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Systematics, fishery and biology of the white sardine *Escualosa thoracata* (Valenciennes, 1847) exploited off Kerala, south-west coast of India

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ABSTRACT

Landings of the white sardine *Escualosa thoracata* (Valenciennes, 1847) indicated a shift in their abundance from north-east to south-west coast of India and a sharp decline in the resource landings during the last decade along the entire range of its distribution. High local demand coupled with competitive price for the species might have led to overexploitation of this otherwise seasonal resources along the major areas of its abundance along the Indian coast. Detailed study on the systematics, fishery and biology of the species landed along Kerala coast was undertaken during 2015 and 2016. Stock assessment studies indicated near optimum fishing pressure on the resource along the Kerala coast.

Keywords: Abundance, *Escualosa thoracata*, Growth, Maturity, White sardine

Introduction

White sardines are small pelagic fishes of the genus *Escualosa* under the family Clupeidae. Globally only two valid species *viz.,* the slender white sardine *Escualosa elongata* Wongratana, 1983 and the white sardine *Escualosa thoracata* (Valenciennes, 1847) (Fig. 1) have been documented. Distribution of the slender white sardine is restricted to the Gulf of Thailand in the western Pacific. The white sardine *E. thoracata* enjoys a wide distribution along Indo-West Pacific region along the coasts of Pakistan, India, Thailand, Indonesia, Philippines, Papua New Guinea and Australia. White sardine supports a seasonal fishery in the areas of their distribution along the Indian coast. They are considered a delicacy especially among coastal community and fetch fairly high unit price. Though the species supports an important fishery in India, information on their biology and population dynamics are limited. Some information on fishery and biology of the species is available from Devanesan and John (1941), Chidambaram and Venkataraman (1946), Devanesan and Chidambaran (1948), Mookerjee and Bhattacharya (1950), Nair (1951; 1972), Dutt (1971), Dutt and Rao (1981), Shivaprakasha and Joseph (1988), Raje *et al*. (1994), Shabir *et al*. (2014) and Sikha *et al.* (2016). The present study was carried out to update the systematics and biological information on the species and to evaluate the present state of the stock along Kerala coast.

Materials and methods

Fishery and biology of the white sardine *E. thoracata* along the Kerala coast were monitored during 2015 and 2016. State-wise landings data of the species collected from catch statistics of the ICAR-Central Marine Fisheries Research Institute (ICAR-CMFRI), Kochi for the period 2007-2015 was used for catch trend analysis.

Length frequency data of the species in the catch was collected following standard random sampling procedure. The length-weight relationship was calculated as per Le Cren (1951). Growth parameters were estimated using the ELEFAN I module of FiSAT software and the Powell-Wetherall plot (Gayanilo *et al*., 1996) and other relevant growth parameters as per Pauly (1979; 1983a; 1984) as well as Pauly and Munro (1984). Mortality and exploitation rates were estimated following Pauly (1980;1983b).

Results and discussion

Systematics

Valid name	:	*Escualosa thoracata*
Class	:	Actinopterygii
Order	:	Perciformes
Suborder	:	Scombroidei
Family	:	Clupeidae
Subfamily	:	Dorosomatinae
Genus	:	*Escualosa*
Species	:	*thoracata* (Valenciennes, 1847)
Common name	:	White sardine

Distinguishing characters

Body fusiform, moderately deep and compressed with strongly keeled belly, mouth superior, dorsal profile of head more or less straight, second supra-maxilla almost

Fig. 1. *Esculosa thoracata* (Valenciennes, 1847)

rectangular. Broad bright silver stripe present along the flank. Distinguished from *Escualosa elongata* by its deeper body and presence of broad silver stripe along the flank. Fin formulae: Dorsal spines (total): 0; Dorsal soft rays (total): 13 - 21; Anal spines: 0; Anal soft rays: 14-19.

Fishery

White sardine fishery is supported by a single species, *E. thoracata* along the coast. They generally form shoals in shallow waters of 5 to 30 m depth zone, preferably close to shore and are caught with encircling nets, particularly ring seines. Small quantity are also caught by gillnets, dolnets and trawls. Motorised and non-mechanised crafts are engaged in the fishery. Shoals of juveniles often enter backwaters and form minor fishery in drag nets, stake nets and cast nets. Along Kerala coast, about 67% of the catch was by ring seines during 2015-16 (Fig. 2). Gillnet contribution was 21%, trawl 4.4% and other traditional gears contributed 7.5%. Fishing operation is done by small outboard units in shallow waters.

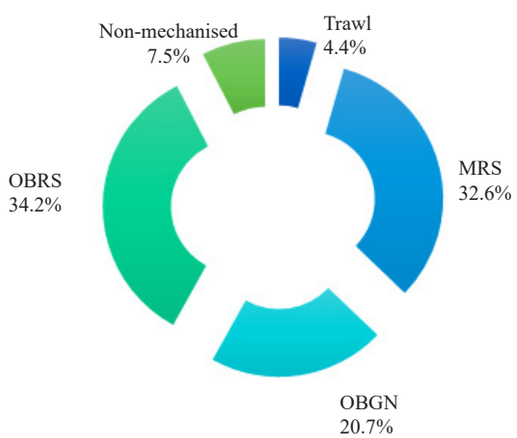

Fig. 2. Major gears contributing to the landings of *Escualosa thoracata* in Kerala during 2015-16

Fishery along the Indian coast exhibited wide annual fluctuation with an average landing of 13,885 t during 2007-12 (Fig. 3). Landings registered a downward trend thereafter with the lowest landings in 2015. Fishery along the Kerala coast improved over the years to a peak of 5044 t in 2014. It dropped steeply to 1689 t in 2015, but increased to an all time high of 5484 t in 2016.

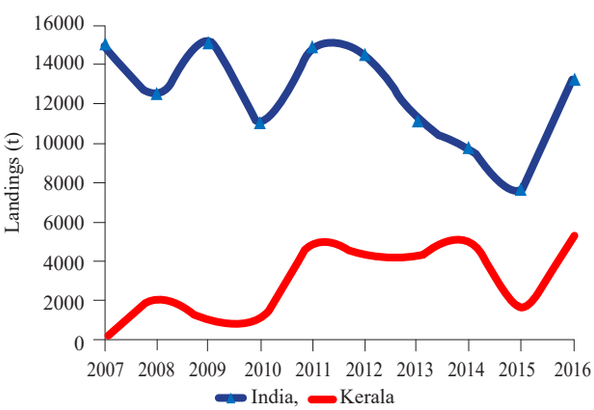

Fig. 3. Trend in the white sardine landings along the Indian coast (2007-2016)

Major contributors to the fishery were Andhra Pradesh, West Bengal and Odisha till 2010 (Fig. 4). Thereafter, fishery along the east coast declined. Kerala, Karnataka and Maharashtra are the major contributors to the white sardine fishery in the recent years.

Size composition in the catch

Catch along the Kerala coast was supported by 36 to 102 mm fishes with 60-90 mm group as the mainstay of the fishery during 2015-16 (Table 1). Reports by earlier workers indicate the fishery was supported by almost similar size groups all along the coast (Devanesan and John, 1941; Chidambaram and Venkataraman, 1946; Devanesan and Chidambaran, 1948; Raje, *et al*., 1994;

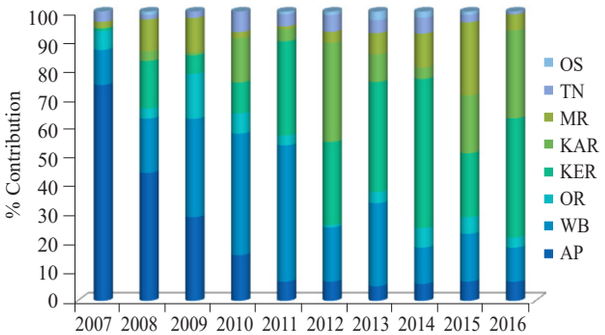

Fig. 4. State-wise contribution of white sardine during 2007-16 OR-Odisha TN-Tamil Nadu, MR-Maharashtra, KAR-Karnataka, KER-Kerala, WB-West Bengal, AP-Andhra Pradesh, OS-Other states

Table 1. Size range of white sardine in Indian waters

Size range (mm)	Area	Author
25-72	Mumbai	Mookerji and Bhattacharya (1950)
100-110	Malabar coast	Nair (1951)
41-105	Mumbai	Raje *et al*. (1994)
4.9-10.9	Mumbai	Shabir *et al*. (2014)
22-111	Mumbai	Sikha *et al*. (2016)
36-102	Kerala	Present study (2015-16)

Shabir *et al*., 2014; Shikha *et al*., 2016). Further, the growth estimate indicated that almost 95-98% of the fishes caught belong to zero year class. Further, the length data shows that fishery at all areas were supported by unimodal population. Nair (1951) also reported only one age group in the fishery, indicating that the species spawns only once in a year and the stock behaves as an annual crop.

Length-weight relationship

Length-weight relationship was estimated for the unsexed population (n-293) as: $W = 0.00459132\ L^{3.295218}$ (Fig. 5). The relationship is also available from the works of Raje *et al.* (1994) and Shabir *et al.* (2014). Raje *et al.* (1994) estimated the relationship separately for both sexes as:

Males : $W = 0.000001508\ L^{3.3946}$

Females : $W = 0.000002561\ L^{3.2706}$

For unsexed population, the relationship was derived as: $W = 0.0048\ L^{3.2367}$ by Shabir *et al.* (2014). These estimates indicate that growth of the species is allometric.

Biology

Food and feeding: Food was dominated by planktonic forms, which included copepods, cladocerans and post-larval forms of shrimps and fishes. Crustaceans constituted a major component of the gut during most months. Phytoplankton were also observed occasionally in the guts in small numbers. Raje *et al.* (1994) reported

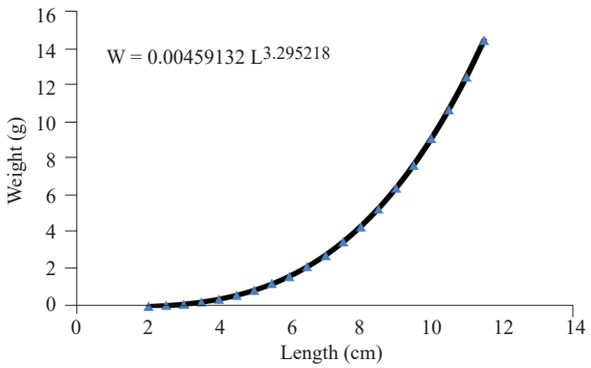

Fig. 5. Length-weight curve of white sardine from Kerala coast

that the species in Mumbai waters feed on copepods, cladocerans, eggs as well as larval forms of fishes, molluscs and crustaceans. It has also been reported that intensive feeding takes place during post-monsoon months, when there is rich production of plankton.

Reproductive biology

Sex ratio: The white sardine population is mostly female dominated along the Kerala coast (Table 2). The M: F ratio of the species during the period was 0.93:1. Reports from Mumbai waters also indicate predominance of females in the population with an annual sex-ratio of 0.83:1 (Raje *et al*., 1994).

Sexual maturity: The species attain sexual maturity in the sea along shallow coastal waters. Full sexual maturity was observed from 66 mm size onwards in both males and females. In females, 50% maturity was observed at 80 mm size and in males at 78 mm. Information on gonadal maturity of the species is also available from the works of Chidambaram and Venkataraman (1946) and Raje *et al.*

Table 2. Sex ratio of white sardine population

Month	Male	Female	Male: Female
Mumbai coast (Raje *et al*., 1994)			
January	55	82	0.67:1
February	67	72	0.93:1
March	57	69	0.82:1
April	109	112	0.97:1
May	75	88	0.85:1
June	52	50	1.04:1
July	65	90	0.72:1
August	6	9	0.67:1
September	-	-	-
October	24	40	0.60:1
November	10	14	0.71:1
December	47	57	0.82:1
Pooled	567	683	0.83:1
Kerala (2015-‘16)			
Present study	185	199	0.93:1

(1994); and on spawning from the reports of Devanesan and John (1941). Chidambaram and Venkataraman (1946) observed maturity in females from 64 mm size onwards and 50% of the females matured at 82 mm in Mumbai waters. Raje *et al.* (1994) reported it as 80 mm from the same area.

Spawning: Maturity studies indicated that they spawn along the Kerala coast during October-February with peak spawning activity during December-January. Fishes with well developed ovaries were observed in the population by early October and fishes with spent ovaries by the end of October. Presence of large proportion of fishes with spent gonads during December-January in the catch indicated this as the peak spawning period.

Spawning season of the species was described by Devanesan and John (1941) as well as Nair (1951) based on the changes in the gonadal condition and occurrence of eggs in the plankton. They confirmed that spawning season of the species along the west coast of India was from November-February with peak activity during January-February. They observed spawning females, with transparent eggs having clear oil globules since November, and fishes with spent and recovering gonads since December with large proportion in January and February.

Fecundity: Fecundity of the species caught along the Kerala coast varied between 6,500 and 8,940 depending on the size of the female (78-99 mm). Nair (1951) estimated their fecundity as 8000 per fish. According to him, left lobe of testis and ovary alone are functional and there is complete atrophy in right gonads in the species which partly accounts for their low fecundity.

Stock status

Growth and longevity: Growth of the species along Kerala coast was estimated following modal progression analysis. The species is found to grow to a maximum size of 105 mm (Fig. 6). They grow to 50, 79, 96 and 106 mm in 3, 6, 9 and 12 months respectively. Longevity was estimated as one year and the von Bertalanffy growth equation was fitted as:

$$Lt = 11.87\left[1\text{-}e^{-2.192\ (t+0.00261)}\right]$$

Information on growth of the species in Mumbai waters is available from the works of Devaraj (1983); Raje *et al*. (1994) and Shikha *et al*. (2016) (Table 3 and 4). Growth is relatively slow and the fish reaches 65.3 to 72.2 mm in six months and 91.8 to 100.8 mm in one year. Mookerjee and Bhattacharya (1950), estimated a growth of 49.5 mm in 6 months from an initial size of 25.5 mm to 75 mm. Their life span in Mumbai waters was estimated as l.7-1.8 years. Nair (1951) inferred the average life span of the species as one year, with only a small proportion surviving beyond one year. Estimates of growth parameters, L_{∞}, K and t_o ranged between 110 and 121 mm; 1.8 and l.85 per year and 0.000095 and -0.00261 year respectively.

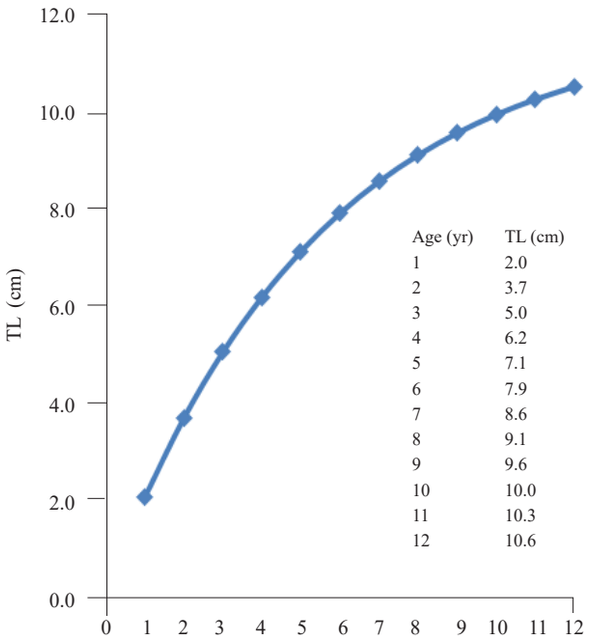

Fig. 6. Growth curve of white sardine (Kerala coast)

Table 3. Growth estimates in mm for white sardine in Indian waters

6 months	1 year	Area	Author
49.5	-	-	Mookerjee and Bhattacharya (1950)
65.3	91.8	Mumbai	Raje *et al*. (1994)
72.17	100.79	Mumbai	Sikha *et al*. (2016)
79.0	106	Kerala	Present study (2015-16)

Table 4. Estimates of growth parameters of white sardine in Indian waters

L_{∞} (mm)	K (year^{-1})	t_o (year)	Area	Author
110	1.8	-	Mumbai	Raje *et al*. (1994)
118.81	1.85	0.000095	Mumbai	Sikha *et al*. (2016)
11.87	2.192	-0.00261	Kerala	Present study (2015-16)

Mortality and exploitation rates: Natural mortality (M) of the species was estimated as 2.43 and fishing mortality (F) as 6.22 (Table 5). Fishing mortality is more than 2.5 times of natural mortality, indicating fairly high fishing pressure on the resource. The exploitation rate (E_{curr}) was

Table 5. Biological reference points estimated for white sardine along Kerala coast

L_r (mm)	L_{max} (mm)	Mean (mm)	Modes (mm)	L_m (mm)	L_c (mm)
36	102	74.5	55-60, 75-80	80	54.2
M	F	E_{curr}	E_{opt}	E_{max}	SSB%
2.43	6.28	0.72	0.72	0.78	38

0.72 which is same as E_{opt}, but lower than the E_{max}. This indicated that the resource is exploited at optimum levels along the Kerala coast.

Estimates of mortalities and exploitation rates for Mumbai coast is available from Shika *et al*. (2016) as: M = 2.79 $year^{-1}$, F = 4.35 $year^{-1}$ and total mortality (Z) = 7.14 $year^{-1}$. The M/K and Z/K values were calculated as 1.86 and 4.22, while exploitation rate and exploitation ratio estimated were 0.556 $year^{-1}$ and 0.557 $year^{-1}$ respectively.

The biological reference points estimated for the species indicated that, the resource is exploited at optimum level along the Kerala coast. The spawning stock biomass was also found to be at fairly high level.

White sardines form only a seasonal fishery throughout their range of distribution along the Indian coast. However, they enjoy considerable local demand irrespective of the abundance of other fishes in the catch. Though the resource did not form a major fishery during earlier days, owing to the domestic preference as a delicacy, the species enjoyed considerable economic importance in the traditional fishery. Despite their domestic demand, they never received much attention from researchers and policy makers due to highly seasonal nature of the fishery, low abundance and production. Fishers however target the resource whenever available, irrespective of the abundance of other resources, owing to local demand and high price. Fluctuations in their fishery, as observed in the present study from the Kerala coast is due to fluctuation in their abundance. Being the natural resident of heavily fished shallow coastal waters, both targeted and non-targeted fishing pressure are always high on the stock, which might have contributed heavily to the declined catch levels from fishing grounds along other parts of the Indian coast. Being coastal in distribution and spawning restricted to shallow waters, spawn survival depend heavily on the coastal environment, competitors and predators. This also might have added to the decline in the fishery along the previously rich fishing grounds. There is dearth of information on the biology and population characteristics of this species, and hence there is need for detailed investigations in order to have proper understanding about the fluctuations in the fishery of the species.

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