

Population dynamics and stock assessment of Delegoa threadfin bream, *Nemipterus bipunctatus* (Nemipteridae), from the Wadge Bank, South India

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Abstract: Fishery, population characteristics and stock estimates of *Nemipterus bipunctatus* were studied during June 2015 to May 2016 from Wadge Bank, South India. This region is characterised by rich biodiversity and has a conducive influence of the Indian Ocean and Arabian Sea. The asymptotic length (L_{∞}), growth coefficient (K) and arbitrary origin of growth (t_0) were estimated as 30.5 cm, 0.85/year and 0.18 respectively. The mortality parameters, total mortality rate (Z), fishing mortality rate and natural mortality rate (M) were estimated as 2.20, 0.95 and 1.25 respectively. Exploitation ratio (E) was found to be 0.57 which showed marginal over exploitation of the species at Wadge Bank. This species has two recruitment seasons, one major season from October to December and another minor season in August. The length structured Virtual population analysis revealed heavy fishing pressure on the length group 24 to 28 cm and hence the delegoa threadfin bream was not found to suffer due to recruitment overfishing in Wadge Bank. Estimated total stock, Maximum Sustainable Yield (MSY) and annual catch were 5625.9348 tonnes, 1935.321t, 2419.152t respectively. Present level of Exploitation rate (U) and Exploitation ratio (F/Z) were estimated to be 0.43 and 0.57 respectively. The study infers the cod end mesh size of the trawls operated at Wadge Bank coast has to be increase from 10 to 25 mm to increase the yield per recruit, the effort could also be maintained as the exploitation ratio of 0.50 to have maximum yield per recruit. The study suggests reducing the present level of effort by 8 percent may be needed to sustain the stock of *N. bipunctatus* in Wadge Bank, South India.

Keywords: Growth, Mortality parameters, MSY, *Nemipterus bipunctatus*, Recruitment overfishing

INTRODUCTION

The threadfin breams (Nemipteridae) are small to medium-sized marine fishes spread in the tropical and subtropical Indo-West Pacific region, but absent in the eastern Pacific and Atlantic oceans (Russell, 1990). They represent a significant component of demersal fish communities and are important to fisheries throughout the Indo-West Pacific (Pauly and Marto-subroto, 1980; Russell, 1990; Harris and Poiner, 1990; Sharum, 2002). A total of six species, *Nemipterus japonicus*, *N. mesoprion*, *N. tolu*, *N. delagoae* (*N. bipunctatus*), *N. luteus* and *N. metopias*, contributed to the fishery along Indian coast. Of these, the first two species contributed to the fishery significantly all along the Indian coast, whereas *N. bipunctatus* form a moderate fishery along the Wadge Bank, South India (Murty, 1992). Although several studies have been made on the stock estimates of threadfin breams from India (Murty, 1983, 1984, 1987; Vivekanandan and James, 1986; Devaraj and Gulati, 1988; John, 1989; Joshi, 2010 and Swatipriyankasen 2014) Information

on catch, effort, growth parameters and biology of *N. bipunctatus* from Indian waters are available from the studies of Muthiah and Pillai 1979; Madanmohan and Velayudhan, 1986 and Hamsa *et al.* (1994). The present study on the stock assessment of *N. bipunctatus*, is the first of its kind in Indian waters, attempted from Wadge Bank, South India.

MATERIALS AND METHODS

The study was carried out for a period of 12 months from June 2015 to May 2016. Length frequency data were collected two times in a month for *N. bimaculatus* to estimate the age, growth and mortality parameters. A total of 2,246 specimens of *N. bimaculatus* were collected mainly from mechanised and motorized fish landing centres along Wadge Bank coast during the 12 months study period (Fig.1). Age and growth were assessed using the FiSAT computer software (Gayanilo *et al.*, 1996). Length frequency data of *N. bipunctatus* were recorded every week. About 300 specimens were collected during every sampling and

the total length and the weight of each specimen were measured and recorded. Age and growth was assessed using FiSAT computer software. The L_{∞} and k values were analysed by non-parametric scoring of VBGF fit using ELEFAN-1. The length frequency data were subjected to model progression technique by splitting the modes using Bhattachary's analysis 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 *N. bipunctatus* were recorded from 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. Total effort in boat days was estimated by multiplying the mean monthly effort expressed in boat days which is the fishing days in a month.

The total mortality rate (Z) was estimated by the length converted catch curve method using FiSAT. The natural mortality (M) was estimated by pauly equation considering the mean annual temperature. The co-efficient 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 *N. bipunctatus*, their natural mortality and fishing mortality. Recruitment pulses of *N. bipunctatus* were analysed from the length frequency data using FiSAT. The total stock (Y/U) and the annual stock (Y/F) were estimated for *N. bipunctatus* using annual catch (Y). Where, Y – Yield, U - exploitation rate and F – Fishing mortality. The exploitation rate (U) was estimated using the equation $U=F/Z(1-e^{-Z})$ (Sparre and venema,1998). The Maximum Sustainable Yield (MSY) was estimated using the equation $MSY=Z(Y/F) 0.5$ described by Gulland (1979). Yield isopleth diagrams of *N. bipunctatus* were derived by FiSAT using L_{50}/L_{∞} and F/Z value.

RESULTS AND DISCUSSION

In the present study multiple modes could be seen in

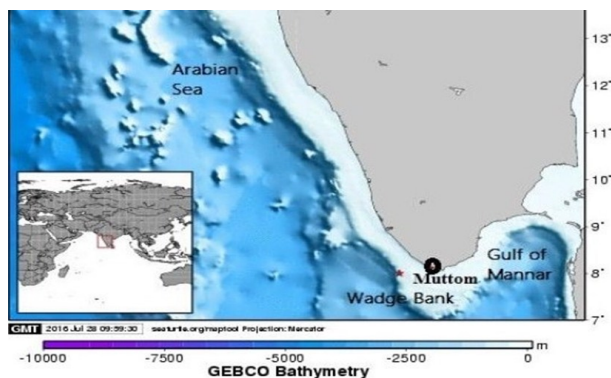


Fig.1. Map showing the study area of Wadge bank (Source; online GIS program MAPTOOL, provided by seaturtle.org).

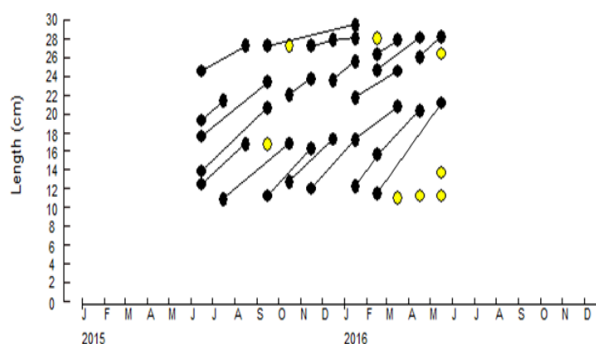


Fig. 2. Progression of modes of various cohorts of *N. bipunctatus*.

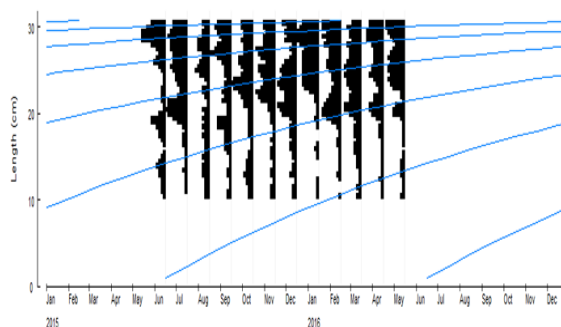


Fig. 3. Von Bertalanffy's growth function plot of *N. bipunctatus*.

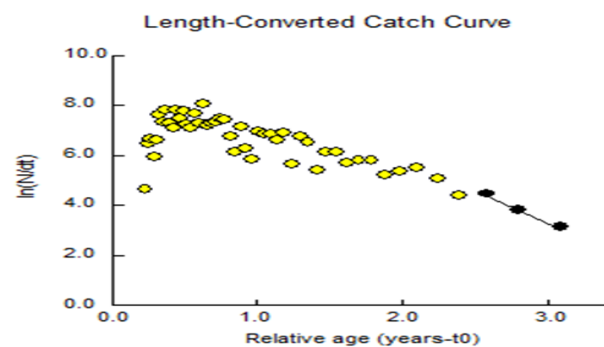


Fig. 4. Length based catch curve of *N. bipunctatus*.

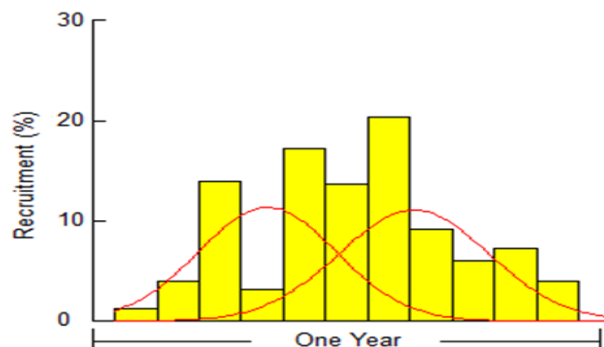


Fig.5. Recruitment pattern of *N. bipunctatus*.

Table.1. Growth parameters of *N. bipunctatus* of Wadge bank.

Species	L_{∞} (cm)	K	M/K	t_0
<i>N. bipunctatus</i>	30.5	0.85	1.12	0.18

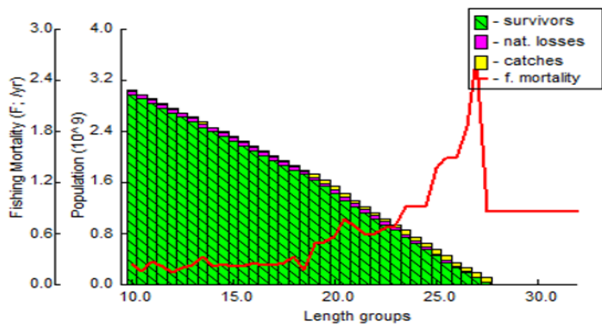


Fig. 6. Virtual population analysis.

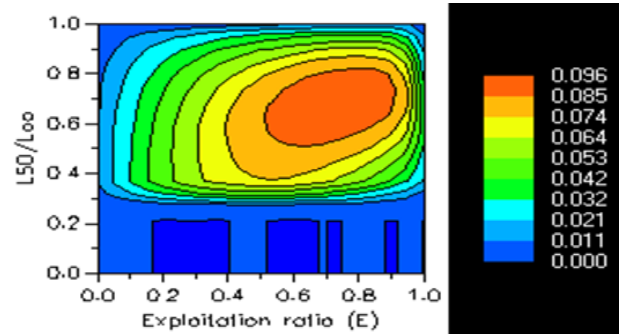


Fig.7. Yield isopleths of *N. bipunctatus*.

the monthly length frequency data and modes were traceable. At least for two consecutive month to assess the growth of cohorts (Fig. 2). The maximum life span was found to be 5 years for *N. bipunctatus*. The Bertalanffy's Growth Function plot of *N. bipunctatus* are represented in Figure 3.

The estimated growth parameters of *N. bipunctatus* are shown in Table.1. The asymptotic length (L_{∞}), growth co-efficient (K), were 30.5 cm and 0.85 respectively. Similarly, Hamsa et al.(1994) estimated the growth parameters from length data of *N. delagoae* landed at Thoothukudi were, L_{∞} = 362 mm and K = 1.0586 per

year which had higher than that recorded in the present study. The factors explaining the relationship between the natural mortality coefficient and growth coefficient (M/K) was 2.00 for *N. bipunctatus*. The generalized von Bertalanffy's growth equation for *N. bipunctatus* are given below; $L(t)=30.5 \{1-\exp-0.85(t-0.18)\}-(1)$.

Mortality, virtual population analysis and recruitment pattern parameters: The mortality parameters and exploitation ratio of *N. bipunctatus* are shown in Table. 2. The natural mortality (M) of *N. bipunctatus* were found to be 0.95. The fishing mortality coefficient (F) of *N. bipunctatus* were 1.25. The estimate

Table.2. Mortality parameters and exploitation ratio of *N. bipunctatus* of Wadge Bank, South India.

Species	Natural Mortality (M)	Fishing mortality (F)	Total instantaneous mortality (Z)	Exploitation ratio (E = F/Z)
<i>N. bipunctatus</i>	0.95	1.25	2.20	0.57

Table.3. Exploitation rate, total stock and annual stock of *N. bipunctatus* in Wadge Bank.

Species	Annual catch (Y) (tonnes)	Exploitation rate (U)	Total stock (Y/U)	Annual stock (Y/F) (tonnes)
<i>N. bipunctatus</i>	2419.152	0.43	5625.9348	1935.321

Table 4. Optimum effort for the exploitation of *N. bipunctatus* of Wadge bank, South India.

Species	Catch (tonnes)	MSY (tonnes)	Different between catch and MSY (tonnes)	Present Effort (boat days)	CPUE	Boat days to increased or decreased to achieve MSY	% of increased or decreased effort to achieve MSY	Optimum boat days for exploitation at MSY
<i>N. bipunctatus</i>	2419.15	1935.32	483.83 (excess)	47552	1.25	384.60 (excess)	0.80 (decrease)	47167

Table. 5. Average catch effort and CPUE of *N. bipunctatus* landed from Wadge bank, South India.

Month	Average number of boats operated	Boat days	Average number landed/boat	Average weight landed boat(kg)	Estimated total landings in weight (kg)	CPUE Kg/boat day
June-2015	115	2760	15	16.5	45540	16.5
July	123	3075	20	26.5	81477	26.5
August	260	6760	32	35.5	239980	35.5
September	285	7410	42	56.6	419406	56.6
October	230	5750	35	42.5	244375	42.5
November	175	4025	26	34.4	138460	34.4
December	180	4320	28	39.5	1093670	39.5
Janaury-2016	135	3510	28	32.6	114426	32.6
February	120	3120	26	35.8	111072	35.8
March	171	4275	22	29.5	126112	29.5
April	117	3042	23	28.7	87305	28.7
May	105	2625	15	18.2	47775	18.2
Total	2016	47552	312	396.3	2419.152	396.3

Table.6. Exploitation ratio and exploitation status of *N. bipunctatus*.

Species	E=F/Z	Exploitation status
<i>N. bipunctatus</i>	0.57	Moderately Over exploited

exploitation ratio of *N. bipunctatus* were 0.57. The estimated 'Z' values of *N. bipunctatus* by length converted catch curve method were 2.20 (Fig. 4). Presently the Z and M calculated for *N. bipunctatus* was lower when compared to stock of the same species of Thoothukudi waters. It could be inferred fishing mortality was higher compared to natural mortality and same trend was evident by at Thoothukudi waters (Hamsa et al., 1999).

The recruitment pattern of *N. bipunctatus* are shown in Fig. 5. The recruits of were recorded throughout the year with a major peak in October to December minor peak in August. However recruitment was evident round the year confirming a year round spawning of this species. Along Vizhinjam coast *N. bipunctatus* was recruited twice a year with a peak during September to June (Madanmohan and Velayudhan, 1986), However in the present study one major peak season could be observed from October to December and minor one in August at Wadge Bank. The major recruitment season coincides with the coast Southwest monsoon and the minor recruitment season falls in monsoon. The results of the length structured Virtual Population Analysis (VPA) employed to recognize the level of mortality on various length groups of *N. bipunctatus* are shown in Fig.6. The fishing pressure on *N. bipunctatus* was more in the length group of 24 cm to 28 cm. Similarly, higher fishing pressure were recorded at the terminal length group for another species of Nemipterids (Murty,1987; Vivekanandan, E.(1991; Joshi, 2010 and Swatipriyankasen et al.,2014)

Stock assessment: The annual catch, total stock and annual stock exploitation rate were estimated for *N. bipunctatus* are presented in Table.3. The MSY, f_{msy} and the exploitation ratio estimated for *N. bipunctatus* are given in Table 5. The total stock of *N. bipunctatus* were estimated to be 5625.9348 tonnes with annual catch being 2419.152 tonnes against the exploitation rate of 0.43 (Table 5). The estimated MSY for *N. bipunctatus* were 1089.708 tonnes respectively. The difference between the annual catch and MSY for the *N. bipunctatus* was 384.60 tonnes and the present effort could be decreased to 0.80 with the f_{msy} as 47167.40 boat days (Table 4). The results of the earlier authors (Murty,1987; Joshi, 2010 and Sen et al,2014) on the stock assessment of nemipterids indicated that the stocks are overexploited along the Kerala coast with the exploitation rate reaching 0.6 to 0.8. Hence the scientific management for this important resources along the Indian coast of Kerala is needed. Similarly, the current exploitation is being continued with the present F, there is every chance for decline in the catch of threadfin breams from the trawling grounds of Ker-

ala. Through the drawing of yield isopleths, an idea about the present level of yield per recruit with various possible combination of exploitation rate can be evolved. 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 *N. bipunctatus* is shown in Fig.7. The result on yield per recruit for *N. bipunctatus* can be possible to achieve the maximum yield with the exploitation rate and L_{50}/L_{∞} of 0.60 and 0.47. The study infers the cod end mesh size off the trawls of Wadge Bank to be increased to 10 to 25 mm so as to increase the yield per recruit, the exploitation need to be optimize between 0.45 to 0.5 to get maximum yield per recruit, against the present exploitation ratio of 0.57 (Table 6). The study also suggests eight percent reduction in the present level of effort besides recommending the fitting of square mesh panel the cod end of trawlers.

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