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Reproductive Biology of *Saurida tumbil* (Bloch 1795) and *Saurida undosquamis* (Richardson 1848) Inhabiting North West Coast of India

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ABSTRACT

To understand the overall changes in spawning, fecundity, length at first maturity and sex ratio of the species Saurida tumbil and Saurida undosquamis inhabiting along North West coast of Indian EEZ were studied during 2010 to 2014. In both the species, the spawning season is single but prolonged, extending from June to March in case of Saurida tumbil whereas in S. undosquamis, it is observed during September to May. Length at first maturity in S. tumbil was between 29-31 cm and in S. undosquamis, 25-27 cm. Male to female sex ratio was found to be 1:0.7 in both the species. Maximum fecundity of 85,359 ova was observed in S. tumbil at the length of 44.6 cm and of S. undosquamis 11,395 ova in 41 cm fish. The peak GSI values were obtained in the month of November (3.83) for S. tumbil and for S. undosquamis in October (4.38).

Key words: *Spawning, Fecundity, Length at first maturity, Sex ratio, Gonado-somatic Index (GSI)*

INTRODUCTION

Among the fishes belonging to the Synodontidae family; *Saurida tumbil*[1] and *Saurida undosquamis*[2] are the two important species harvested along the Indian EEZ. These species contribute to the fishery in Indian waters; their catches reported during 2016 were 94,817 Kg forming 2.61% of the total marine fish production. The North-west coast of India covers two maritime states *viz.* Gujarat and Maharashtra. The contribution of lizardfish fishery from the state of Gujarat was 22,077 tonnes (2016) showing increasing trend (11%) when compared to 17,653 tonnes in the year 2015. The state of Maharashtra contributed to the tune of 2,567tonnes during 2016 with an increaseof 12% from the previous year. The contribution of *S. tumbil* in the state of Maharashtra accounts to about 90% followed by *S. undosquamis* 10%[3].

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The lizardfish fishery was dominated by these two species in both states. These two species are exploited along the Indian coast by trawl nets as they are demersal in nature.

Different fishes from different ecosystems have various adaptations to overcome certain problems or unsuitable conditions. Several marine fishes in Indian waters are known to breed or have at least one of their peaks spawning during the South-west monsoon (June–September) on the west coast[4]. Study of the maturity stages of species together with observation on the condition and measurements of ova diameter are useful in determining the season and periodicity of spawning. Size and age at first maturity is of immense use in designing a fishing gear for a particular fish stock so as to allow the juveniles to escape from the net during fishing operations to get a chance to spawn at least once in its life span before it gets caught[5]. Conventionally the sex-ratio indicates the proportion of male and female individuals in the natural population. This is expected to be 1:1 in nature. Variation from this are often observed in fish because of the behavior of the sexes, their differential growth patterns, environmental factors and fishing causing deviation in the natural population which is assumed to be 1:1. Variation in sex-ratio is observed between different species and different stages of the same species as per the literature. The dominance of one sex might be the result of behavioral differences between the sexes, which is a result of differential fishing, one being fished more than the other [6].

Internationally, many scientists worked on different reproductive aspects of lizardfishes. Rajkumar *et al.,* [7] investigated the maturation and spawning of *S. undosquamis* from Visakhapatnam coast, while, Raje *et al.,* [8] worked on *S. tumbil* from Mumbai waters based on the data collected during 1991-95 from different landing centres. Since 2004, there is no published data on the fishery and biology of lizard fishes. The present investigations were carried out with a view to estimate the size at first maturity, spawning season, sex-ratio and fecundity of*S. tumbil* and *S. undosquamis* occurring along the North-west coast of India.

MATERIAL AND METHODS

Samples of *Saurida tumbil* and *Saurida undosquamis* were collected on a monthly basis from the Fishery Survey of India vessel, MFV *Matsya Nireekshani* which was deployed for demersal resources survey along the North West coast in the area between 18°-23°N. Besides data collection through survey vessels, weekly data collection was also carried out at two major landings centers at new Ferry Wharf and Sassoon Dock located in Mumbai, Maharashtra. The data from the period 2010-2014 has been considered for this study. The fish samples collected in this survey vessel and landing centers were brought in the laboratory and length, weight measurements were recorded before cutting open the gut. After determining the sex and stages of maturity, the female gonads were considered for estimation of ova diameter, fecundity and maturation spawning analysis. Five stages of maturity suggested by Qasim[4] have been followed to understand the maturity of the species. The stages are a) immature virgins b) matured virgins c) ripening d) ripe and e) spent.

A total 865 female specimens of *Saurida tumbil* and 753 female specimens of *Saurida undosquamis* were obtained for the analysis. The length range of *S. tumbil* was between 13-53 cm and of *S. undosquamis* was 13-41 cm. Male to female sex ratio was derived from total number of samples collected during the study. For estimation of fecundity, Rao[9] method was followed based on the ova diameter count. The ova count per gram sample of the ovary has been taken into consideration for estimating the number of mature ova that are likely to be spawned since the eggs in *S. tumbil* is shed in batches. The size at which 50% of the fish were mature was considered to be the size at first maturity. The spawning season was determined on the basis of ova-diameter studies and the percentage frequency of females in different stages of maturity during different months.

RESULTS

Spawning season

Considering the percentage occurrence of mature gonads (Stage IV), the ova-diameter frequencies were analysed and indicated that the spawning period in *S. tumbil* is single but prolonged, extending from June to March, with the peak in September and that the eggs are shed in 5 or 6 batches. The highest percentage of specimens with ripe ovaries was found during September (52.69%) followed by July (35.71%) and August (26.53%). About 23 specimens with spent ovaries were found during December to May months in varying percentages. However, the highest percentage of spent specimens were observed during January (52.11%) and March (21.73%). A large percentage of specimens caught during the pre-monsoon months *viz*. April and May had gonads in the first and second stages of development.

In *S. undosquamis*, the spawning period is also single but prolonged similar to *S. tumbil*, but the spawning period is differ and extends from September to May, with the peak in November. The highest percentage of specimens with ripening ovaries was observed during September (13.33%) followed by March (11.11%). Spent ovaries were also seen during the month of February and March in varying percentage. However, the highest percentage of specimens in stage V were observed during March (5.56%) and February (3.92%). The Percentage occurrence of females in different maturity stages of gonads of *S. tumbil* and *S. undosquamis* during different months are presented in fig. 1 & 2.

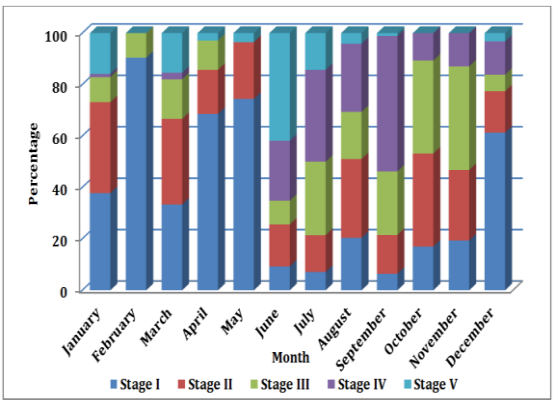

Fig. 1: Percentage occurrence of females in different maturity stages of gonads of *S. tumbil*

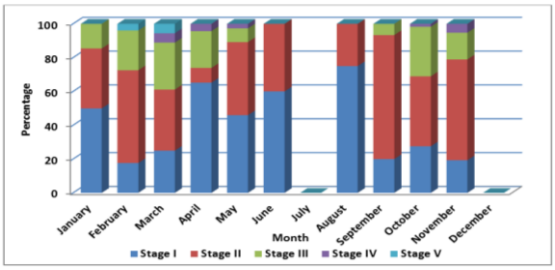

Fig. 2: Percentage occurrence of females in different maturity stages of gonads of *S. undosquamis*

Size at first maturity

The female specimens of S. *tumbil* and *S. undosquamis* observed in the study below the size of 15.0 cm and 17.0 cm in total length respectively was found to be immature. The percentage occurrence of females in various stages of maturity was grouped into 2.0 cm length group. The fishes having gonads of Ist and IInd stages of maturity were treated as immature while those of IIIrd and IVth stages were considered as mature for calculating the size at first maturity. The percentage of mature females of both the species plotted against different length groups are shown in Fig. 3& 4.

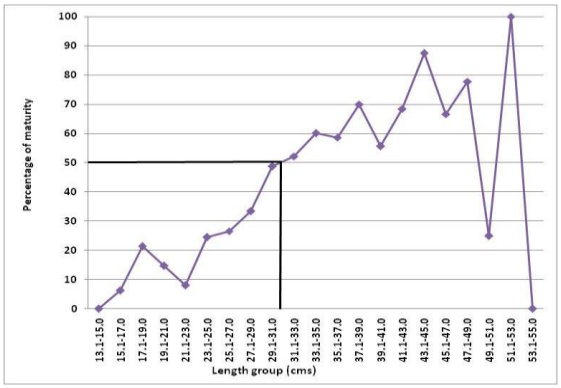

Fig. 3: Length at first maturity in *S. tumbil*

In *S. tumbil*, fully maturing specimens started appearing in size group 27-29 cm forming only 33%, in the next size group of 29-31 cm with 49% and in the next size group 31-33 cm, 52% of females were found to be mature. In the size group 33-35 cm, 60% of the females were found to be mature. In higher groups, the percentage occurrence of mature females was in the increasing order and 100% maturity was observed in the length groups from 51cm. The size at which 50% of the fish were found to be mature is 31 cm in total length.

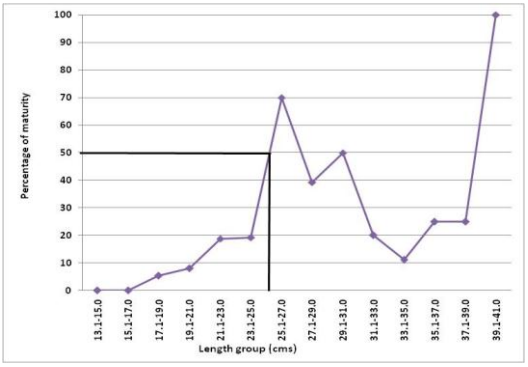

Fig. 4: Length at first maturity in *S. undosquamis*

In *S. undosquamis*, fully maturing specimens started appearing in size group 19-21 cm forming only 8%, in the next size group of 21-23 cm with 19% and in the next size group 23-25 cm, 19% females were found to be mature. In the size group 25-27 cm, 70% of the females were found to be mature. In higher group, the percentage occurrence of mature females was in decreasing order and 100% maturity was observed in the length group from 41 cm. The size at which 50% of the fish were found to be mature is 25 cm in total length.

Sex Ratio

A total of 2165 specimens of *S. tumbil* were examined for deriving male to female sex ratio. Of which, 1300 were males and 865 females with a ratio of 1:0.66 (60% males and 40% females). The month-wise sex ratio varied from 1:0.4 in July to 1:1.19 in September. In June, September and October the sex-ratio was found to be more than equal where females are more than males. During nine months *viz.* January, February, March, April, May, July, August, November and December the males outnumbered the females with a ratio of 1:0.85, 1:0.37, 1:0.52, 1:0.37, 1:0.57, 1:0.4, 1:0.77, 1:0.96 and 1:0.63 respectively.

In order to study the proportion of the sexes represented at various sizes, 1440 males and 865 females were grouped into 2 cm length intervals and the percentages were calculated in different length groups. The percentage of males shows an increasing trend from 21 cm length onwards. In 35-37 cm length group the sex ratio observed was 1:1. From 37 cm length onwards, the females outnumbered the males and in 41.0-43.0 cm length group 83% were females with a sex ratio of 1:4.75. It is therefore evident that the ratio of females to males was higher in adult fish population.

A total of 1840 specimens were considered to determine sex ratio in *S. undosquamis.* Out of 1840 specimens examined, 1087 were males and 753 females with a ratio of 1:0.69 (59% males and 41% females). The month-wise sex ratio varied from 1:0.33 in April to 1:24.0 in January. During the months February, March, April, June, August and November the males outnumbered the females with a ratio of 1:0.55, 1:0.59, 1:0.33, 1:0.45, 1:0.49, 1:0.80 and 1:0.53 respectively. During January (1:24.0), September (1:1.36) and October (1:1.57), a higher ratio was observed with respect to females. The highest ratio of males with respect to females was observed during January (1:24.0). The proportion of the sexes represented at various sizes, 821 males and 753 females were grouped into 2 cm intervals and the percentages in different length groups were calculated. The percentage of females shows an increasing trend from 25.0 cm length onwards. In 15-17cm length group the sex ratio observed was 1:0.18. From 25.0 cm length onwards, the females outnumbered the males and in 33.1-35.0 cm length group 80.00% were females with a sex ratio of 1:4.50. It is therefore evident that the ratio of females to males was higher in adult fish population. In order to know the reliability of the results derived, a chi-square test was conducted. It is noticed that the variation in male to female sex ratio which was coming under the chi-square parameter of H_1 which clearly indicates that there is no equality of male and females specimens.

Chi-square analysis for *S. tumbil*:

	Male	**Female**	**Total**
Observed Frequency	1300	865	2165
Expected Frequency	1082.5	1082.5	2165

X^2 **(Cal),** X^2=87.40

X^2 **(Tab),** $X^2_{(0.05,\ 1)}$ = 4.368

As calculated value is greater than the table value of X^2 , H_o **is rejected**

i.e. there is no equality among males and females

H_o= There is equality among males and females

H_1= There is no equality among males and females

Chi-square analysis for *S. undosquamis*:

	Male	Female	Total
Observed Frequency	1087	753	1840
Expected Frequency	920	920	1840

X^2 **(Cal),** X^2= 60.62

X^2 **(Tab),** $X^2_{(0.05,\ 1)}$ = 3.029

As calculated value is greater than the table value of X^2 ,H_0 **is rejected**

i.e. there is no equality among males and females

H_0= There is equality among males and females

H_1= There is no equality among males and females

Fecundity

Ovaries in penultimate stages of spawning were considered for determining the fecundity of the fishes. The fecundity of the different individual specimens showed remarkable variation and the number of ova in *S. tumbil* was found in the range of 34,582-85,359 ova. The maximum fecundity of 85,359 ova was observed in a fish measuring 44.6 cm in total length and the minimum fecundity of 34,582 ova was observed for an individual measuring 30.0 cm length. The average fecundity of the species in the present study was calculated as 59,971 ova.

The fecundity of individual specimens of *S. undosquamis* was found to be varying between 17,744-76,395 ova. The minimum fecundity of 17,744 ova was observed in a fish measuring 29.0 cm in total length and the maximum fecundity of 76,395 ova was observed for an individual measuring 41.0 cm in total length. The average fecundity of the species in the present study was estimated as 47,070 ova. The correlation between fecundity &length of fish, fecundity &weight of the fish and fecundity & weight of the ovary was derived for both the species is given below:

S. tumbil

Linear relationship between fecundity and length of fish

F = - 40278 + 1565.4*L (r = 0.4637)

Linear relationship between fecundity and weight of fish

F = 4386.6 +28.612*W (r = 0.4093)

Linear relationship between fecundity and weight of fish ovary

F = -9976.4 + 1228.9*W (r = 0.7426)

S. undosquamis

Linear relationship between fecundity and length of fish

F =-9159.5 + 490.56*L (r = 0.8553)

Linear relationship between fecundity and weight of fish

F = 1461.3 +20.023*W (r = 0.9022)

Linear relationship between fecundity and weight of fish ovary

F = 2029.2 + 371.35*W (r = 0.9733)

When compared to linear relationship between fecundity and length of the fish, weight of the fish and weight of the ovary, the species *S. tumbil* is showing better correlation between fecundity and weight of the ovary. However, it is observed that when the ovary weight is more, fecundity decreases due to presence of large number of immature ova. On other side, in case of *S. undosquamis*, the correlation is positive in all the parameters.

Intra-species indices of fecundity

The relative fecundity or the average numbers of ova per gram body weight are compared among the two species. The results indicated that the *S. tumbil* produces the maximum number of 37.153 ova per gram body weight than *S. undosquamis* with 29.138 ova. The indices reveled that, trend in production of ova per gram ovary weight was found to be higher in *S. tumbil* with 760 ova when compared to *S. undosquamis* with 614 ova. It is observed that the size of the ovary of *S. tumbil* is comparatively bigger than the *S. undosquamis* and therefore, the average number of ova in *S. tumbil* is higher than the *S. undosquamis.*

Gonado-somatic Index (GSI)

Monthly observation of the GSI values for both the species revealed that, the highest GSI value obtained in the month of November (3.83) in respect of *S. tumbil* while, *S. undosquamis* is showing highest in the month of October (4.38).The range of GSI values varied between 0.32-3.83 in *S. tumbil* and in *S. undosquamis* it was 0.38-4.32 (Fig.5).

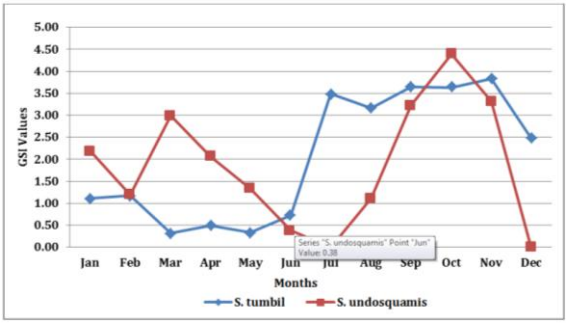

Fig. 5: Gonado-somatic index (GSI) of *Saurida tumbil* and *Saurida undosquamis*

DISCUSSION

The present study derived the spawning season, size at first maturity, sex ratio, fecundity and GSI values. In both the species, the spawning season observed to be single but prolonged. The spawning period for *S. tumbil* was between June to March with a peak in September and in *S. undosquamis*, from September to May with the peak in November.

Liu and Tung[10] worked on reproduction and spawning ground of *Saurida tumbil* along the Taiwan strait. El-Ganainy [11-13] who emphasized in his research, on biological aspects, population dynamics and fishery assessment on *Saurida undosquamis* from the Gulf of Suez and Red Sea respectively. Golani[14] studied biology of the Red Sea migrant, *Saurida undosquamis* in the Mediterranean Sea. El-Greisy[15] studied on reproductive biology and histology of *Saurida undosquamis* from the Mediterranean Coast of Egypt.Biology of the female Lizardfish, *Saurida tumbil* reproductive from the Persian Gulf was observed by Abbaszadeh *et al.,*[16]. Bakhsh[17] also worked on reproductive biology of *Saurida tumbil* in the Jizan Region of the Red Sea. Magdy *et al.,*[18] investigated growth and reproduction of *Saurida undosquamis* from the Gulf of Suez, Egypt. Faltas[19] and Budnichenko & Dimitrova[20] are also some of the investigators who work on lizard fishes along Egyptian Mediterranean waters and Arabian Sea respectively.

The information on maturation and spawning of lizardfishes in Indian waters is very inadequate, except the works of Rao[21] on maturation and spawning of lizard fishes *(saurida* sp.) from north-western part of the Bay of Bengal. Dighe [22] described the different aspects of biology of *Saurida* sp. from Mumbai coast. Singh *et al.,* [23] on fecundity of *Saurida tumbil* off Bombay coast. Muthaiah [24] on the fishery and biology of Saurida spp., from the Karnataka coast. Sivakami[25] worked on maturation and spawning *S. undosquamis* from Cochin coast, Sivakami *et al.,* [26] on fishery, biology and population dynamics of *S. undosquamis* off Visakhapatnam coast.

The studies are in agreement with the results of Ali[27], Raje *et al.,*[8] , Soofiani *et al.,*[28] and Halfawy *et al.,*[29] where, they observed the spawning season was single but prolonged and the season was in between August to December in case of *S. tumbil* and in *S. undosquamis*, September to December. The Male to Female sex ratio in general to be 1:1 but, in the present case this sex ratio is varied significantly and shown 1:0.6 & 1:0.7 in *S. tumbil* and *S. undosquamis* respectively. Fofandi[30] reported asynchronous sex ratio in both the cases throughout the year which is in agreement with the work from the Veraval coast of India. The size at first maturity observed at the length of 31 cm in *S. tumbil* which is very close to the value (29.6 cm) obtained by Metar *et al.,*[31]. In case of *S. undosquamis*, the length at first maturity observed at 25 cm. The fecundity obtained for *S. tumbil* in the present study is in the range of 34,582-85,359 ova which is the range of results obtained by Raje *et al.,* [8] and for *S. undosquamis;* the range was 17,744-76,395 which is in the line of the results derived by Rao[21]. The correlation analysis revealed that the linear relationship between fecundity and the weight of the ovary indicating that as in case of *S. undosquamis*, the ovary grows; the fecundity also increases while in case of *S. tumbil*, it is showing negative values. The GSI obtained in the present study is in the range of 0.32-3.83 in *S. tumbil* with a peak in November and in *S. undosquamis* it was 0.38-4.32 with a peak in November. These are close to the values of Soofiani *et al.,*[28].

CONCLUSION

The results obtained in the present study revealed that the matured female specimens are found throughout the year. The spawning season is single and prolonged in both the species. Sex ratio was found to be asynchronous. If the male ratio is dominated over females, it may likely to modify the sexual composition of the stock in future. Therefore, proper management and research of this fishery is needed for bringing the stocks to the sustainable level. Though these species

have uniform characteristics in different parts of the world, changes in the environment due to pollution may cause the difference in the stock structure and their biology and these aspects needs to be addressed in future research. Although these species are contributing to the marine fishery in India, it is not fully exploited. Therefore, the present work may guide to enhance new research approaches for further exploitation and also better management could be adopted.

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