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Fishery, biology and population dynamics of *Parapenaeopsis stylifera* at Calicut

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ABSTRACT

Results of the study based on the data collected at Calicut on the fishery and biology of *Parapenaeopsis stylifera* for a period of five years from 1987 to 1992 are given. The average annual catch and catch per unit effort were 306 tons and 16.6 kg respectively. The peak landings were observed during October -January. Shrimp formed 7.4% of the total trawl landings and 49.8% of the shrimp catch was contributed by *P.stylifera*. The size range of female was 46-130mm and in male, 51-110mm. Males outnumbered females in the total catch and the difference was statistically significant. Mature females occurred throughout the season and the size at first maturity was 74.6 ± 1.013 mm. The growth parameters, L_{∞} , k and t_0 were 132.03 mm, 0.1912 and 0.088 respectively for females and 111.8 mm, 0.2065 and 0.398 respectively for males. Total average mortality rate was 6.41 (females) and 9.83 (males). Yield per recruit and cohort analysis revealed that further increase in effort would affect the stock adversely.

Introduction

Eventhough prawn landings of India is only around 12% of the total landings, its demand in foreign countries has resulted in the continuous increase in the fishing pressure. About 70% of the total prawn landings in India is constituted by penaeid prawns and Kerala ranks first in its production. *Parapenaeopsis stylifera* locally known as 'Karikkadi' is the dominant one among penaeid prawns in Kerala and it is landed mainly by trawlers. Though published information on the fishing and population characteristics of the above mentioned species from Indian coast is available (George, 1961; George and Rao, 1967; Mohamed, 1967; George *et al.*, 1968; Rao, 1973; Kurup and Rao, 1974; Muthu *et al.*, 1978; Kagwade,

1980; Ramamurthy, 1980; Suseelan and Rajan, 1987). There is no published information of this species from Puthiappa-Kozhikode region except that of Menon (1953). Hence the present study was conducted at Puthiappa - Kozhikode (Kerala) to understand the population characteristics and stock position of *P.stylifera* based on the data collected during the period 1987-1992.

Materials and methods

Catch and effort data were collected thrice in a week from Puthiappa trawl landing centre and estimated to the respective months. For length-frequency study, the total length of the shrimp was taken in 'mm' and classified into 5 mm size groups. To obtain length - weight

relationship 83 females and 99 males were used and fitted with a regression in the form $\log W = a + b \log L$, where 'W' is the weight in grams and 'L' the total length (from tip of the rostrum to tip of the telson) in cm (Pauly, 1983). Maturity stages of the females were noticed in fresh condition and grouped into five stages namely immature, early maturing, late maturing, mature (ripe) and spent. To determine the size at first maturity, immature and early maturing were grouped together as 'immature' while late maturing, mature (ripe) and spent were classified as 'mature'. (Rao, 1989). The size at first maturity was found out by statistical method (Uduppa, 1986). Since the data collected for biological studies in 1989-'90 was inadequate, has not been included. For mortality and stock assessment studies average of the data collected during 1990-'91 and 1991-'92 only were used. The methods used for population dynamics and stock assessment are given in concerned sections.

The fishing ground of Kozhikode lies between 11°N and 11°45'N. The trawl nets are being operated at 6 to 40 m depth range where the bottom is muddy. But Karikkadi fishery is restricted to a depth range of 6 to 20m.

Shrimp fishing is mainly done by small mechanical boats of 14 m length. Trawl net is the main gear used for fishing, though gears such as boat seines, cast nets, disco nets (mini trawl), ring seines and gill nets are also used. The cod end of trawl nets measure between 10 and 15 mm. Usually fishermen go for fishing early in the morning (0300 hrs. to 0500 hrs) and return by evening (1330 to 1700 hrs) after 3 to 5 hauls of 1 to 1½ hours duration. In 1987 and 1988, the fishery ended by May and resumed in October whereas, in 1989 and 1990, it resumed by November. In 1991, the fishing started from September onwards. Generally trawling was carried out throughout the

year except during south-west monsoon (June to August). In these months, the fishing was suspended due to the ban on trawling, inclement weather and rough sea.

Results

Fishery

The catch, effort and CPUE for the period 1987-'88 to 1991-'92 showed wide fluctuations between the years. Thus the catch varied from 377.5 t in 1990-'91 to 1263 t in 1991-'92. The effort varied from 12423 units in 1989-'90 to 28041 units in 1991-'92 and the CPUE from 23.4 kg in 1990-'91 to 45 kg in 1991-'92. It could be seen that the maximum catch, effort and CPUE were recorded in 1991-'92, whereas the minimum of these were recorded in different years. Thus the minimum catch and CPUE were recorded in 1990-'91, whereas the minimum effort was observed in 1989-'90. The average monthly catch, effort and CPUE showed that November to March formed the productive period though at times October and April also accounted for very good catches. However, the peak landing in different years was in different months and it was December during 1987-'88, November during 1988-'89, January during 1989-'90, March during 1990-'91 and December during the following year. Generally though the maximum effort expended were also in the same months of peak landing, the highest CPUE was not observed in the corresponding months. Thus the highest CPUE was observed in October, November, April, May and March for the periods 1987-'88, 1988-'89, 1989-'90, 1990-'91 and 1991-'92 respectively. It could also be seen that both the catch and CPUE were exceptionally higher during October to March in 1991-'92.

Annual percentage of *P. stylifera* in the shrimp catch varied from 35.4 in 1987-'88 to 56.2% in 1991-'92 with an av-

erage of 49.8% (Table 1), which clearly indicates its importance in the prawn fishery. The annual catch and CPUE showed the same pattern of fluctuation as that of shrimp catch and CPUE with the minimum of 154.2 t and 9.6 kg in 1990-'91 and maximum of 709.6t and 25.3 kg in 1991-'92.

Monthly average catch was better from October to April. But the CPUE was almost of the same range in all the months of fishery except during October to November. In these two months, the CPUE was higher and October accounted for the highest CPUE. The maximum percentage contribution was generally seen in the months with maximum CPUE.

Biology

Length frequency : In general the size of female ranged from 46 to 130 mm with the mode at 86-90 mm and 51-55 mm while the males ranged from 51 to 110

mm with a dominant mode at 76-80mm. However there were slight variations in the size range and mode in different years. Thus the size ranges of females were 46 to 130 mm with a major mode at 81-85 mm followed by two minor modes at 91-95 mm and 71-75 mm in 1987-'88, 51 to 130 mm with a mode at 86-90 mm in 1988-'89. In 1990-'91 the size ranged from 51 to 130 mm with a major mode at 86-90mm and minor mode at 71-75 mm and 106-110 mm. In 1991-'92, the size range was 61 to 130 mm and the mode was at 96-100 mm.

In males, the size varied from 51 to 105 mm with a mode at 76-80 mm in 1987-'88 and 1988-'89. In 1990-'91, the size range was 51 to 110 mm with the mode at 71-75 mm while the size range was 51 to 100 mm with a mode at 76-80 mm in 1991-'92.

Sex ratio : The annual sex ratio showed the dominance of males in 1987-'88 and 1988-'89. In 1990-'91, the sex ra-

TABLE 1. Month wise catch % in shrimp catch and CPUE of *Parapenaeopsis stylifera*

Year	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1987-88 Catch(kg)		8160		28101	39513	32411	25700	28183	12117	174185
% in shrimp catch		37.8		72.7	40.4	33	31.2	38	15.2	35.4
CPUE (kg)		8.4		30.7	11.6	8.2	6.9	8.3	3.2	8.6
1988-99 catch	719	122		2142	134882	25603	19252	21818	52519	257057
% in shrimp catch	4.6	4.3		36.8	89.3	32.6	28.2	25.3	95.0	51.0
CPUE	0.4	0.5		11.0	47.0	8.5	8.1	10.3	19.9	16.9
1989-90 catch	44509	18981	No fishery		10604	50330	68111	32505	8705	233745
% in shrimp catch	51.1	67.1			53.8	60.8	60.5	40.3	37	53.8
CPUE	21.5	23.9		No fishery	9.9	23.3	25.4	12.7	8.0	18.8
1990-91 catch	10928	10255			7086	24490	20877	28392	52127	154155
% in shrimp catch	45.0	58.0			44.0	48.8	23.3	48.0	43.4	40.8
CPUE	20.2	30.1			5.9	8.3	5.1	9.0	13.7	9.6
1991-92 catch	77923	46426	470	144948	91826	88639	130166	57609	71602	709609
% in shrimp	56.0	49.0	64.0	86.3	70.8	37.7	71.0	56.0	34.0	56.2
CPUE	34.9	12.0	3.0	49.7	23.1	22.0	31.1	25.0	24.3	25.3
Average catch	33520	167889	470	583978	56782	44295	52821	33701	39414	305750
% in shrimp	50.5	50.9	63.9	82.4	68.5	40.6	49.4	41.9	37.1	49.8
CPUE	16.6	13.6	3.6	43.5	22.7	13.7	15.4	12.5	13.8	16.6

tio was equal, whereas in 1991-'92 females dominated the catch. In the monthly ratio also the dominance of males was noticed in almost all the months. Thus it dominated from October to February in 1987-'88, from November to March in 1988-'89. But in 1990-'91 the sexes were equal, whereas, in 1991-'92 females dominated in all the months except February. Chi-square analysis was applied (Snedecor and Cochran, 1967) to test the significance of difference in sex ratio and it revealed that the difference was significant at 0.05 level in 1987-'88, 1988-'89 and 1991-'92 and also for the total period, 1987-1992 (Table 2).

Maturity condition : Month-wise analysis showed the presence of all maturity stages in all the months during

In the month-wise average, more number of immature females occurred in March-May, early maturing were recorded in good numbers in all the months and late maturing in December-January. The percentage of mature females was more from October to December with a peak in October and spent were maximum in November. In the size-wise analysis of maturity condition, early maturing stage were recorded from 61mm onwards and late maturing from 66mm onwards, whereas mature and spent stages were observed from 76-80 mm onwards. The size at first maturity estimated (Uduppa, 1986) was 74.6 mm ± 1.013 in females.

TABLE 2. CHI-SQUARE analysis of sex ratio

Year	Sex ratio (%)		Chi-square Value	Table value	DF	Significance at 0.05 level
	Female	Male				
1987-88	46.8	53.2	32.96	12.6	6	S
1988-89	40.7	59.3	28.049	11.1	5	S
1990-91	50.0	50.0	-	-	4	NS
1991-92	57.0	43.0	54.21	12.59	6	S
Total	49.1	50.9	95.22	45.44	6	S

different years eventhough the domination of maturity stages fluctuated between different months. In 1987-'88, immature female occurred more in October-November, early maturing in March, late maturing in January and mature in December and March. In 1988-'89 immature females dominated in February-March, early maturing in December-January, mature in October and spent in November. During 1990-'91 females in immature stage dominated in May, early maturing in January and March. More number of mature and spent females were observed in February. In 1991-'92, early maturing dominated in December and February, late maturing in January, mature and spent in November.

Estimation of growth parameters

Modal progression analysis for age : Size frequency data collected for the samples were plotted in the graph and progression of monthly modes were traced by a smooth growth curve. The modes thus traced were tabulated chronologically and the average size attained were calculated. These curves were extrapolated to get the probable month of birth separately for females and males (Fig. 1). The lengths thus obtained for 6,12 and 18 months old females were 89.4 mm, 118.5mm and 127.7 mm respectively, whereas, the size of males in respective months were 76.6,101.6 and 108.8 mm.

Estimation of 'L₀₀' : L₀₀ of females and

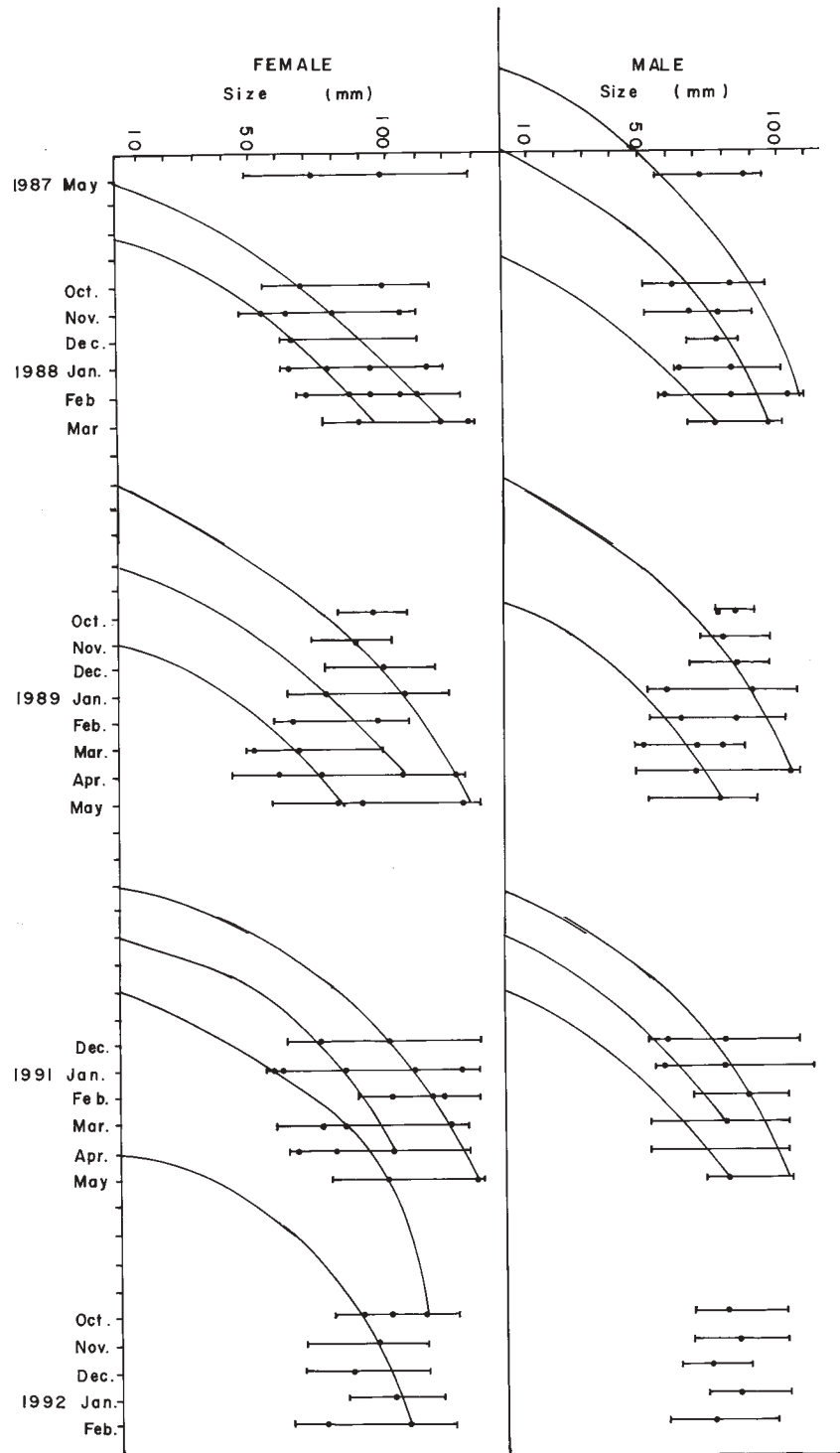


Fig.1. Size distribution and modal progression of *Parapenaeopsis stylifera*

males were calculated by using Powell-Wetherall method (Wetherall *et al.*, 1987) and found out as 132.03 mm for the former and 111.8 mm for the latter.

Estimation of 'K' and 'to' : 'K' and 'to' were estimated by using the Von Bertalanffy plot (Sparre and Venema, 1992). The values of 'K' (monthly) were 0.1912 for females and 0.2065 for males. 't₀' was calculated as 0.088 months for females and 0.398 months for males.

Estimation of natural mortality (M) : The natural mortality was estimated based on longevity as suggested by Alagaraja (1984). The M 1% values (Natural mortality corresponding to 1% survival) thus obtained were 2.5 for females and 2.7 for males.

Estimation of mortality coefficient (Z) : The mortality coefficient for each year (1990-'91 and 1991-'92) was calculated separately from linearised length converted catch curve based on length composition data (Pauly, 1983, 1984 a, b and c).

The values were as follows :

Year	Female	Male
1990-'91	3.73	7.13
1991-'92	9.09	12.53
Average	6.41	9.83

The fishing mortality (F) was found out as 3.91 for females and 7.13 for males.

The fishing mortality and total mortality rates by sizes were found out using length-cohort analysis (Jones, 1984). The data for the years 1990-'91 and 1991-'92 were pooled and average was taken for this study. The average total mortality rate by size thus obtained was 5.72 for females and 8.82 for males. The fishing mortality was calculated as 3.22 (female) and 6.12 (male). In this analysis F/Z was assumed to be 0.5.

Estimation of selectivity : The left hand side of the catch curve was used in re-

gression analysis (Sparre and Venema, 1992) to estimate selection and the length at first capture (L_{50%}) was found out as 77.1 for females and 75.77 mm for males. The corresponding t_{50%} values were found out as 0.44 years and 0.49 years for females and males respectively.

The gear selectivity curve was obtained from the different F-values of Jones' cohort analysis by using Si-F(i)/Max (Fj) where F(i) is the fishing mortality of the size group (i) and Max (Fj) is the maximum value of the fishing mortality among all size groups (Sparre and Venema, 1992). L_{50%} obtained using this formula was 84 mm in females and 76 mm in males.

Length - weight relationship : The length - weight relationship of females and males were as follows :

Female : $\text{Log } W = -2.2098 + 2.9581 \log L$ (r=0.977)

Male : $\text{Log } W = -2.2257 + 2.9781 \log L$ (r=0.945)

Where 'W' is the weight in grams and 'L' is the length in centimeter.

Beverton and Holt yield per recruit analysis : The formula used to find Y/R is $Y/R = F \exp(-M(tc-tr) W_{00}(1/Z-3S(Z+K) + 3S^2/(Z+2K)-S^3/(Z+3K)))$ (Sparre and Venema, 1992). The parameters were as follows :

Parameters	Female	Male
F (present)	3.91	7.13
M	2.50	2.70
tc (years)	0.44	0.49
tr (years)	0.169	0.247
W ₀₀ (grams)	12.8	7.82
K(annual)	0.2944	2.478
to(years)	0.0073	0.033

As per the analysis, Y/R for the present F(3.91) in females was 1.78 gms

and in males, 1.34 gms for the present F(7.1). The analysis showed that Y/R increased with the effort in both females and males but when it reached a certain level the marginal increase was very less. At the current level of exploitation, the biomass of the males is about 19% of its virgin biomass and biomass of females, about 28% of its virgin biomass (Fig. 2). From the graph it is clear that the present level of fishing is very near to F-MSY es-

pecially in the case of males.

Thompson and Bell yield and biomass production : Thompson and Bell analysis (Sparre and Venema, 1992) was carried out to find out the effect of fishing on yield and to estimate MSY. In the case of females, MSY obtained for the F-factor 1.4 (present F=1) whereas, in the case of males it is 0.8 (present F=1). That means, to obtain the MSY, the present level of fishing is to be reduced by 20% in the case of males. Eventhough, the MSY of female was obtained for the factor 1.4, the variation from the present yield was very low. However, the total yield was maximum for the factor 1.2 (Table 3).

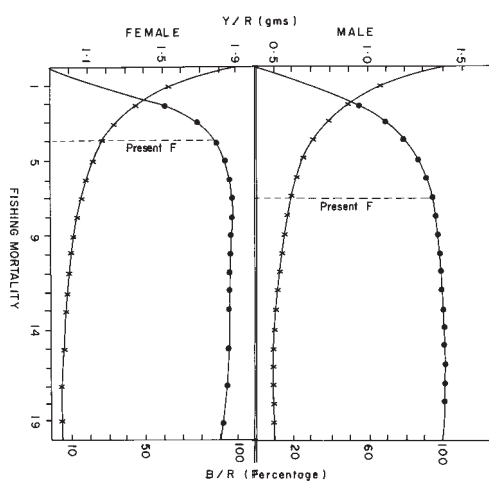


Fig.2. Beverton and Holt's yield per recruit curve and the corresponding biomass per recruit curve as a function of 'F'

Discussion

Though the catch effort of *P. stylifera* showed wide fluctuations, it formed about 50% of the total prawn catch. In this study a size range of 46 to 130 mm and 51 to 110mm were obtained in female and male respectively. Kurup and Rao (1974) observed males of size range 53 to 123 mm from the trawl fishery of Ambalapuzha. In Mangalore, the size range of this species was 38 to 120 mm (Ramamurthy, 1980). From Cochin Suseelan and Rajan (1987) reported a size

TABLE 3. Thompson and Bell analysis for yield and biomass of *Parapenaeopsis stylifera*

(F (Factor) X	Female	Yield (Tonnes) Male	Total Yield	Total Biomass
0	0	0	0	483
0.2	180.4	112.5	292.9	308
0.4	265.6	148.5	414.1	220
0.6	306.7	159.8	466.5	170
0.8	326.4	162.80 (MSY)	489.2	142
1.0	335.2	162.77	498.0	126
(present F)				
1.2	338.4	162.0	500.4 (MSY)	100
1.4	338.6(MSY)	160.7	499.3	98
1.6	337.2	159.4	496.6	92
1.8	335.1	158.2	493.3	86
2.0	332.5	156.9	489.4	81

range of 35 to 95 mm in males and 40 to 120 mm in females.

A preponderance of males was noticed in the first three years and then a decrease in percentage in the subsequent years. George *et al.* (1963) observed domination of female in the prawn catches off Cochin while George and Rao (1967) reported a preponderance of males. Kurup and Rao (1974) observed the dominance of females in the catch but a higher proportion of males in the lower size groups as in the studies of George *et al.* (1963). As opined by Kurup and Rao (1974) the domination of males in the present study may be due to differential growth.

The present study showed that this species is a continuous breeder and the main breeding season is from October to December with a peak in October. The breeding months were March to May in Bombay waters (Shaikhmahmud and Magar, 1957), November to January and April in Cochin waters (George *et al.*, 1968), October to December in Ambalapuzha (Kurup and Rao, 1974), November to December and April-May from Mangalore (Ramamurthy, 1980). These observations including the present one confirm to the general observations of Suseelan and Rajan (1987) that this species is a continuous breeder with a definite peak, which vary from place to place and year to year. Moreover the availability of mature individuals from the inshore waters of Calicut support the observations of Shaikhmahmud and Tembe (1960), Menon (1952) and Chopra (1943) that this species attain sexual maturity in coastal waters and are not migratory for the purpose of breeding.

The size at first maturity for female *P. stylifera* was estimated as 74.6 ± 1.013 mm. The present observation is in conformity with the observations of other workers i.e. 75 mm (Menon, 1953), 63.2mm (Rao, 1968), 71mm (Ramamurthy, 1980) and 70mm (George

et al., 1968). However, Kagwade (1980) mentioned 105.5 mm as size at first maturity for this species.

The value of L_{00} of females as 132 mm in the present study is in agreement with the observations of Kurup and Rao (1974), Ramamurthy (1980), Alagaraja *et al.*, (1986) and Suseelan and Rajan (1987). But the L_{00} value of 111.8 mm for males differs slightly from the values found out by other workers. The values are 113.8mm (Ramamurthy, 1980), 114 mm (Alagaraja, 1986) and 108mm (Suseelan and Rajan, 1987). However Kurup and Rao (1974) estimated a higher L_{00} of 125.7 mm for males. The monthly 'K' values in the present study were 0.1912 (female) and 0.2065 (male). The 'K' values obtained by Suseelan and Rajan (1987) as 0.0875(female) and 0.0992(male) were very low when compared to the present observations and the values found out by Kurup and Rao (1974) as 0.14 for female and 0.12 for male and by Ramamurthy (1980) which were 1.49 for females and 2.87 for males.

In the present study, the size of females estimated were 89.4 mm, 118.5 mm and 127.7mm after 6,12 and 18 months respectively and for males the size in respective months were 76.6, 101.6 and 108.8mm. According to Menon (1953) it attains a size of 90 to 100mm in one year. Kurup and Rao (1974) estimated a size of 91mm and 117 mm for males and 98 mm and 123 mm for females after one and two years respectively. Ramamurthy (1980) also reported a size of 90 and 95 mm for male and female respectively after one year and the sizes after two years were 110 and 125mm. The sizes estimated from the ' L_{00} ' and 'k' values given by Suseelan and Rajan (1987) were 88mm for females and 75mm for males after one year and 118 mm and 98 mm respectively after two years ('to' was taken as zero). All these estimates in general show differential growth for male and female. The

present study reveals that females upto 16 months and males upto 15 months old are common in the fishery. The age at first capture is five months in females and 6 months in males.

The mortality study showed that males are facing heavy fishing stress, which in a way is evident in the sex ratios also. The average annual yield of *P. stylifera* at the present level of exploitation is very near to the maximum sustainable yield and it is advisable to maintain the same level of fishing effort.

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