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Population dynamics of *Nemipterus japonicus* (Bloch) in the trawling grounds off Cochin

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ABSTRACT

Population dynamics of *Nemipterus japonicus* (Bloch), the dominant species of threadfin breams fished off Cochin was studied during the period 2000-2002. *N. japonicus* was dominant during south-west monsoon and its spawning season extended from May to November. The estimated VBGF parameters were L_α= 318 mm, K= 0.69 yr^{-1}(males), and L_α = 265 mm, K= 0.77 yr^{-1}(females) indicating marked growth difference between the two sexes of *N. japonicus.* The study indicated that the present fishing effort along Cochin has reached an optimum level. The maximum yield in the present level of F can be obtained by increasing the length at first capture by 177 % of the present yield. The reduction in the cod-end mesh size unless stopped will lead to recruitment overfishing over a period of years.

Keywords: Fishery, Growth, *Nemipterus japonicus*, Population dynamics, Spawning

Introduction

The threadfin breams, comprising of about 6 species form an important fishery along the Kerala coast. Among the two species *Nemipterus japonicus* (Bloch) and *Nemipterus mesoprion* (Bleeker) landed at Cochin Fisheries Harbour, the former contributes about 41% to the total threadfin bream landings. Exploratory studies have revealed the presence of threadfin breams in the deeper waters (Silas, 1969; Nair and Reghu, 1990). Some information on the catch, effort and biology of *N. japonicus* from Cochin are available (Vinci, 1983; Nair and Jayaprakash, 1986; John, 1989; Murty *et al.*, 1992). However, this is the first attempt to study the differential growth rate of *N. japonicus* which have a bearing on the population dynamics of the stocks.

Materials and methods

Samples of *N. japonicus* were obtained at weekly intervals from the commercial trawlers operated off Cochin during 2000-2002. Samples were brought to the laboratory and data on total length, weight, sex and stages of maturity were collected and appropriately raised to the monthly catch estimates. Three hundred and seventy five female specimens in the length range of 70-240 mm with gravid and running maturity stages were considered for determining the spawning season. Growth parameters were estimated using the von Bertalanffy growth equation: $Lt = L_\infty (1- e^{-K(t-to)})$ in FiSAT (Gayanilo *et. al,* 1988; Sparre and Venema, 1991). A total of 2418 fishes in the length range of 70-310 mm (total length) were used for estimation of growth parameters. The length at infinity (L_∞) values and their associated growth coefficient (K) values were selected using FiSAT.

The rate of total instantaneous mortality (Z) and exploitation ratio (E) was estimated from the length converted catch curve of Pauly (1983) using the total annual length frequency distribution of the catch. The natural mortality rate (M) was estimated using the equation of Pauly (1980) and for this purpose, the temperature in the fishing grounds was taken as 27 ^{0}C following Suseelan and Rajan (1989). The fishing mortality (F) was calculated as F = Z - M.

Estimation of exploitation ratio (U) was done using the equation (Beverton and Holt, 1957; Ricker, 1975):

$$U = \frac{F \quad (1-e^{-(F+M)})}{F+M}$$

The annual total stock (Y/U) and standing stock (Y/F) were estimated by taking the annual catch of the species (Y) during 2000-2002. The value of Y/F thus obtained was taken as the biomass (B) during the exploited phase of the fishes in the trawling grounds.

Estimation of yield and biomass at different levels of F and t_c was made using Beverton and Holt's (1957) yield per recruit analysis. The smallest length in the catch over the two-year period was taken as length at recruitment (L_r). The length at first capture (L_c) was taken as equal to the length at recruitment. The values of W_α was estimated as 290 g from the length-weight relationship, the values of

t_r was estimated as 0.2 taking 70 mm as the smallest length at recruitment (L_r) and t_c=0.2 from L_c=70 mm for *N. japonicus.* Estimation of yield at different values of F and length at first capture was calculated and presented in the form of a graph.

Results and discussion

Spawning season

Ripe fishes (stage IV) were observed from May to November with highest abundance during July-August, indicating the peak spawning season. Earlier studies have indicated that peak spawning was during June-January off Cochin (Vinci, 1983), December - May along Andhra coast (Krishnamoorthi, 1973b; Dan, 1980), August-April off Kakinada (Murty, 1984), June-March off Chennai (Vivekanandan and James, 1986), November-May off Mangalore (Murty *et al*., 1992) and September-April off Mumbai (Raje, 2002).

Growth parameters

The estimated VBGF parameters of length at infinity (L_α) and growth coefficient (K) of *N. japonicus* (male, female and pooled) for the period 2000-2002 indicated difference between the two sexes (Table 1). The parameters of growth estimated by earlier workers using different methods shows that the values of L_α ranged from 23.5 to 38.2 cm and K from 0.12 to 1.00 yr^{-1} (John, 1989; Murty *et al*., 1992; Zacharia, 1998). The values obtained in the present study are well within the ranges known for this species. Sainsbury and Whitelaw (1984) estimated von Bertalanffy growth curve of *Nemipterus peronii* from Australia and inferred that the growth parameters of sexually differentiated individuals differ significantly. Granada *et al*. (2004) obtained von Bertalanffy equation for males and females and they were significantly different showing that males grew faster than females in *Nemipterus bathybius* off Japan.

Age and growth

The analysis of the data for males and females were done separately to study variation in growth. The length and weight attained by male and female along the same period were different (Fig. 1). Age and growth attained by *N. japonicus* from different localities are given in Table 2. The difference in growth of males and females of *N. japonicus* observed in the present study can be compared with the earlier studies which reported differential growth with males attaining larger length than females (Eggleston, 1972; Krishnamoorthi, 1976; Amornchairojkul and Boonwanich, 1982; Murty, 1984). Differential growth in this species in seas off Kuwait has also been reported (Samuel, 1990).

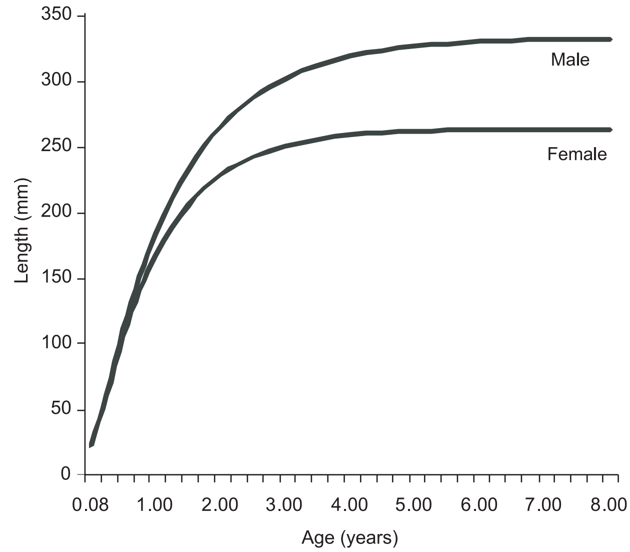

Fig. 1. Growth curve of male and female *N. japonicus* in the trawl landings off Cochin

The higher growth rate in males has been attributed to less energy diverted/required for reproduction and production of gametes in males compared to females resulting in higher somatic growth in males (Clarke, 1983). In addition to the above, migration during monsoon due to several reasons including temperature, enhances the differential growth rate of *N. japonicus* (Eggleston, 1972). In general, fishes show similar growth pattern in males and females. In some cases there is differential growth in initial stages after which there will be a compensatory growth period in males as well as females which results in similar growth rate. The sexwise difference in age and growth as well as mortality observed in the present study in *N. japonicus* can be considered to be an adaptation for maximizing the production of female biomass and to minimize the intraspecific competition for food resources. Although the differential growth theory is prevalent among nemipterid species, there is a possibility of sex change in some of the species. This recent view has been supported by Young and Martin (2004) in the case of *N. peronii*, *Scolopsis* spp. and *Pentapodus* spp. which show hermaphroditism. The actual mechanism and time of sex change have not been fully understood so far and much attention is needed on the reproductive studies of this species.

Mortality

The estimated total mortality (Z), fishing mortality (F) and natural mortality (M) of *N. japonicus* for the period 200-2002 showed difference in males and females (Table. 1). The results obtained by catch curve method were taken for the stock assessment studies. The fishing mortality obtained in the present study ranged from 0.59 to 1.28 (male) while for female it ranged from 0.73 to 1.98.

Table 1. Population parameters of *Nemipterus japonicus* from Cochin during 2000-2002

	Year	L_α (mm)	K	Z			M	F	E
				Catch curve method	Jones/van Zalinge plot	Beverton and Holt model			
Male	2000	247	1.020	2.430	1.776	2.108	1.3	1.13	0.47
	2001	308	0.816	1.890	2.099	1.949	1.3	0.59	0.31
	2002	338	0.700	2.580	3.246	2.450	1.3	1.28	0.50
	Pooled	316	0.690	2.320	3.158	2.020	1.3	1.02	0.44
Female	2000	265	1.008	3.280	3.203	3.312	1.3	1.98	0.60
	2001	230	1.000	2.030	1.816	2.250	1.3	0.73	0.36
	2002	241	0.750	3.120	3.962	3.036	1.3	1.82	0.80
	Pooled	243	0.770	2.060	2.605	2.020	1.3	0.76	0.37
Pooled	2000	257	1.300	3.210	2.225	2.754	1.3	1.91	0.60
	2001	304	1.220	5.090	3.226	4.890	1.3	3.79	0.74
	2002	328	0.900	2.900	2.842	2.781	1.3	1.60	0.55
	Pooled	325	0.795	3.350	3.858	3.040	1.3	1.87	0.56

The estimated natural mortality (M) was 1.3 which was comparable with those reported by earlier workers where the values ranged from 0.50 to 2.52 (Krishnamoorthi, 1978a; Murty, 1983, 1984, 1987; Vivekanandan and James, 1986; Devaraj and Gulati, 1988; John, 1989; Murty *et al.*, 1992; Zacharia, 1998).

Stock assessment of N. japonicus

During the period 2000-2002, an estimated 1383 t of threadfin breams were landed at Cochin of which *N. japonicus* formed 40.7%. The total stock (Y/U) in the fishing ground fluctuated from 1336 (2000) to 1665 t (2002) and the average was 1058 t while the standing stock (Y/F) ranged from 380 (2000) to 508 t (2002) with a mean of 140 t (Table 3). The average estimated catch was 563 t and estimated fishing mortality (F) was 1.87 landed by 4849 units of multiday trawlers (MDT) and 5749 units of single day trawlers (SDT). The catch per unit effort (CPUE) and catch per hour (CPH) for MDT were 115 kg unit^{-1} and 4 kg h^{-1} while that for SDT were 98 kg unit^{-1} and 14 kg h^{-1} respectively. The present fishing effort along Cochin has presently reached the optimum level and further increase in catches from the present fishing grounds is unlikely. Recent estimate on the potential of threadfin bream landings of Kerala coast shows a difference of +3805 t from the annual average yield and suggests a reduction in the number of units for the sustainable yield of the resources (Sathianandan *et al.,* 2008).

Table 2. Comparison of age and growth attained by *N. japonicus* from different localities

Location	Growth (mm)			Reference
	1 year	2 year	3 year	
Veraval	188	266	303	Gopal and Vivekanandan, 1991
Cochin	136	185	233	Vinci, 1983
Chennai	165	254	286	Vivekanandan and James, 1986
Kakinada	185	255	285	Murty, 1984
Visakapatanam	123	161	186	Rao and Rao, 1986
Andhra-Orissa coast	150	210	240	Krishnamoorti, 1973b
Cochin (mlae)	181	259	293	Present study
Cochin (female)	159	217	238	Present study

Table 3. Yield, total stock and standing stock of *N. japonicus* off Cochin during 2000-2002

Year	Catch (Y) (t)	F	M	Z	U	Total stock (Y/U)	Standing stock (Y/F)
2000	725	1.91	1.3	3.21	0.542632	1336	380
2001	503	3.79	1.3	5.09	0.632110	796	133
2002	844	1.60	1.3	2.90	0.509918	1655	528
Mean	563	1.87	1.3	3.17	0.531933	1058	301

Yield per recruit

The yield per recruit for different values of F keeping the values of t_c (0.58) and M (1.3) as constant shows that Y_w/R increases with F reaching maximum of 12.65 g and corresponding B/R was 5.75 g for *N. japonicus* (Fig. 2).

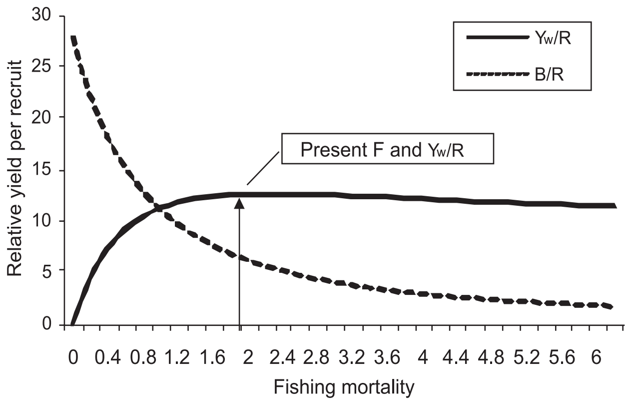

Fig. 2. Yield per recruit (g) and biomass per recruit (g) in *N. japonicus* (current F and Y_W/R are shown by small vertical arrow)

Yield assessment with reference to F

In both male and female of *N. japonicas*, the maximum yield corresponds to 536 t at 100% of the present effort. Thus there is no scope for increasing the yield from the current level of effort from the present fishing grounds. Murty *et al.* (2003) reported that MSY of *N. japonicus* corresponds to 60% of the present effort. During the last decade, the MSY showed an increase of 40% and reached up to 100% of the present effort. This may be due to the increase of multiday fishery of *N. japonicus* from deeper waters and expansion of fishing grounds to deeper waters.

Yield assessment with reference to L_c

In the case of *N. japonicus,* male and female combined, maximum yield corresponds to 844 t at 240% of the present

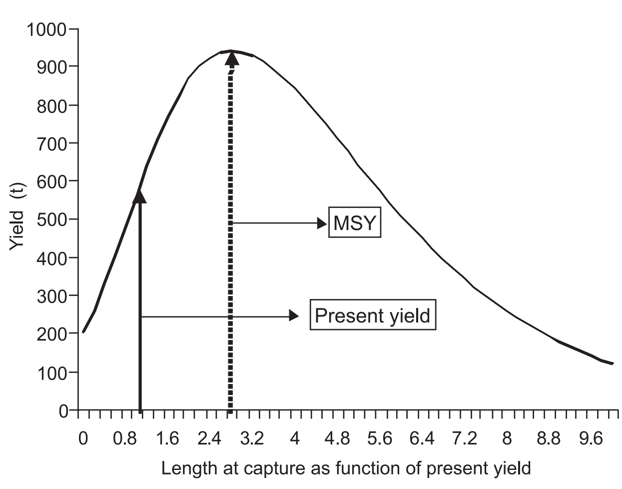

Fig. 3. Estimated yield of *N. japonicus* as function of different length at capture as expressed as percentage of present yield

t_c (177% of L_c) and the yield will be 167% of the present yield (Fig. 3). The maximum yield in the present level of F will be obtained by increasing the length at first capture to 177% of the present and the recommended L_c value for the MSY is 123 mm. This can be achieved by increasing the cod end mesh size from the present level of 15-20 mm to 35-40 mm, which will yield better catches. Murty *et al.* (1992) estimated the maximum yield of *N. japoniucs* at 200% of present t_c. The present values are little above the earlier results and indicate an increase of length at first capture from the present will yield better.

Threadfin breams, spawn over extended periods and the inshore areas serve as nursery grounds for the species. Continued trawling in littoral waters can lead to undesirable consequences and the yield of threadfin breams also have reached levels where further increase in the same does not seem to be possible from the present fishing grounds (Murty *et al.*, 2003). The reduction of the cod-end mesh size of trawl nets can result in the reduction of lengths at first capture, L_c which will in turn cause recruitment overfishing over a period of years (Murty *et al.*, 2003). One of the studies along the Karnataka coast inferred that the present yield could be increased to the MSY level by increasing the effort by 10% whereas the MSE would be at 80% of the present fishing effort (Zacharia, 1998). The abundance of threadfin breams (640 kg h^{-1}) in exploratory surveys (Vinci, 1983) and higher catch rates (235-718 kg $unit^{-1}$) during monsoon (Nair and Jayaprakash, 1986) are the two positive factors of the fishery. The decrease in cod end mesh size (Murty *et al.*, 1992), removal of spawning population and observed localization of the fishery very near to river systems owing to large scale discharge of nutrients from rivers (Krishnamoorthi, 1973 b) are the major negative factors of the fishery. The observed growth differences of male and female *N. japonicus* add to the complexity of management of the fishery. Comparing the earlier stock assessments (John, 1989; Murty *et al.*, 2003) with the results of the present study, it appears that the resources are not showing any considerable increase, even though the actual fishing effort and area of fishing operation have expanded, which indicates the need for scientific management for this important resource along the Kerala coast. If the fishery continues with the present F, there is every chance for decline of the catch of threadfin breams from the present trawling grounds.

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