

### **8.1. Introduction**

Fish has been a major commodity in trade for more than thousand years and seafood has significantly influenced the living conditions of coastal people all over the world. Fishing and fisheries contribute more than any other animal production activity to protein intake in most of the developing regions of the world. India has an extensive coastline of about 8129 km, comprising estuaries, lakes, lagoons, swamps, and mudflats extending between 8° 4' and 37° 6' north latitudes, and 67° 7' and 97° 25' east longitudes.

Indian Ocean occupies an area of 20.8 % of the world ocean; it yields only about 8.2 % of the total global fish catch (Pandey and Shukla, 2005). In addition, India is blessed with vast inland water resources in the form of rivers, estuaries and mangrove wetlands. The total fish catch of India for 2004 was 6,399,390 tones in which production from inland water was more than 50 %.

Sillaginids or sandwhittings are highly esteemed food fishes in Indian waters from Hoogly River in the east coast to Goa in the west coast (Sujatha, 1987). Among Sillaginids occurred in Indian waters, *S. sihama* is commercially the most important. Fishing for *S. sihama* is carried out all

round the year with peak during the months of monsoon (June – September), when the sea fishing is suspended.

Although Goa is the smallest maritime state of India, it contributes about 3 % of the total marine fish catch in the country (John, 2006). The total fish production of Goa was 101 thousand tones in 2005. *S. sihama* forms a minor but important fishery from both marine and inland waters in Goa. The species is locally referred to as “*Muddoshi*”. Although, it is a highly esteemed fish by the medium and rich classes due to which it commands high price, it is available in small quantities during different seasons in the market.

Although, traditional culture of marine finfish has been practiced in Goa, these are known to be used for traditional culture of two major cultivable groups, namely Milkfish *Chanos chanos* and Grey mullets *Mugil cephalus* (Nammalwar, 1997).

In the view of its importance in the fishery and absence of any published information on the fishery of this species from this area, the present study was undertaken. The data used have been collected from Directorate of Fisheries, Government of Goa, Panaji.

## **8.2. Fishing Methods**

In India, large varieties of crafts and gears have been designed for marine and inland fishing. The fishing methods used for *S. sihama* are the same that commonly operated in estuaries and backwaters. The main types of gear commonly used in the Mandovi - Zuari estuarine system and inshore waters for the capture of this species are Hook and line, stake net, Gill net and shore seines. Accidentally they are also caught during trawling. Slight modification has been made to these gears to suit local condition.

### **8.2.1. Hook and Line**

This is the ancient method for catching fishes. The principle of line fishing is to offer a bait to entice the fish. The gear consists of a string made of nylon and cotton firmly tied with a small hook at the end. The free end of the line is attached with long bamboo stick (2 - 5 meter long). The baits used (clams meat, shrimp and Nereid worms) are fixed on the hook. The hook having bait remains in the water and the bamboo stick is held in hand. This method used to capture *S. sihama* in Mandovi - Zuari estuarine system and also in inshore waters of Goa throughout the year.

### **8.2.2. Shore seines**

Shore or beach seines are generally used during the monsoon months when fishing in deeper areas is not possible due to changes in weather

condition. This gear is small shore seine consisting of some pieces of rectangular nets joined together. It is operated from the beach to surround a small area of the inshore waters. As the fish trapped in the encircled regions, the net is then dragged on the shore. It is used throughout the year especially during monsoon seasons in estuaries and inshore waters.

### **8.2.3. Gill nets**

These nets are locally referred to as "*Kanta*". These are wall-like nets of various sizes and meshes. It is made of number of pieces of variable lengths joined together. Floats are attached to the net to keep it vertical and straight. Capture is, however, more successful in the night due to invisibility of the nets. Gill nets are operated close to the mouth of the estuary. During monsoon season, bigger sized fishes of the species are caught in large numbers by these nets as the mesh size is sufficient to catch the larger fish.

### **8.2.4. Stake net**

Stake net is set depending upon the tidal direction. The gear has conical netting and is made of nylon twine. The net also consists of a scare line tide to the stake with coconut leaves for driving the fish into the net. While the head robe is tide to the stake, lead sinkers are attached at the base of the net. Generally, bamboo poles are used as stakes. The gear is operated at a depth of about 4 - 5 meters and the net is set facing

direction of the tide. Once the gear is set an area of about  $\frac{3}{4}$  to 1 km is encircled by the scare line using a dug out canoe. Then the scare line is slowly brought towards the net to direct the fishes into the net. Later, the net is hauled vertically and catch is removed.

### **8.3. Age and Size composition**

The commercial catches of *S. sihama* ranged from 85 to 234 mm in total length from Zuari estuary through out the year. The predominant size groups in the catches ranged between 120 and 170 mm length. Only small numbers of fishes measuring upto 225 mm were found in the catches.

Comparing with age determination data, the catches comprised of one to two year groups. The largest size group upto 225 mm and at about three years old forms only a small portion of the catch. The later group was caught during monsoon months. From the above trends, it was found that fishes of size ranged from 120 to 170 mm when they are almost one to two years old and are the predominant in the catches of *S. sihama* in Goa.

### **8.4. Productions of *Sillago sihama***

Although *S. sihama* forms one of the economically important species of fishes from Goa coast, its contribution is minor in both marine and inland catches. The importance of *S. sihama* as food fish is perhaps under estimated because in many areas they are taken by small-scale fishermen

using seine net and hook-and-line in large quantities and do not necessarily enter records of commercial catches (McKay, 1992).

The percentage contribution of *S. sihama* in the total fish catch of Goa during the period from 1997 to 2005 is given in Table 8.1. and the annual fluctuation of its catch is shown in Fig. 8.1.

Goa has one of the most productive fishing grounds along the west coast of India. These grounds provide several commercially important species of finfish as well as shellfish. The total fish catch of Goa fluctuating between 60075 metric tones and 103091 metric tones during 1997 - 2005 with an average of 76815.67 metric tones. During 1997 to 2005, the catch of *S. sihama* increased from 42 metric tones (0.05 % of total catch) in 1997 to 190 metric tones (0.27 %) in 2001, with an average of 106.56 metric tones (0.14 %). The fluctuation in the annual catch of *S. sihama* may be attributed to multi-fishing. Comparing with the total catch *S. sihama* has a poor landing during the period 1997 - 2005, despite its economic importance.

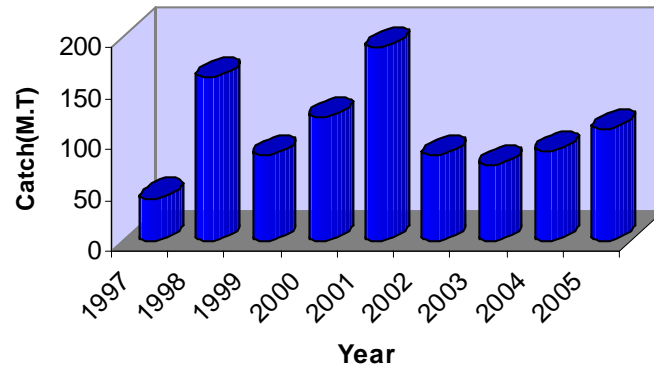
Table 8.2. shows the production of *S. sihama* from marine and inland waters of Goa during 1997- 2005. It is clear from table that the landing of *S. sihama* from marine water fluctuated between 5 metric tones in 2003 to 55 metric tones in 1998. While the Catches of *S. sihama* from inland

**Table 8.1.** Percentage contributions of *S. sihama* of the total fish catch of Goa during 1997 – 2005.

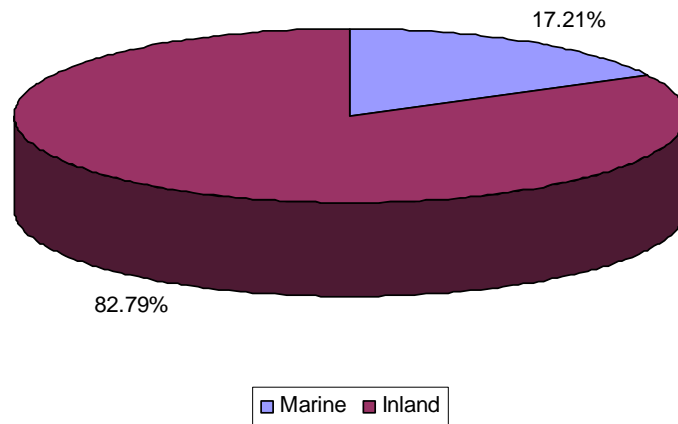
Sr.No	Year	Marine catch (M. Tonnes)	Inland catch (M.Tonnes)	Total
1	1997	10	32	42
2	1998	55	106	161
3	1999	13	72	85
4	2000	15	107	122
5	2001	17	173	190
6	2002	8	77	85
7	2003	5	70	75
8	2004	15	74	89
9	2005	27	83	110

**Table 8.2.** Production of *S. sihama* from Goa waters during 1997 – 2005.

Sr.No	Year	<i>S. sihama</i> catch (M.Tonnes)	Total catch (M.Tonnes)	%
1	1997	42	91277	0.05
2	1998	161	67236	0.24
3	1999	85	60075	0.14
4	2000	122	64563	0.19
5	2001	190	69386	0.27
6	2002	85	67563	0.13
7	2003	75	83756	0.09
8	2004	89	84394	0.11
9	2005	110	103091	0.11



**Fig. 8.1.** Total catch of *S. sihama* from Goa waters during 1997 – 2005.



**Fig. 8.2.** Average percentage contribution of *S. sihama* from marine and inland waters of Goa during 1997 – 2005.



water fluctuated between 32 metric tones in 1997 and 173 tones in 2001. This indicates that the catch of *S. sihama* from inland waters was better than that from marine (Fig. 8.2.).

### **8.5. Culture Possibilities**

Aquatic animals including fishes hold a greater productive potential than terrestrial animals for many reasons. The most important reasons are the body temperature, which is near that of their environment, and the body density is similar to habitat (Parker, 2002). With these two properties, the energy required to regulate the body temperature and that to overcome gravity can be directed towards growth. This can enhance the growth rate. Another important feature of aquatic animals is that they inhabit multidimensional environment, where different species inhabit different space and position within the water body. This expands the aquaculture options at one site. In addition, the efficient food conversion increases the nutritional values of the animal.

Choosing a fish species for aquaculture is important for successful culture (Parker, 2002). The candidate species should have a number of features for successful culture, these are:

- Reproductive habits must be understood.
- The fish should produce massive quantities and occur frequently.

- Egg and larvae requirements, a stable supply of seed must be available.
- The next factor to consider is the nutritional needs and feeding habits.
- Adaptability to crowding.
- Disease resistance.
- Market demand.

*S. sihama* possesses most of the features of a candidate species mentioned above. In the recent past, *S. sihama* has been considered for culture in both freshwater and saltwater systems (Dhulkhed and Ramamurthy, 1977; Kaliyamurthy, 1979; James *et al.*, 1976, 1984a, 1984c; Alagarwami, 1990). It has a prolonged spawning season, spawns more than once in a single spawning season, having high egg production. Hence, the seed are available throughout the year. Earlier workers have reported the abundance and seed resources availability in different seasons and regions. Small-sized Juveniles of *S. sihama* have been observed in the Gulf of Mannar and the Palk Bay during rainy season (Radhakrishna, 1957 and James *et al.*, 1984d), from the south Kanara coast (Ramamurthy and Dhulkhed, 1975), from Gangoli estuary (James *et al.*, 1976). Fry of *S. sihama* were obtained in the surf region of the sea at

Calicut during January- February and October (Mohan, 1980). Post-larvae and Juveniles of *S. sihama* were available in good quantities throughout the year in the Pulical Lake (Ramamurthy *et al.*, 1978; Ramamurthy, 1985; Roa *et al.*, 1984) and in Palk Bay (James *et al.*, 1984). They were also reported in the fishery resource of Uttara Kanada District (Reddy and Shanbhogue, 1990). In Goa waters, it is available in large number in the inshore waters in all the months (Ansari *et al.*, 2006). Thus, it seems that the seasonal abundance of the seeds of *S. sihama* may be similar in both east and west coasts of India with slight variation in the peak months of abundance.

*S. sihama* feeds on a wide range of food items, which can be supplied directly from the environment. Being a non-predatory, it can be cultured in a poly culture system along with other species. Some experiments were carried out on the poly culture. At Mangalore *S. sihama* was cultured with *Chanos Chanos*, *Liza macrolepis*, and *Penaeus indicus*, and the growth rate of 10.6 mm, 57.4 mm, 28.2 mm, respectively, were recorded. At Tuticorin *Chanos chanos*, *Valamugil seheli* and *S. sihama* were kept in pen culture, and the average monthly growth increment recorded were 22.7 mm, 26.9 mm and 16.8 mm, respectively. Rabbit fishes, groupers and sandwhiting *S. sihama* were cultured in a cage culture (James *et al.*, 1984b). The average monthly growth rate for *S. sihama* was 10 mm. The results of these experiments are encouraging.

Considering the biological information available of *S. sihama* and its ability to withstand very wide range of salinity (Bal and Rao, 1984), *S. sihama* is suitable for culture in both the brackish water and fresh waters.

Owing to the natural abundance of the seeds of *S. sihama* and its demand in the local market, culture of the species should be attempted on a large scale in Goa waters. This will increase the yield and generate employment opportunities for the fishermen communities.

Goa with about 105 km long coastline has vast resources of marine shellfish and finfish. Fish is a protein rich food and for the state of Goa it assumes special significance as it forms one of the chief components in the diet of about 90% of the population (Ansari, 2004). *S. sihama* is a highly esteemed fish, due to which it commands high price in the local market. It forms a minor but important fishery from both marine and inland waters in Goa.

In view of its importance in the fishery and absence of any published information on its eco-biology and fisheries from Goa coast, the present study was undertaken for a period of sixteen months from January 2004 to April 2005. The highlights of the results are as follows:

### ***Environmental parameters***

Seasonal variation of the major hydrographical parameters such as temperature, salinity, dissolved oxygen and pH of Zuari Estuary were recorded during the study period. The study revealed that southwest monsoon rain and land drainage seem to play an important role in changing the physico-chemical parameters of the estuarine waters.

The temperature and salinity values were low during monsoon than during pre and post-monsoon seasons. Rainfall has a direct effect on the temperature and

salinity. In contrast to salinity, dissolved oxygen values increased during monsoon months. Higher values of pH were recorded during pre-monsoon and post-monsoon, and low during monsoon coincident with the decrease in salinity.

### ***Morphometrics***

Interrelationships between morphometric measurements of *S. sihama* were statistically analyzed. Fourteen parameters were used and regression equations for each were formulated to evaluate the growth rates of different body measurements in relation to total length. The equations describing these relationships in male and female, respectively, are

<b>Standard length</b>	Y= -6.3971 + 0.9067 X,	Y = -5.3507 + 0.8974 X
<b>Head length</b>	Y= 4.6721 + 0.2013 X,	Y= 2.9188 + 0.2196 X
<b>Snout length</b>	Y= 1.6364 + 0.095 X,	Y= -0.7322 + 0.1160 X
<b>Postorbital length</b>	Y= 0.1737 + 0.0996 X,	Y= 1.272 + 0.0887 X
<b>Interorbital length</b>	Y= -1.3067 + 0.0642 X,	Y= -0.4908 + 0.0851 X
<b>Eye diameter</b>	Y= 1.6411 + 0.0441 X,	Y= 1.9332 + 0.0427 X
<b>Pre first dorsal fin</b>	Y = 3.8917 + 0.2743 X,	Y = -2.1307 + 0.3255 X
<b>Pre second dorsal fin</b>	Y = -4.5639 + 0.5186 X,	Y = -5.4519 + 0.5281 X

<b>Pre pectoral length</b>	$Y = -5.4735 + 0.2741 X,$	$Y = 0.8617 + 0.2677 X$
<b>Pre pelvic length</b>	$Y = 1.8355 + 0.2681 X,$	$Y = 0.0166 + 0.2879 X$
<b>Pre anal length</b>	$Y = -3.8179 + 0.5086 X,$	$Y = -7.7459 + 0.5428 X$
<b>Body depth</b>	$Y = -4.4198 + 0.1862 X,$	$Y = -3.6020 + 0.1815 X$
<b>Depth through anal fin</b>	$Y = -6.4499 + 0.1915 X,$	$Y = -7.6755 + 0.2014 X$
<b>Caudal peduncle depth</b>	$Y = 0.5395 + 0.0616 X,$	$Y = 0.6470 + 0.0612 X,$

(X represents total length and Y the other variables)

Of the fourteen morphometric characters examined the maximum growth rate in relation to total length was noticed in standard length and the minimum was observed in eye diameter. Established correlation coefficients (r) showed high positive significant correlation ( $P < 0.001$ ) in both the sexes. The highest correlation coefficient was observed between total length and standard length ( $r = 0.998$ ) in male and ( $r = 0.999$ ) in female. The lowest was between postorbital length and eye diameter ( $r = 0.889$ ) in male and ( $r = 0.836$ ) in female. Comparisons of slopes estimated in above relationships showed significant differences between male and female ( $P < 0.001$ ) except for the relationship between caudal peduncle length and total length.

### ***Food and Feeding habits***

According to type of food *S. sihama* can be classified as euryphagous carnivores, feeding on a wide range of planktonic and benthic organisms. The monthly percentage composition of food revealed that *S. sihama* feeds mainly on crustacean, polychaete, fish larvae and mollusca.

The ontogenetic dietary change was distinctive in *S. sihama* in the present study. Small fishes are exclusively planktonic feeders subsisting mainly on small crustacean, crustacean eggs and larvae, fish eggs, molluscs larvae and polychaetes. The planktonic prey in the diet of *S. sihama* is gradually decline in fishes above 94 mm total length and being replaced by benthic food items (polychaetes, crabs, small prawns, Shrimps, Amphipods, Isopods, Tannaids, Molluscs and fish larvae).

The feeding activity of *S. sihama* fluctuated with season as well as maturity stages. The intensity of feeding was high during pre-spawning (March - May) and post-spawning seasons (January - February), low during spawning season (June - December).

### ***Reproduction***

Maturity stages were classified based on the macroscopic appearance of gonads and microscopic study of the intra-ovarian eggs in female. Accordingly, five



maturity stages were recognized in *S. sihama*. They are immature, maturing, mature, ripe and spent.

The ova diameter studied indicate the gradual continuous maturation processes in the species. Presence of more than one mode of ova within a wide size range in the matured ovaries revealed that *S. sihama* spawn intermittently throughout the year with a peak in September - November. The percentage frequency of mature gonads also suggests that this species has a prolonged spawning season extending from June to December with highest spawning activity during September to December in both the sexes.

In the present study, the smallest size at which mature specimens were found was 138 mm and 135 mm in male and female, respectively; while the 50 % maturity was found to be at 155 - 164 mm size group. Hence, 155 - 164 mm was considered as the size at which both the sexes attain sexual maturity when they are  $\geq 2$  years old.

The sex ratio of the population shows that the sexes are equally distributed with a ratio of 1: 1.13 of male : female.

The fecundity values were found to vary from 11,376 to 103,695 in specimens ranging between 150 mm to 342 mm with mean fecundity value of 42,575. Relationships between fecundity and other parameters such as total length of fish, weight of fish and weight of gonads were statistically analyzed. Fecundity

showed significant linear relationship with the three parameters with high degree of association being 0.73, 0.77 and 0.76, respectively.

### ***Age and growth***

Age of the fish was determined by growth check on hard parts (otolith). The determination made on the basis that successive rings are formed as the fish grows in age. The mean length of *S. sihama* at various age groups e.g. 0+, 1, 2, 3 years was estimated as 88, 130.9, 168.3 and 199.8 mm, respectively. The relationship between total length of the fish and length and weight of the otolith revealed that there was a highly significant association between total length of fish and length and weight of the otolith ( $r = 0.94$  &  $0.93$ ) ( $P < 0.001$ ), the regression equations were given as:

$$Y \text{ (T.L.)} = 1.474 + 0.0364 X \text{ (O.L.)}$$

$$Y \text{ (T.L.)} = - 0.0492 + 0.0006 X \text{ (O.W.)}$$

Since, it was not possible to determine the age directly from the length frequency data, it was done based on the data of otolith study. The average lengths were 86.9, 129.2, 166.9 and 202.2 mm at 0+, 1, 2, 3 years, respectively.

The growth parameters were determined by VBGE model based on the otolith study data. The growth equations derived by analytical and graphical methods are:

$L_t = 390[1 - e^{-0.1537(t - (-1.65))}]$  &  $L_t = 388 [1 - e^{-0.1526(t - (-1.6))}]$ , respectively.

There was a close agreement between the mean length at various age groups and growth rate derived by the three methods. This suggests the validity of otolith in age determination of tropical fishes.

The length-weight relationship separately for male and female was found to be as:

$$\text{Male : } \log W = - 5.1691 + 3.0045 \log L$$

$$\text{Female : } \log W = - 5.2898 + 3.0633 \log L$$

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 indicating perfect relationship between the two parameters in both sexes. Since, there was no significant difference between the slopes "b" of the two regressions, a common regression for both sexes was calculated as:

$$\log W = - 5.2462 + 3.0420 \log L$$

Variation of the regression coefficient value 'b' from cube law using 't' test revealed that although the "b" value was almost equal to 3 in both sexes, female showed significant departure from 3. This suggests that only male of *S. sihama* inhabiting this area is following the cube law showing isometric growth pattern.

The pattern of fluctuation of relative condition factor during different months of the year seems to be similar in both sexes of *S. sihama*. This pattern was found to simulate the pattern of the gastro somatic index. Although feeding intensity showed a positive correlation with Kn values, the fluctuation in Kn of both the sexes could not be attributed to feeding intensity or reproductive cycle alone. It seems that there is an interrelation between feeding intensity and reproduction and these two factors are the most important factors influencing the Kn *S. sihama*.

### ***Biochemical composition***

Seasonal variation in the biochemical composition of the muscle of *S. sihama* were studied and the average values of the major components were  $77.8 \pm 1.03$  % moisture content,  $3.2 \pm 0.62$  % lipids,  $22.49 \pm 1.77$  % protein and  $0.53 \pm 0.07$  % carbohydrate. The results indicate inverse relationship between moisture content and lipids. The protein content goes on increasing during the spawning season when the lipid content decreases, suggesting that there is an alternative use of protein and lipid as energy source in this species. Variation in biochemical composition in the present study seems to be governed by spawning cycle and feeding activity.

### ***Fishery and Culture possibilities***

*S. sihama* forms about 0.14 % Of the total fish catch of Goa. It forms a minor but economically important fishery in Goa. Although, it is highly esteemed by the

medium and high classes in Goan society, *S. sihama* is present in the local market in a limited quantity. The catches comprised of two to three year groups (120 - 170 mm length). Hook and line, gill net, small shore seine and stake net are the main gears used for the capture of this species in the estuarine, inshore and backwaters.

Study of different aspects of the ecology and biology of *S. Sihama* indicates the suitability of this species for culture in both the brackish water and fresh waters.

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