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Demographic characters and stock assessment of Pink ear emperor, *Lethrinus lentjan* (Lacepède, 1802) from the Wadge Bank, South India

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Original Article

Abstract

Population characteristics and stock estimates of *Lethrinus lentjan* were studied during June 2015 to May 2016 from Wadge Bank, South India. The asymptotic length (L_∞), growth coefficient (K) and arbitrary origin of growth (t_0) were 53.5 cm, 0.25/year and -0.81 respectively. Among the mortality parameters, fishing mortality was found to be higher (0.79) compared to natural mortality. Exploitation ratio (E) was found to be 0.56 showing marginal overexploitation of the species at Wadge Bank and the exploitation rate (U) was 4.8. Estimated total stock, estimated annual stock, Maximum Sustainable Yield (MSY) and annual catch (Y) were 14074.17 tonnes, 8551.39 t, 6028.73 t and 6755.601 t respectively. The study suggest that the cod end mesh size of the trawls operated at Wadge Bank coast to be increased from 10 to 25 mm to decrease the yield per recruit and for achieving the optimum exploitation of this species.

Keywords: *Lethrinus lentjan, total mortality, recruitment overfishing, maximum sustainable yield, exploitation rate, yield per recruit.*

Introduction

The pink ear emperor *Lethrinus lentjan* (Lacepède, 1802) has distribution throughout the Indo-West Pacific from the Red Sea and East Africa to southern Japan and Samoa. It is found in a variety of habitats including coral reefs, sea grass beds and mangroves from near shore to a depth of 75 m (Randall, 1995).The diet of this species consists of crustaceans, molluscs, echinoderms, polychaetes and fishes (Carpenter and Allen, 1989). Juveniles prefer more of amphipod and crustacean larvae, while adults target mainly on crustaceans, molluscs, and echinoderms (Toor, 1964).Thisspecies is a protogynous hermaphrodite and exhibits a protracted spawning season (Currey *et al.,* 2013). In some areas, particularly in Thailand, this species shows spawning aggregation (Tamelander *et al.*, 2008). The life span is at least 19 years (Grandcourt, 2002).

In India, the rocky areas of the Wadge Bank (4000 square miles) have predominance in major perches like serranids, lutjanids and lethrinids which constitute sizeable fishery (Mitra, 1987). The major species recorded in the landings of pigface breams/ emperor breams in India are *L. lentjan, L. nebulosus, L. ramak, L. mahsena, L. conchyliatus, L. elongatus* and *L. miniatus*. Of these, the first two species contributed significantly to the fishery all along the Indian coast, whereas *L. lentjan* form a moderate

fishery along the Wadge Bank, South India. The landings of lethrinids in India during 2016 was 12519 t, which formed about 3% of the total perch landings of the country. Southeast coast of India contributed the major share of landings of lethrinids in India (Zacharia and Najmudeen, 2017). It forms a component of commercial and artisanal fisheries throughout its range and has also experienced localized overfishing.

Several studies have been made on the stock estimates of pig face breams on a global perspective (Grandcourt, 2002; Leigh *et al.,* 2006; Motlagh *et al*., 2010; Marriott *et al*., 2011, Grandcourt *et al*., 2011 and Currey *et al.,* 2013). In India, Vasantharajan *et al.* (2017) studied the age, growth and mortality parameters of *L. lentjan* at Tuticorin coast. Information on age, growth, mortality parameters, recruitment pattern, VPA and stock assessment has not been attempted so far in the Wadge Bank, South India. Presently the study is first of its kind at Wadge Bank, and such an indepth research has not been attempted so far.

Material and methods

The study was carried out for a period of 12 months from June 2015 to May 2016. Length frequency data was collected on fortnightly basis for *L. lentjan* to estimate the age, growth and mortality parameters. A total of 3,600 specimens of *L. lentjan* were collected mainly from mechanised and motorized fish landing centres along Wadge Bank coast during the 12 months study period, while fishing ban sampling was taken from artisanal fishing boats (Fig.1). Age and growth were assessed using the FiSAT computer software (Gayanilo *et al.,* 2005). Length frequency data of *L. lentjan* were recorded every month. About 300 specimens were collected during every sampling and the total length and the weight of each specimen were measured and recorded.

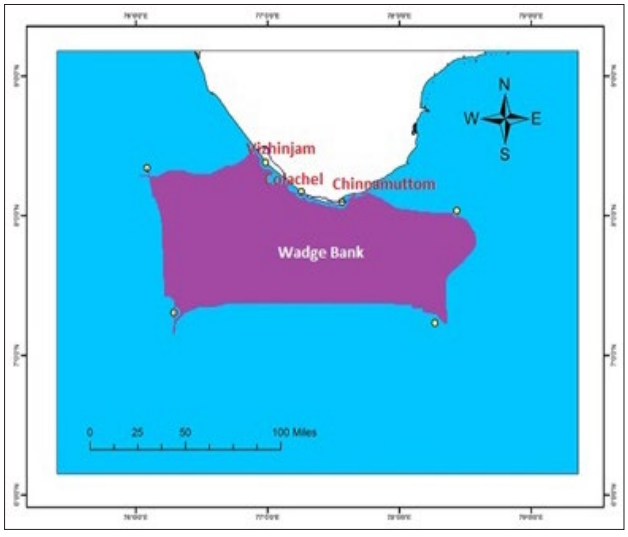

Fig. 1. Map showing the Study Area of Wadge Bank, South India

Length frequencies were raised to correspond to the weight of the catch assessed for the day and subsequently for the month following Sekharan (1962). The age and growth were assessed using the FiSAT computer software II (Gayanilo *et al.*, 2005). The asymptotic length (L_∞), growth coefficient (K) and arbitrary origin of growth (t_0) values were analyzed by non-parametric scoring of von Bertalanffy growth function (VBGF) fit using ELEFAN-1. The length frequency data were subjected to model progression technique by splitting the modes using Bhattacharya's method followed by linking of the means. To assess the standing stock, total annual stock, maximum sustainable yield, and to optimize the effort, catch effort data were collected. The mean catch of *L. lentjan* was recorded for 10% of the fishing boats in a fishing day and was multiplied with effort made in trawling hours in the days of observation to obtain the estimates. The daily catch estimates were used to estimate the monthly mean catch which was multiplied by the no. of fishing days of the corresponding month to obtain the monthly catch. The total effort in boat days was estimated by multiplying the mean monthly effort expressed in boat days, which are the fishing days in a month. The total mortality rate (Z) was estimated by the length converted catch curve method (Pauly, 1983) using FiSAT. The natural mortality (M) was estimated by Pauly equation considering the mean annual temperature (Pauly, 1984). The coefficient of fishing mortality (F) was derived using the relationship $Z=F+M$. The length structured VPA of FiSAT was used to find out the size of each length group of *L. lentjan*, their natural mortality and fishing mortality. The recruitment pulses of *L. lentjan* were analyzed from the length frequency data using FiSAT. The total stock (Y/U) and the annual stock (Y/F) were estimated for *L. lentjan* using annual catch (Y) where, Y is Yield, U is exploitation rate and F is fishing mortality. The exploitation rate (U) was estimated using the equation $U=F/Z\ (1-e^{-z})$ by Sparre and Venema (1998). The Maximum Sustainable Yield (MSY) was estimated using the equation described by Gulland (1956). Yield isopleth diagrams of *L. lentjan* were derived by FiSAT using L_{50}/L_∞ and F/Z value.

Results and discussion

Length- weight relationship

The regression equation for length–weight relationship of pooled and a common relationship was obtained for both the sexes combined: Pooled: log W= 0.015 + 2.906 log L (R2 = 0.938) in Wadge Bank, South India by Karuppasamy (2016). Vasantharajan *et al.* (2015) reported the length-weight relationship of *L. lentjan* as W= Log W =–2.043 + 3.027 Log L (r2=0.97) at Tuticorin coast.

Age and Growth

In the present study, multiple modes could be seen in the monthly length frequency data and modes were traceable (Fig. 2). Life span was found to be 9 years for *L. lentjan* during the present study. The von Bertalanffy's growth function plot of *L. lentjan* was represented in Fig. 3. The mean age and size at sexual maturity for male *L. lentjan* was 1.8 years and 24.6 cm L_m and 2.4 years and 27.7 cm L_m for females (Carpenter *et al.*, 2016). The estimated growth parameters of *L. lentjan* are shown in Table 1. The asymptotic length (L_∞), growth co-efficient (K) and t_o were 53 cm, 0.25/year and 0.81 respectively. Similarly, Grandcourt *et al.* (2011) estimated the natural, fishing and total mortality for *L. lentjan* to be 0.22 $year^{-1}$, 0.22 $year^{-1}$ and 0.44 $year^{-1}$ respectively in Southern Gulf of Abu Dhabi in United Arab Emirates. The L_∞ and K were high for this species at Tuticorin coast reported by Vasantharajan *et al.* (2017). Rathacharen *et al.* (1999) reported the L_∞, K and t_o of *L. lentjan* from the Mauritius coast as 78.26, 0.235 and -0.6111 respectively. The L_∞, K and t_o values estimated for this species from Persian Gulf and Oman Sea were 67.2 cm, 0.16 and–1.161 respectively (Motlagh *et al.*, 2010). The asymptotic length was comparatively less in the present study which can be due to more fishing pressure along the Wadge Bank. In addition, the rate of growth was also less in this region compared to the specimens observed from Oman Sea. The factors explaining the relationship between the natural mortality coefficient and growth coefficient (M/K) was 2.48 for *L. lentjan*.

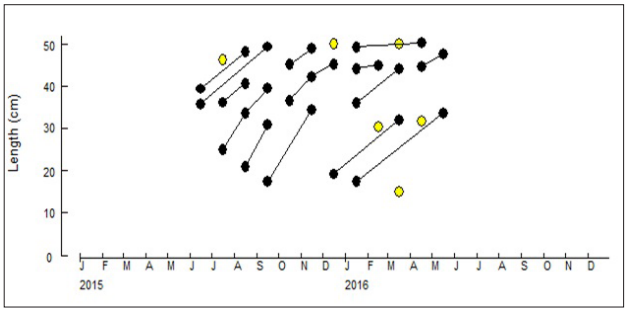

Fig. 2. Progression of modes of various cohorts of *L. lentjan*

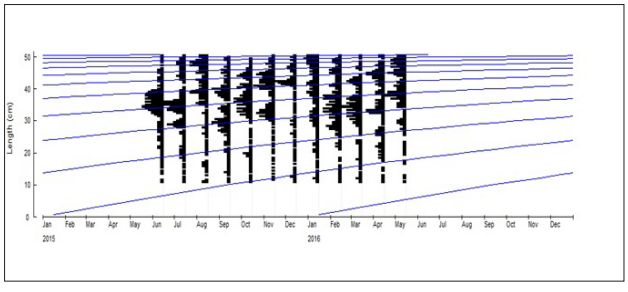

Fig. 3. Von Bertalanffy's Growth function plot of *L. lentjan*

Table 1. Growth parameters of *L. lentjan* of Wadge Bank

Species	L_∞ (cm)	K	M/K	t_o
L. lentjan	53.5	0.25	2.48	0.81

Mortality, virtual population analysis and recruitment pattern parameters

The mortality parameters and exploitation ratio of *L. lentjan* are shown in Table 2. The natural mortality (M) of *L. lentjan* was found to be 0.62. The fishing mortality co-efficient (F) of *L. lentjan* was 0.79. The estimated exploitation ratio (E) of *L. lentjan* was 0.56. The estimated 'Z' values of *L. lentjan* by length converted catch curve method was 1.41 (Fig. 4). The 'Z' value observed in the present study is found to be higher than the value recorded by Rathacharen *et al.* (1999) from Merutions coast, confirming high fishing pressure in Wadge Bank. It is also interesting to note that the fishing mortality was higher when compared to that of Motlagh *et al.* (2010) in Perusian waters, further conforming the occurrence of less sized specimens with less asymptotic length and also with high fishing pressure. The estimated 'Z' observed in the present study was found to be higher than the specimens of this species in Tuticorin waters (Vasantharajan *et al.*, 2017).

The recruitment pattern of *L. lentjan* is shown in Fig. 5. The recruits were recorded once in the year with a major peak in July to October and minor peak in March. However recruitment was evident round the year confirming a year round spawning of this species. Along Tuticorin coast,

Table 2. Mortality parameters and exploitation ratio of *L. lentjan* of Wadge Bank

Species	Natural Mortality (M)	Fishing mortality (F)	Total instantaneous mortality (Z)	Exploitation ratio (E = F/Z)
L. lentjan	0.62	0.79	1.41	0.56

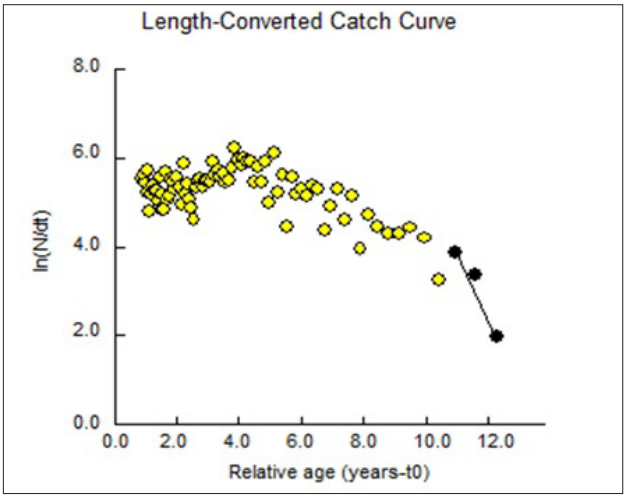

Fig. 4. Length based catch curve of *L. lentjan*

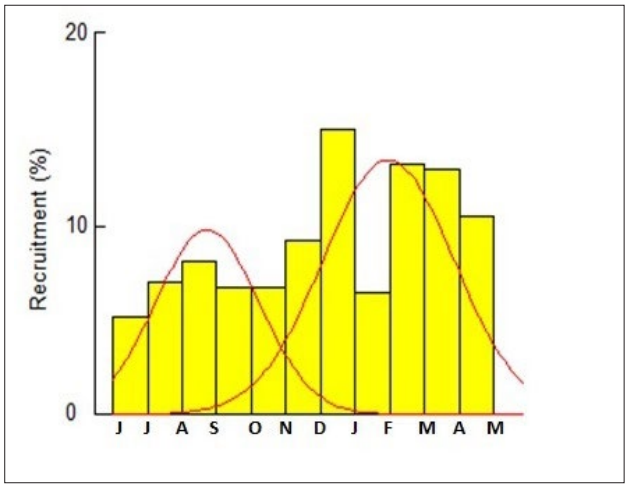

Fig. 5. Recruitment pattern of *L. lentjan*

L. lentjan shows recruitment twice in a year with a peak during April, July and August (Vasantharajan *et al.,* 2015), while in the present study one major peak season was evident from July to October and minor one in March at Wadge Bank. The major recruitment season coincides with the southwest monsoon and the minor recruitment season falls in summer. The results of the length structured VPA employed to recognize the level of mortality on various length groups of *L. lentjan* are shown in Fig. 6. The fishing pressure on *L. lentjan* was more in the length group 20.5 and 31 cm and the natural mortality was low in the length groups from 36.5 cm onwards. According to Vasantharajan *et al.* (2015), higher fishing pressure was recorded at the terminal length group for the same species between 56.0 cm to 65 cm and the natural mortality was low in the length group of 59 cm. Hence it could be inferred that the fishing pressure was more in matured groups at Wadge Bank, as L_m was observed to be 26 cm in this coast.

Stock assessment

The present effort was calculated by 47552 boat days in respective landing centers of the Wadge Bank. The annual catch, total stock and annual stock exploitation rate were estimated for *L. lentjan,* (Table 3). The MSY, fmsy and the exploitation ratio estimated for *L. lentjan* are given in Table 5. The total stock of *L. lentjan* was estimated to be 14074.17 tonnes with annual catch being 6755.601 t against the exploitation rate of 0.48 (Table 5). The estimated MSY for *L. lentjan* was 6028.73 t. The difference between the annual catch and MSY for the species was 727.21t and the present effort could be decreased to 11 % with the fmsy as 5119 boat days (Table 4). Similarly, the MSY estimated was 10683.84 t against the annual catch of 7799.208 t for *L. lentjan* from Tuticorin coast by Vasantharajan *et al.* (2015). In the present study exploitation ratio was found to be similar to that observed at the Tuticorin coast.

Table 3. Exploitation rate, total stock and annual stock of *L. lentjan* of Wadge Bank

Species	Annual catch (Y) (tonnes)	Exploitation rate (U)	Total stock (Y/U)	Annual stock (Y/F) (tonnes)
L. lentjan	6755.601	0.48	14074.17	8551.39

Table 4. Optimum effort for the exploitation of *L. lentjan* of Wadge Bank, South India

Species	Catch (tonnes)	MSY (tonnes)	Different between catch and MSY (tonnes)	Present Effort (boat days)	CPUE	Boat days to be decreased to achieve MSY	% of decreased effort to achieve MSY	Optimum boat for exploitation at MSY
L. lentjan	6755.601	6028.73	-727.21(less)	47552	0.14	-5118.74 (less)	-11	42433.0 0

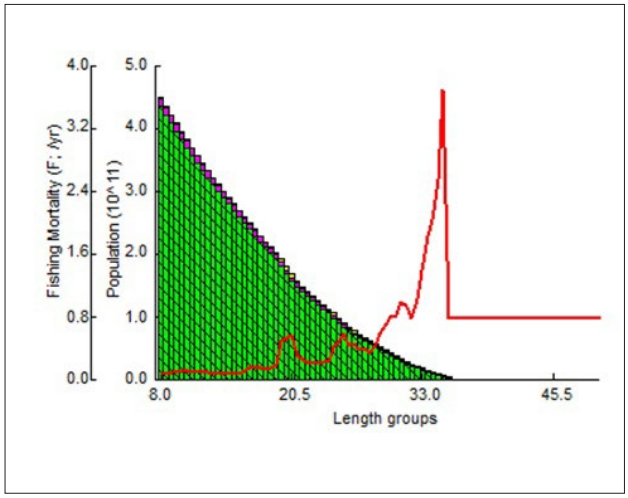

Fig. 6. Length structured Virtual Population Analysis of *L. lentjan*

Table 5. Exploitation ratio and exploitation status of *L. lentjan*

Species	E=F/Z	Exploitation status
L. lentjan	0.56	Slightly over exploited

The results of the earlier authors (Al-Qishawe *et al*., 2017; Joshi, 2010 and Swatipriyanka *et al*., 2014) on the stock assessment of *L. nebulosus* and *Nemipterus japonicus* indicated that the stocks are relatively overexploited along the fishing ground at Jubail marine sanctuary park of Saudi Arabia and west coast of India. Similarly, if the current level of exploitation is continued there is every chance for decline in the catch of *L. lentjan* in the trawling grounds of Wadge Bank, south India.

Through the drawing of yield isopleths, an idea about the present level of yield per recruit with various possible combination of exploitation rate could be obtained. Yield isopleth is one of

the prediction tools in stock assessment studies. By using yield isopleths, one can get an idea about the present level of yield per recruit with various possible combinations of exploitation rate and gear (L_{50}/L_{∞}). The yield per recruit for *L. lentjan* is shown in Fig. 7.

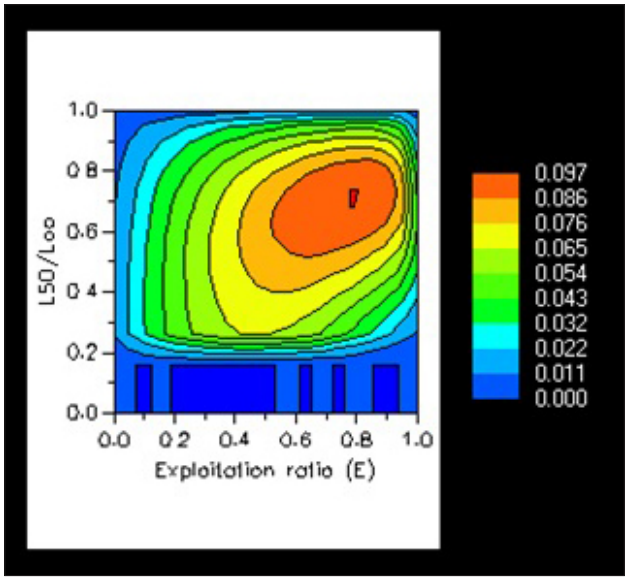

Fig. 7. Yield isopleths of *L. lentjan*

The result on yield per recruit for the species predicts that the maximum yield can be possible with the exploitation rate and L_{50}/L_{∞} of 0.56 and 0.5 respectively. For *L. lentjan,* it can be possible to achieve the maximum yield with the present exploitation rate. The study also infers that the cod end mesh size of the trawls of Wadge Bank has to be increased to 10 to 25 mm so as to increase the yield per recruit, the exploitation need to be optimized between 0.45 to 0.5 to get maximum yield per recruit, against the present exploitation ratio of 0.56 (Table 6). The study also suggests that, for minimizing the catch, effort for the *L. lentjan* could be decreased to the tune of 11% by decreasing the number of boats.

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