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Fishery, biology and population dynamics of *Metapenaeus dobsoni* (Miers 1878) from Kerala, south-west coast of India

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ABSTRACT

The fishery and population dynamics of the flowertail shrimp *Metapenaeus dobsoni* along the Kerala coast was studied based on landings at Cochin Fisheries Harbour during the period 2005 to 2007. Kerala ranked first in the production of *M. dobsoni* (>50%), followed by Tamil Nadu. The average annual catch and catch per unit effort of *M. dobsoni* was 2,526 t and 115.2 kg respectively. It formed 70% of the total penaeid shrimps landed in trawls. Peak landings were observed from April to June followed by November to January. The size range of male and female was 51-100 mm and 51-125 mm, respectively. The male-female sex ratio was 1:1.21. Mature females occurred throughout the period of observation and the size at first maturity was 60 mm. Growth parameters L_∞, K and t_0 were estimated as 103 mm, 2.01 y^{-1}, -0.00018 and 130, 2.51 y^{-1}, -0.000046 for male and female, respectively. Length at recruitment (L_r) was found to be 53 mm for both sexes while the length at 50% capture (L_{c50}) was 65 mm for males and 70 mm for females. Recruitment was found to occur in most of the months with peak (>70%) during June to November. Natural mortality (M), fishing mortality (F), total mortality (Z), exploitation rate (E) and E_{max} were 2.17, 5.57, 7.74, 0.72, 0.81 and 2.00, 5.83, 7.83, 0.74, 0.680 for males and females, respectively. Higher values of E indicated that the resource is overexploited. Results of Beverton and Holt yield per recruit analysis and Thompson and Bell analysis revealed that at the present fishing effort, spawning stock biomass was above 20% suggesting that the fishery is sustainable.

Keywords: Flowertail shrimp, Growth, Maturity, Mortality, Recruitment pattern, Sex ratio

Introduction

About 70% of the total shrimp landings in India is constituted by penaeid shrimps and Kerala ranks first in its production. The shrimp fishery off Kerala, as in other regions of India is multispecies in character, accounting for about 33,000 t (Pillai *et al.,* 2007). At present, over 59% of this catch is landed by trawlers, with Sakthikulangara and Cochin being the two major shrimp landing centres. Shrimp fishing grounds off Cochin lie between lat. 9.54' 16.86° N, and long 75.55' 48.92° E, covering a distance of about 35 km along the coast. The flowertail prawn, *Metapenaeus dobsoni* (Miers, 1878), locally called as 'poovalan chemmeen' or 'thelly chemmeen', is extensively caught from both east and west coast of India. Cochin Fisheries Harbour is the second largest trawl landing centre in Kerala and is one of the important trawl landing centres in the country for *M. dobsoni*. Apart from trawl, *M. dobsoni* is also caught in considerable quantities in traditional ring seines and forms a major catch in the mudbank fishery, particularly during the monsoon period. Various aspects of *M. dobsoni* such as bionomics (Menon, 1951, 1955, 1957), growth (Banerji and George, 1967), breeding (George, 1964; Rao, 1970), sex distribution (George and Rao, 1967), population characteristics (Kurup and Rao, 1974), fishery and biology (George *et al.,* 1963; George, 1970; Ramamurthy *et al.,* 1978; Ramamurthy and Sukumaran, 1984) and stock assessment (Alagaraja *et al.,* 1986; George *et al.,* 1988; Paralkar Smitha and Devaraj, 1990; Sukumaran *et al.*, 1993) have been studied earlier. As recent information on the fishery and population dynamics of *M. dobsoni* off Cochin is lacking, the present study was undertaken to assess the stock of *M. dobsoni* based on the landings by commercial trawlers at Cochin Fisheries Harbour (CFH) for the period 2005 - 2007.

Materials and methods

Data on catch and effort were collected twice in a month from trawl landings at CFH from January 2005 to

December 2007. For length-frequency studies, the total length of the shrimp was taken in 'mm' and classified in to 5 mm size groups. The length-weight relationship of *M. dobsoni* was calculated from 395 females and 291 males using the exponential equation, $W = a L^b$ (Le Cren, 1951) where W = body weight (g), L = total length (from tip of the rostrum to tip of the telson) (mm), *a* = proportionality constant, and *b* = regression coefficient. The chi-square test (Snedecor and Cochran, 1967) was applied to test the significant difference if any in the monthly sex ratio. Maturity stages of females were identified following Rao (1967) and length at first maturity was estimated by fitting the frequency of mature females to a logistic curve and plotting the proportion of mature individuals against length class (King, 1995).

Growth parameters *viz*., asymptotic length (L_∞) and annual growth co-efficient (K) were estimated using the ELEFAN I module of FiSAT software (ver. 1.2.2) by pooling the length frequency measurements of three years. An additional estimate of L_∞ and Z/K values obtained using the Powell-Wetherall plot (Gayanilo *et al*., 1996) was compared with that obtained from ELEFAN I before arriving at final values. The length-based growth performance index, φ was calculated as given in Pauly and Munro (1984). The probability of capture and size at first capture (L_c) were estimated as in Pauly (1984) and the age at zero length (t_0) from Pauly's empirical equation, $Log (-t_0) = - 0.392 - 0.275 Log L_\infty - 1.038K^{-1}$ (Pauly, 1979). Length-at-age was estimated using the von Bertalanffy growth equation, $L_t = L_\infty (1-e-k^{(t- to)})$. Natural mortality (M) was calculated by taking the mean sea surface temperature as 28°C and total mortality (Z) from length converted catch curve (Pauly, 1983) using FiSAT software. Fishing mortality (F) was estimated using the formula, F = Z - M. Exploitation rate was estimated from the equation, E = F/Z and exploitation ratio from $U = F/Z* (1-e^{-z})$. The mid-point of the smallest length group in the catch was taken as length at recruitment (L_r). Recruitment pattern was studied from recruitment curves using final estimated values of L_∞, K and t_0. The value of asymptotic weight (W_α) was derived from the value of L_∞ and the estimated length-weight relationship. Maximum sustainable yield (MSY), maximum economic yield (MEY) and spawning stock biomass (SSB) were calculated using Thompson and Bell model (Sparre and Venema, 1998) and the relative yield per recruit (Y/R) and biomass per recruit (B/R) at different levels of F using LFSA package (Sparre, 1987).

Results and discussion

Fishery

The average annual catch of *Metapenaeus dobsoni* for the period 2005–2007 was 2,526 t, which contributed 70% to the total penaeid shrimp trawl landings at CFH along the Kerala coast. Earlier studies have also reported higher catch (41%) of *M. dobsoni* in trawl fishery off Kochi and 19% from Neendakara (George *et al*., 1980). The catch showed an increasing trend, fluctuating between 2,319 t in 2005 and 2,954 t in 2007 with a slight dip in the year 2006. Details of the catch, effort and catch per hour (CPH) are given in Table 1. Nandakumar *et al*. (2001) studying the shrimp fishery from trawl landings at Sakthikulangara during 1986 to 2000, also reported fluctuating trend in the catch of *M. dobsoni* which increased from 365 t in 1986 to 2,511 t in 1991 which then declined to 1,434 t in 2000. The average monthly catch and CPH of *M. dobsoni* during 2005-2007 were 632 t and 4.6 kg h^{-1}, respectively. The highest average monthly catch, effort and CPUE were recorded in May with a peak in landings from April to May and December to January (Table 2).

Length frequency

Size range of females ranged from 51 to 126 mm with the major mode at 81- 85 mm while the males ranged from 51 to 100 mm with a dominant mode at 76 - 80 mm. However, there were slight variations in the size range and modes of different years. In contrast, Suseelan *et al.* (1992) reported slightly lower size ranges with 36 - 100 mm for males and 36-120 mm of total length for females.

Length-weight relationship

The length-weight relationship derived for females and males were as follows:

Female: $W = 0.0075 L^{2.9}$ (r=0.96)

Male : $W = 0.0066 L^{2.94} L$ (r=0.95)

Table 1. Catch and effort of *Metapenaeus dobsoni* at Cochin Fisheries Harbour (2005-2007).

Year	Effort units	Actual fishing hours	Catch (t)	% in penaeid shrimp catch	CPH (kg)
2005	23881	552143	2319	63	4.2
2006	20198	411607	2305	77	5.6
2007	21684	476452	2954	69	6.2
2005-2007 (average)	21921	480067	2526	70	5.3

Table 2. Seasonal abundance of *M. dobsoni* at Cochin Fisheries Harbour during 2005-2007.

Month	Unit effort	Actual fishing hours	Catch (t)	CPUE (kg h^{-1})	% in total peneaid shrimp catch
January	4391	74426	454	6.1	87.9
February	4827	83333	425	5.1	82.5
March	5304	114595	848	7.4	83.4
April	9684	207353	1410	6.8	78.4
May	11867	257534	1880	7.3	74.6
June	4970	130250	1042	8.0	81.4
July	Trawl ban				
August	5374	143333	43	0.3	4.9
September	3360	100000	10	0.1	4.0
October	4593	133333	40	0.3	9.3
November	4324	81167	487	6.0	82.4
December	7069	121948	939	7.7	85.8
Average	5480	120606	632	4.6	56.2

Sex ratio

Females outnumbered males in the catch throughout the year with an overall male-female sex ratio of 1:1.21. Monthly sex ratio also showed dominance of females in almost all the months, highest being observed in the month of May except in the year 2005, when females dominated in April. Chi-square test indicated significant dominance ($p<0.05$) of females particularly in the months from October to December and February to April. Similar observations were made along the Mangalore coast (Ramamurthy *et al*., 1978). The differential sex ratio observed in this species from backwaters and other coastal areas of Kochi is probably related to the migrations of females (Menon, 1955; 1957). George and Rao (1967) opined that distribution of the sexes varies significantly from month to month and differential sex ratios may be due to the breeding migrations of females.

Maturity

Month-wise analysis showed the presence of all maturity stages in all the months during the years of observation. However, the dominance of maturity stages fluctuated between different months. On an average, immature females occurred more during January to May and August to November while mature ones appeared during November to June with a minor peak during August to November, and spent shrimps, during January to June with second peak during August to November. Length at first maturity was calculated as 60 mm (Fig. 1). Rao (1968) estimated size at maturity to be slightly lower than 64 mm and when the national status of this resource was assessed, the minimum size at maturity of the female was found to be 64 mm in total length (Sukumaran *et al*., 1993). Higher percentage of late mature and mature females from November to February may be taken as an indicator of peak breeding season. George (1962) observed the species to breed throughout the year with peak breeding in November and a second peak during June - August. Although Menon (1951; 1955) has not mentioned year round breeding for this species, the peak seasons suggested therein is in agreement with the present observation.

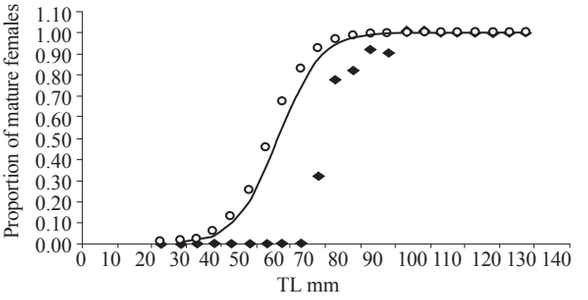

Fig. 1. Length at maturity of *M. dobsoni* (female)

Growth parameters

The asymptotic length L_∞ was estimated as 130 mm for females and 103 mm for males. The values of 'K' (monthly) were 2.51 y^{-1} for females and 2.01 y^{-1} for males. The growth performance index, φ was 1.548 and 1.250 and t_0 was calculated at -0.000046 and -0.00018 years for females and males, respectively. The von Bertalanffy growth equation for female was: $L_t = 130\ [1 - e^{-2.51\ (t + 0.000046)}]$ and $L_t = 103\ [1 - e^{-2.01\ (t + 0.00018)}]$ for male. Sukumaran *et al.* (1993) obtained slightly higher K and L_∞ values for males (2.4, 139 mm) and females (2.76, 145 mm) when this resource was assessed with pooled data from different centres along the Indian coast. In contrast, studies from Mangalore coast revealed lower values for L_∞ and K with 109, 1.44 and 121, 2.16 for males and females, respectively (Ramamurthy *et al*., 1978). The L_∞ and annual K were reported to be 140 mm and 1.69 in females and 117 mm and 1.89 in males from the Kakinada coast (Lalitha Devi, 1987). All these estimates in general show differential growth rate for male and female.

The lengths obtained for 6, 12 and 24 months old females were 98 mm, 122 mm and 130 mm respectively, whereas, the corresponding length of males were 69, 92 and 102 mm (Fig. 2). The length at capture (L_c) for females and males was estimated at 70 mm and 65 mm, which correspond to ages (t_c) of 0.42 and 0.5 year, respectively. The asymptotic weight (W_∞) estimated from the length-weight relationship was 6.3 and 12.74 g for males and females, respectively. Kurup and Rao (1974) observed the species from Ambalapuzha to attain sizes of 97 and 122 mm in case of males and 115 and 138 mm in females at the end of the first and second year. But the reports of Sukumaran *et al*. (1993) stated that the species can grow from 90 to 120 mm and 100 to 130 mm in males and females at the end of six months and one year, respectively. Banerjee and George (1967) revealed slightly higher size ranges for shrimps off Kochi with 95 mm, 114 mm and 118 mm at the end of first, second and third year, respectively. Differential rate of growth in sexes was noticed in this species as observed by Menon (1955) and George (1962). The age group that forms the fishery are females of 9 months and males of 8 months. The age at 50% capture (L_{c50}) is five months in females (70 mm) and six months (65 mm) in males.

Mortality and exploitation

Mortality rates M, F and Z were estimated as 2.00, 5.83 and 7.83 for females and 2.17, 5.57, 7.74 for males. E and E_{max} were, 0.74 and 0.680 for females and 0.72 and 0.813 males, respectively (Fig. 3 and 4). The rate of exploitation for *M. dobsoni* (0.73) was lower than E_{max} (0.78) indicating the sustainability of the fishery.

Recruitment pattern

M. dobsoni was recruited to the fishery in all months of the year with two peaks during May-June and August. The smallest length of recruitment to the fishery was 51 mm which corresponds to an age of 4 months.

Yield and biomass estimates

The yield and biomass/recruit and yield and biomass curves showed that the maximum yield of 2,543 t and yield/recruit of 2.46 g can be obtained by decreasing the present effort of fishing by 20%. At the existing level of fishing (F=1), these yields were 2,526 t and 2.4 g. The biomass and biomass per recruit achieved at 20% reduction from the present effort is 557 t and 0.53 g, respectively. But with the present rate, the biomass and biomass per recruit were very low *i.e.,* 443 t and 0.42 g. Although a small

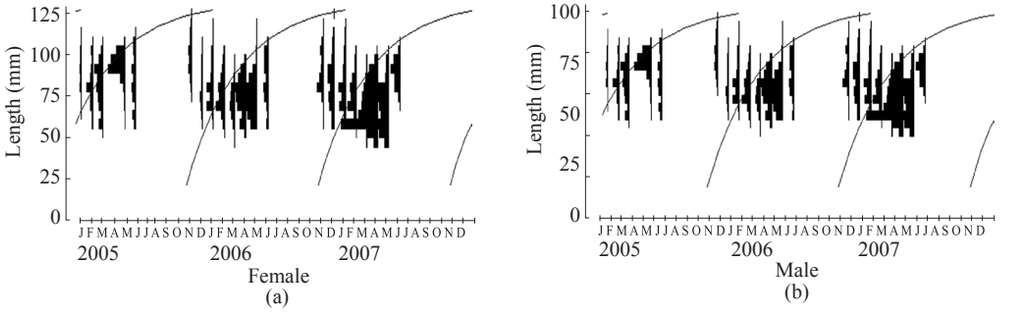

Fig. 2. Length frequency data with super imposed von Bertalanffy growth curve (VBGF) fitted for *M. dobsoni*

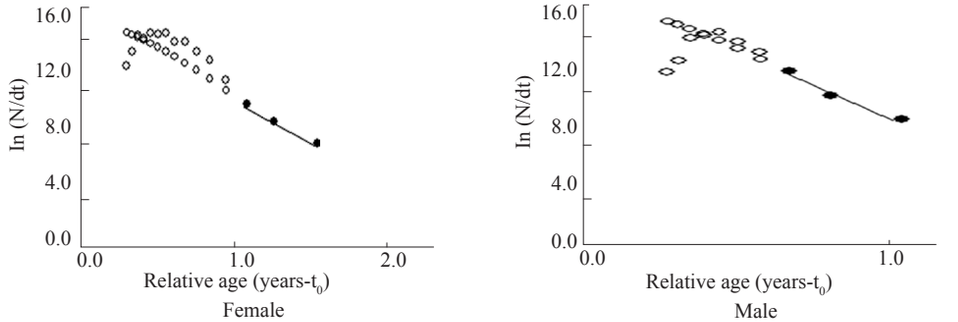

Fig. 3. Mortality parameters of *M. dobsoni* landed at Cochin Fisheries Harbour during 2005-2007

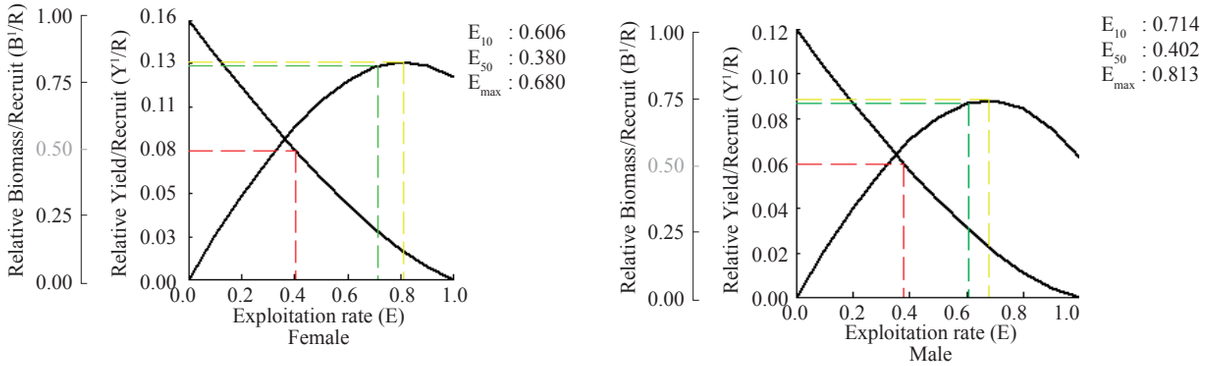

Fig. 4. Beverton and Holt relative yield per recruit analyses of *M. dobsomi*

increase (68 t) in yield is seen by increasing the fishing effort by 20%, corresponding values for biomass (365 g) and biomass/recruit (0.35 g) are comparatively less. So to get an optimum yield close to MSY, reduction in current fishing effort by 20% is advisable.

Length based

Maximum sustainable yield obtained for the F-factor (present F=1) was 2,526 t (Fig. 5). Even though the MSY obtained for the factor (F= 0.8) was slightly high (2,543 t), variation from the present yield was very low. But if spawning stock biomass is taken as the biological reference point (BRP) at F-factor (present F=1) it is 35.6% and by reducing the fishing mortality by 20%, spawning stock biomass increased to 41%. However at present F (F=1), reduced F (F=0.8) and F = 1.2, spawning stock biomass was maintained above the standard limit, at 20% which indicates sustainable fishery.

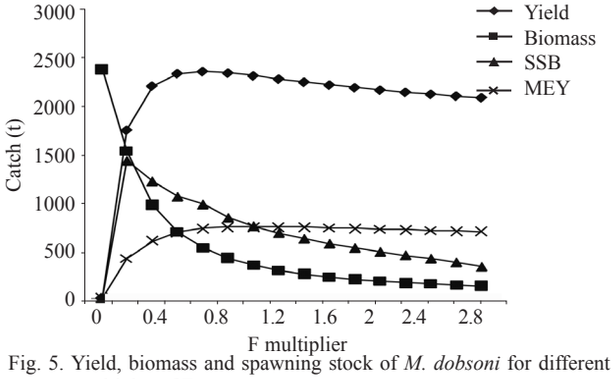

Fig. 5. Yield, biomass and spawning stock of *M. dobsoni* for different multiples of F

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