitation rate E = 0.63 gave an indication that *S. sihama* fishery is facing moderately higher fishing pressure in these estuaries. l_c was estimated as 14.45 cm, l_m=16.5 cm and l_{opt}= 20.7cm. The length-weight relationship was found to be $W = 0.02471\ L^{2.56}$. W_∞ was estimated as 197g. The life span of the species is around 4.22 years. A note on the spawning season and recruitment pattern is also included in this paper.

Introduction

Even though many studies have been conducted on the stock assessment of marine fishes from India, very few attempts have been made on the stock assessment of estuarine fishes. In this direction a study was initiated on the stock assessment of commercially important estuarine fishes of the southern Karnataka, extending from Talapady to Byndoor along west coast of India. For the purpose, 5 major estuaries viz., Netravathi-Gurpur, Mulky, Kallyanapura, Mabukala and Gangolli were selected. It was observed that *Sillago* spp., *Gerres* spp. and mullets form 40% to 55% of total estuarine fishes landed along the southern part of Karnataka coast and some of them are commercially important. An attempt is made in this paper to estimate the population parameters and to study the spawning season of Indian sand whiting *S. sihama* based on samples collected during the years 2000 and 2001 from these estuaries.

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Material and methods

Indian sand whitings are mainly caught

by cast net, gill net, hooks and lines and shore seines mesh sizes ranging from 24 mm to 60 mm from estuaries and inshore waters. A total of 2,175 specimens of *S. sihama* in the size range of 10.5 to 31.5 cm were sampled for recording total length (in cm from tip of snout to tip of lower caudal fin) body weight (in grams, weighed using an electronic balance). For estimating population parameters, the length measurements of 2 years data were grouped and pooled with 1 cm class interval, monthwise and analysed using the FiSAT software (Gayanilo *et al.*, 1996).

An initial estimate of asymptotic length (L_∞) was obtained through the Powell-Wetherall method (Pauly, 1986; Wetherall 1986). The values of L_∞ and K obtained from ELEFAN I method were used to correct the data for selection of the gear (Sparre, 1985). For this the length-converted catch curve was applied along with an estimate of natural mortality (M), using Pauly's empirical formula (Pauly, 1980). The values of probability of capture corresponding to each length class were obtained. The estimated probability values were then applied to the original length frequency data. The corrected data was then run in the search routine in the ELEFAN I programme using Response surface analysis and scan of K values. The L_∞ and K values thus obtained were taken as the final growth parameters of *S. sihama*. The total mortality coefficient (Z) was estimated using length- converted catch curve method (Pauly, 1983a). Final estimates of natural mortality (M) and fishing mortality (F) were derived and thereby the exploitation rate (E). Alternatively, Z value was estimated by Jones and van Zalinge method (1981). Having estimated L_∞ and K values, the independent estimate of t_0 was derived as – 0.0284 by using very approximate empirical equation of Pauly (1979). This value of t_0 was used with L_∞ and K to study the age and growth of *S. sihama*. The output of growth curve was obtained and length based growth performance index φ' was calculated (Pauly and Munro, 1984). Length at first capture (l_c) was estimated by the method of Pauly (1984) corresponding to the first point in the descending limb of the linearised catch curve.

The mean size at first maturity (l_m) was derived by plotting percentage cumulative number of fishes in stage III+ and above against total length. The length corresponding to 50% cumulative frequency of the sigmoid curve was taken as l_m. Length-weight relationship of *S. sihama* was derived for pooled length-weight data of 2,175 specimens. Spawning season was estimated based on the graph of average relative condition factor (K_n) values against each month for monthwise pooled length frequency data of 2 years. The range of sharp decline in K_n value was considered as the spawning season. Recruitment pattern was studied from recruitment curves using final estimated values of L_∞, K and t_0. The estimate of optimum length corresponding to maximum yield was derived following Beverton, 1992. Life span of Indian sand whiting was estimated as 3/K (Pauly, 1983b).

Results

Estimation of growth parameters

The method of Powell and Wetherall plot when applied to original pooled length frequency data of *S. sihama* gave preliminary estimates of L_∞ = 33.09 cm (Fig.1). The final value of L_∞ and K as estimated by ELEFAN I routine were 33.0 cm and 0.71 year^{-1} respectively. The catabolic coefficient K - the rate at which there is decrease in the average growth rate - has increased from 0.6 to 0.71 year^{-1}. Thus the estimated growth parameters of *S. sihama* from estuaries of the southern coast of Karnataka were L_∞ = 33 cm, K = 0.71 year^{-1} and t_0 = -0.0284. The largest fish available in the sample was 31.5 cm. The growth performance index of *S. sihama* was found to be 2.88.

Output of growth curve and length at age

The output of growth curve showed that the birth date of *S. sihama* was during September-October. The growth curve represented 4 cohorts. From the growth curve, the mean length of 1, 2, 3 and 4-year old fishes were estimated as 17, 24, 29 and 30 cm respectively.

Estimation of Z, M, F and E

From length-converted catch curve (Fig.2), final estimate of total mortality Z was at 3.79 year^{-1} whereas from Jones and van Zalinge method Z was found to be 3.28. The estimate of natural mortality M from Pauly's equation was 1.41 at T = 29^{0}C. According to Del Norte (1988), M can also be derived as M ≅ 2K, which is true in the above case. The fishing mortality F was estimated as Z - M = 2.38. The exploitation rate E was estimated at 0.63, which indicates moderately high fishing pressure on *S. sihama* in the estuaries of Dakshina Kannada coast.

Length at first capture and mean size at first maturity

The length at first capture l_c of *S. sihama*

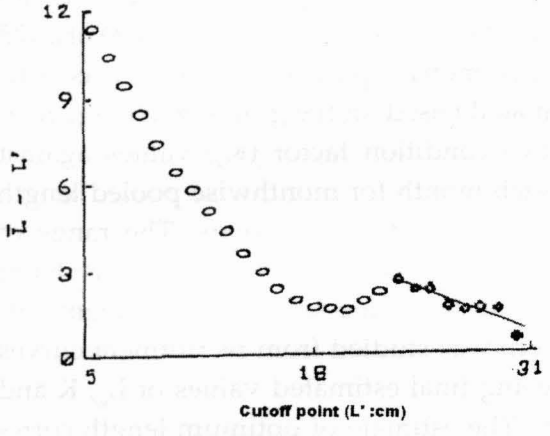

Fig. 1. *Powell and Wetherall plot estimating L_∞ and Z/K for the pooled length frequency data in the years 2000 and 2001 (L_∞ = 33.09 and Z/K = 2.934, r = -0.955)*

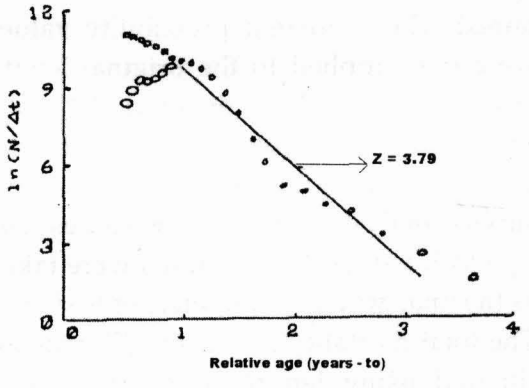

Fig. 2. *Length converted catch curve of* Sillago sihama *to estimate total mortality*

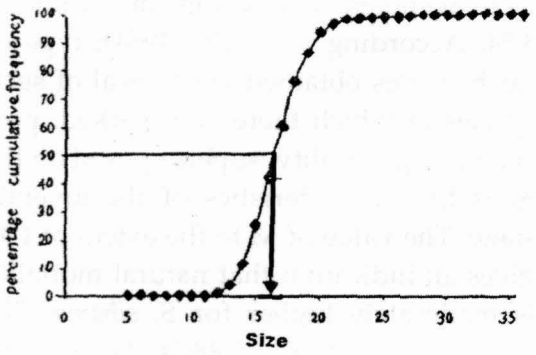

Fig 3. *Estimation of mean length at first maturity of* Sillago sihama *for the pooled length*

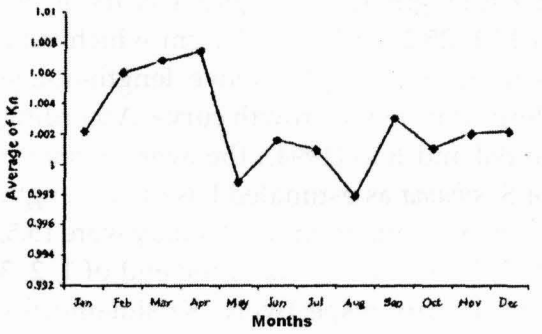

Fig. 4. *Estimation of spawning period of* Sillago sihama *based on monthly average Kn values for pooled data of years 2000 and 2001*

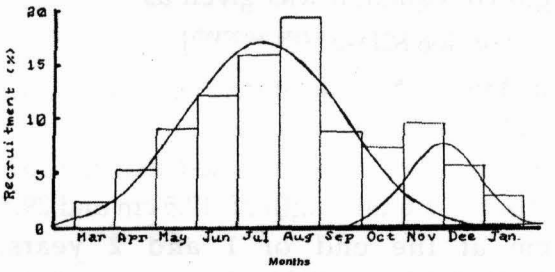

Fig. 5. *Recruitment curves of* Sillago sihama *for the corrected length frequency data based on* L_∞ *= 33.0 cm, K = 0.71 and* t_0 *= -0.0284*

was estimated at 14.45 cm, while from Figure 3, mean length at first maturity l_m was found to be 16.5 cm which is higher than l_c value. The optimum length l_{opt} of the said species to be caught for maximum yield is 20.7 cm.

Length-weight relationship

From the pooled length frequency data of 2 years, the length-weight relationship of *S. sihama* was found to be $W = 0.0247 L^{2.56}$. The t-test showed isometric growth (H_0: $\beta = 3$) and *b* was found to be significant ($t = 5.032$, $p < 0.05$). From the length-weight relationship the maximum asymptotic weight (W_∞) of the species was estimated as 197grams.

Spawning season

The monthly length-weight relationships were used to derive average relative condition factor (K_n) for each month (Fig. 4). Obviously *S. sihama* spawns twice in a year during April-May and September-October.

Recruitment pattern

Figure 5 depicts the recruitment curves of *S. sihama* based on the estimated growth parameters. It is seen that the recruitment process takes place continuously in 2 pulses of unequal strength (82% and 18%) with peak in August and November having mean sizes 4.60 ± 1.9 cm and 8.96 ± 0.94 cm respectively.

Discussion

The growth parameters of *S. sihama* were $L_\infty = 33$ cm, $K = 0.71$ year^{-1} and $t_0 = -0.0284$ from the estuaries of the southern coast of Karnataka. The growth curve consisted of 4 clear cohorts from which the mean length at 1, 2, 3 and 4 years were estimated as 17, 24, 29 and 31cm respectively. From the von Bertalanffy growth equation the estimated

mean length at 1, 2, 3 and 4 years of life is 17.1, 25.2, 29.2 and 31.1 cm which very well agree with the above length-at-age derived from the growth curve. According to Bal and Rao (1994), the average length of *S. sihama* as estimated based on length frequency data from Kali Estuary were 15.5, 20.5, 24.5 and 27.5 cm at the end of 1, 2, 3 and 4 years respectively. Krishnamurthy and Kaliyamurthy (1978) studied the age and growth of *S. sihama* from Pulicat Lake using otoliths and the von Bertalanffy growth equation was given as

$$l_t = 406.82[1-e^{-0.2276\ (t-0.27457)}].$$

Reddy and Neelakantan (1992) studied age and growth of *S. sihama* from Karwar waters. They have reported that the fish attained a total length of 17.5 cm and 29.5 cm at the end of 1 and 2 years. Radhakrishnan (1957) has reported the dominance of 1-3 age group of *S. sihama*, and that the mean length of 1, 2, 3 and 4-year old fishes were 14.29, 19.03, 22.41 and 24.02 cm respectively. He found that old ones were very rare. According to Palekar and Bal (1960) the mean length of 1,2,3 and 4 year old fishes of *S. sihama* from Karwar waters were 14.79, 19.03, 22.41 and 23.02 cm respectively. Obviously the present estimate of mean length-at-age data of *S. sihama* are not comparable with the above findings. This may be due to variation in the growth, related to environmental conditions existing in the various estuaries.

The estimation of total mortality Z = 3.79 by catch curve analysis was nearer to the estimate 3.28 obtained by Jones and van Zalinge method. Hence the 2 estimates were averaged to record mean Z value as 3.54. According to Pauly (1984), type of catch curves obtained are typical of such species in which there is a marked, post spawning mortality, superimposed on the mortality characteristics of the juvenile stage. The value of M to the extent of 1.41 gives an indication that natural mortality is moderately higher for *S. sihama*. The fishing mortality F = 2.38 is also an indication of intensive commercial fishing of the species as also revealed by the exploitation rate 0.63.

The length at first maturity (16.5 cm) is attained when the fish is approximately 1 year old. Bal and Rao (1994) have opined that at Rameswaram Island the size at first maturity of *S. sihama* was found to be 130-140 mm when they are 1 year old; from Kali Estuary 274 mm for males and 235 for females (average value 255 mm); from Netravathi Estuary 151 mm and from Gangolli Estuary 191 mm. Palekar and Bal (1961) have reported that mean size of first maturity of this fish from Karwar area was 129 mm. Krishnamurthy and Kaliyamurthy (1978) have estimated the size at first maturity from Pulicat Lake as 225 mm. Jayasankar (1991) reported the first maturity size of males and females as 159 mm and 179 mm respectively from which the mean size at first maturity was found to be 169 mm which is nearer to the present estimate. Thus the present estimate of l_m is nearer to the earlier estimates except from Kali Estuary and Pulicat Lake. It is seen that estimate of l_m is higher than l_c value in *S. sihama* and there is possibility that fishes were caught before they start spawn-

ing. The situation is obvious from the index of reproduction stress 0.44, which means that the species is vulnerable to fishing before it attained a length of 14.5 cm. The optimum length of capture of *S. sihama* for maximum yield would be 20.7cm, which means that increase in mesh size of gears is required to avoid the young fishes.

According to Gowda (1984), in *S. sihama* inhabiting the coastal and estuarine waters of Mangalore region, the value of *b* was 2.95 which is more than the present value of 2.56 for the pooled value from 5 estuaries. According to Bal and Rao (1994), the *b* value of this species from Rameswaram Island was 2.88 and a = 0.0150; and from Kali Estuary $b = 2.89$ and $a = 0.00001247$ for males, $b = 2.54$ and $a = 0.00000778$ for females. Radhakrishnan (1957) reported that *b* value is same at 2.88 in *S. sihama* from Mandapam and Rameshwaram areas. Krishnamurthy and Kaliyamurthy (1978) have reported that in juveniles and the adults *b* values were 3.02 and 3.08 respectively. Thus the variation in *b* values may possibly be due to factors related to ecosystem and biological phenomena like maturity stages, feeding behaviour, competition for food, etc.

As indicated in Figure 4, *S. sihama* spawns twice in a year during April-May and September-October. According to James *et al.*(1976) *S. sihama* has a prolonged breeding period extending from August to April in Mangalore region. Gowda (1984) has also reported prolonged spawning season for this species from Netravathi-Gurupur estuary over several months during August-March and May-June period with the peak in September. Bal and Rao (1994) have reported that this fish spawns once in a year. In Rameswaram Island (Radhakrishnan, 1957), the spawning season was from August-February with the peak in October. On the contrary, the present pattern of spawning in *S. sihama* from estuaries of the southern coastal Karnataka is evidenced from 2 recruitment spells of the species corresponding to 2 spawning seasons as could be seen from Figure 5. The spawning season seems to be continuous due to the fact that 2 recruitment curves are overlapping each other with unequal spawning intensity as can be evidenced from percentage of recruits. Thus there seems to be varying spawning season in *S. sihama* in different regions.

It is estimated that the maximum life span of *S. sihama* is 4.22 years as revealed by the 4 cohorts and the growth curve.

References

Bal, D.V. and K. Virabhadra Rao.1994. *Marine Fisheries of India*. Tata MCgraw - Hill Publishing Company Limited, New Delhi. pp 314- 325.

Beverton, R.J.H. 1992. Patterns of reproductive strategy parameters in some marine teleost fishes. *J.Fish Biol.*, **41** (B) : 137-160

Del Norte, A. G. C. 1988. Aspects of growth, recruitment, mortality and reproduction of the scallop *Arnusium pleuroneates* in the Lingayen Gulf, Philippines. *Ophelia*, 29(2): 153-168.

Gayanilo, F.C. Jr., P.Sparre and D.Pauly. 1996. The FAO-ICLARM Stock assessment Tools (FiSAT) User's Guide. *FAO Comp. Info. Ser. (Fish).*, No. 8, Rome, FAO. 126 pp.

Gowda, H. H. 1984. Observations on the biology of the Indian sand whiting *Sillago sihama* (Forsskal) from Netravathi-Gurupur estuary. *M.F.Sc Thesis*; University of Agriculture Sciences , Bangalore.

James, P.S.B.R.,T.J. Varghese and K.V.Devaraj. 1976. Some observations on the possibilities of culture of Indian sand whiting *Sillago sihama*

(Forsskal) in brackish waters. *J. Inland Fish. Soc. India,* **8** : 212-220.

Jayasankar, P. 1991. Sillaginid fishes of Palk Bay and Gulf of Mannar with an account on the maturation and spawning of Indian sand whiting, *Sillago sihama* (Forsskal). *Indian.J.Fish.*, **38** (1): 13-25.

Jones, R. and N.P. van Zalinge. 1981. Estimations of mortality rate and population size for shrimps in Kuwait waters. *Kuwait Bull. Mar.Sci.*, **2** : 273-288.

Krishnamurthy, K.N. and Kaliyamurthy. 1978. Studies on the age and growth of sand whitings *Sillago sihama* (Forsskal) from Pulicat lake with observations on its biology and fishery. *Indian J. Fish.*, **25**(1&2): 84-97.

Palekar, V.C. and D.V.Bal .1960.Observations on the length frequencydistribution of the Indian sand whiting, *Sillago sihama* (Forsskal) from Karwar waters. *J. Zool. Soc. India.* **12**(1) : 104-113.

_____ 1961. Studies on the maturation and spawning of the Indian sand whiting, *Sillago sihama* (Forsskal) from Karwar waters. *Proc. Indian Acad. Sci.*, **54**(2) : 76-93.

Pauly, D. 1979. Theory and management of tropical multispecies stocks. A review, with emphasis on the south-east Asian demersal fisheries. ICLARM Studies and Review, 1 : 35p.

_____ 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *J. Cons. CIEM*, **39**(3): 175-192.

_____ 1983 a. Length converted catch curves : a powerful tool for fisheries research in tropics, (Part I). *ICLARM. Fishbyte*, **1**(2) : 9- 13.

_____ 1983 b. Some simple methods for the assessment of fish stocks. *FAO Fish. Tech. Pap.*, 234 : 52 pp.

_____ 1984. Length-converted catch curves: a powerful tool for fisheries research in the tropics (Part II). *ICLARM. Fishbyte*, **2**(1): 13-14.

_____ 1986. A simple method for estimating the food consumption of fish populations from growth data and food conversion experiments. *Fish. Bull,. (US)* **84**:827-840.

_____ and J.L.Munro. 1984. Once more, on the composition of growth in fish and invertebrates. *Fishbyte*, **2**(1) : 21

Radhakrishnan, N. 1957. A contribution to the biology of Indian sand whiting *Sillago sihama* (Forsskal). *Indian. J .Fish.*, **6**(1) : 254-283.

Reddy C.R and B.Neelakanten. 1992. Age and growth of Indian whiting, *Sillago sihama* (Forsskal) from Karwar waters. *Mahasagar*, **25**(1): 61- 64.

Sparre, P. 1985. *Introduction to tropical fish stock assessment*. Manual I, FAO Rome, 339pp.

Wetherall, J.A. 1986. A new method for estimating growth and mortality parameters from length-frequency data. *ICLARM. Fishbyte* **4**(1): 12-14.