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FISHERY AND BIOLOGY OF PENAEID PRAWNS AT HARNAII, MAHARASHTRA

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ABSTRACT

Penaeid prawn fishery at Harnaii in Ratnagiri District of Maharashtra was investigated during fishing seasons of 2002-03 and 2003-04 from mechanized (MLD) and hand operated trawlers (HT). During the two years, MLD contributed 86% and HT 14% to the average annual penaeid prawn catch of 2,242 t. The catch showed two peaks, a major during October-December and a minor during April-May in both the gears but abundance of the individual species differed.

P. stylifera, M. affinis, S. crassicornis, M. brevicornis, P. merguiensis and M. dobsoni mainly constituted the fishery and their species composition, seasonal abundance, annual size distribution and monthly mean size were investigated. Biological studies on food, size at maturity, spawning period, sex-ratio and juvenile abundance were carried out to explain temporal abundance of the species in the fishery. Among the species *P. stylifera, M. affinis* and *S. crassicornis* exhibited distinct seasonality with two spawning peaks, one in pre-monsoon and the other in post monsoon period to produce two discrete broods while *P. merguiensis* despite two spawning peaks exhibited a single dominant brood. *M. brevicornis* showed monsoon and post-monsoon spawning while *M. dobsoni* showed only post-monsoon spawning. Migrations between nearshore and offshore waters resulted in mixing of the broods and they remained inseparable in the catch.

Keywords: penaeid prawn fishery, biology, spawning seasons, recruit abundance.

INTRODUCTION

Along the coastline of Maharashtra, Harnaii (17°48'N 73°05') in Ratnagiri district has emerged one of the major marine fish landing centers during the past two decades. It is a natural port where passenger ships plying between Mumbai and Goa used to have a stop over until early 1970s; therefore existing port facilities are being used by the fishing boats for berthing and landing of fish, in addition to beach landing by the carrier boats. Traditionally the fisherfolk at Harnaii practised gillnet and seasonal *dol* net fishery, but export demand and the lucrative price offered for the penaeid prawns lured them to shrimp trawling. Though trawling in Ratnagiri district commenced in early 1960s (Ranade and Waknis, 1965), it started at Harnaii much later, in early 1980s and prospered in 1990s. Since late 1990s the fishery has been facing problems of unsteady catch and fishers are complaining of lower returns over the years. Since penaeid prawns are the most important resource and contribute substantially to the economics of trawling, it is necessary to document the fishery and bring a detailed account of it. Such information, in the light of problems faced by the fishery, may prove beneficial for regulation and management in future for the sustainability.

Prawn resources of Maharashtra have been described (Kunju, 1967; Kagwade, 1987) and accounts of the fishery at Mumbai (Shaikhmahamud and Tembe, 1960; Mohamed, 1967; Ramamurthy 1994; Deshmukh *et al.* 2002) and Ratnagiri (Ranade and Waknis 1965) are available. Biological information of various species of penaeid prawns is reported mainly from Mumbai waters (Shaikhmahamud and Tembe 1960; Kagwade 1980; Kunju 1967; Sukumaran, 1978). The present investigation gives a detailed account of penaeid prawn fishery, composition of the species, their seasonal abundance, size structure, food and reproductive biology of the species comprising the prawn fishery.

MATERIAL AND METHODS

Fishery data on catch, effort and species composition were collected intensively for two days in every month from August 2002 to May 2004. The number of mechanized and hand operated trawlers were estimated monthwise by taking into consideration actual number of boats landed on the days of observation and the number of fishing days in a month. The fishing effort in hours was estimated from the hauls taken by the trawlers during day and night, and standard duration of each haul (1.5-3 hrs) by inquiry. Additional fishery data collected by Fishery Resources Assessment Division of CMFRI for 4-6 days in a month were also used to supplement the fishery information. At least 20% of the trawlers were sampled on the observation days for the species composition of prawns. The fish catch was sorted species wise on the deck of the trawlers and the penaeid prawns were auctioned on the beach, where weight of the prawns was estimated by eye estimation. Many a times actual weight of the catch of prawns was available at the collection centres of the fish merchants and suppliers at the landing centres. Although catch of prawns from MLD and HT was landed separately, it was not possible to study the biology, including size of the species, from the HT independently.

At the landing centre random samples of six species were taken from at least three boats each day for sex, size (total length in mm) and maturity condition of the females and the data pooled for both the observation days. A random sample collected on the second day was iced and brought to the laboratory for detailed microscopic examination of foreguts, maturity and ovarian condition. The guts were analysed by the points method in which 0-20 points were assigned for the fullness of the gut and volume of different food items and Index of preponderance (Natarajan & Jhingran, 1961) of the food items was calculated for the four important species. Maturity condition of females was determined monthwise by following Rao (1968) and the size at maturity of the females was determined by logistic curve (King, 1995) by pooling mature and ripe females. In case of males, only those with united petasma were considered for the logistic curve. Prawns below the minimum size of maturity were treated as juveniles and after pooling them sex-wise, the monthly percentage of juveniles was calculated for the species. Sex ratio was tested monthwise and annually by Chi square method.

Craft and gear

A total of 200 mechanized trawlers based at Harnaii, in addition to 150-200 trawlers from the neighbouring villages operate from the port. These trawlers are 9.5-13m OAL with wooden hull fitted with 65 BHP engines and power winches, which generally undertook 2-3 days fishing (multi-day trawler MLD) and operated at 15-40 m depth. About 40 wooden boats of 8.5-10.5 m OAL having 25-30 BHP engines (locally called 'Dipco') but without winch also operated trawl net in 5-15 m depth and always undertook single day fishing. Since the net is operated manually the craft is also called hand trawler (HT).

MLD trawl net is 24-26 m long with 22 m foot rope, 55-60 kg otter boards and 15-20 mm cod end mesh while HT trawl net is 15-18 m in length, 15-25 Kg otter boards and 12-15 mm cod end mesh. During daytime MLD took 3-4 hauls and at night 1-2 hauls while HT hauled the net during day only 2-3 times.

RESULTS

Fishery

In the two fishing seasons of 2002-03 and 2003-04 (August-June), MLD landed estimated catch of 8,491 t and 3,014 t of total fish contributing 85.6% and 95.8% while HT landed 1,424 t and 133 t contributing 14.4% and 4.2% to the total trawl landings at the centre respectively.

Monthwise estimated catch, cpue (in Kg/trawling hr) and percentage of penaeid prawns landed by MLD and HT during 2002-03 and 2003-04 are given in Table 1. During the fishing season (September-June) of 2002-03 estimated catch of 2,455 t of penaeid prawns was landed by MLD at the catch rate of 6.5 Kg/hr; the catch was maximum in December (675.5t) and minimum in September (16t) and the contribution of penaeid prawns to total fish was 28.9%. However, in 2003-04 the estimated catch dropped to 1,392 t at the catch rate of 4.0 Kg/hr. In this season the catch was low in August (26.9 t), which increased to maximum in September (182.8t), but declined in December (89.5t) to improve again in February (218 t). During the season prawns contributed 46.2% to the total fish catch.

In HT, during the fishing season of 2002-03 a total of 577 t of prawns was landed at the catch rate of 7.3 Kg/hr (Table 1). The catch increased to maximum in December (176.8 t) but declined in March (19 t). It increased again in April (54.1 t) to drop in June (10.6 t); the percentage

Table 1: Monthwise estimated catch (t), CPUE (kg/hr) and % of penaeid prawns by trawlers (MLD) and hand operated trawlers (HT) at Harnai during fishing seasons of 2002-03 and 2003-04

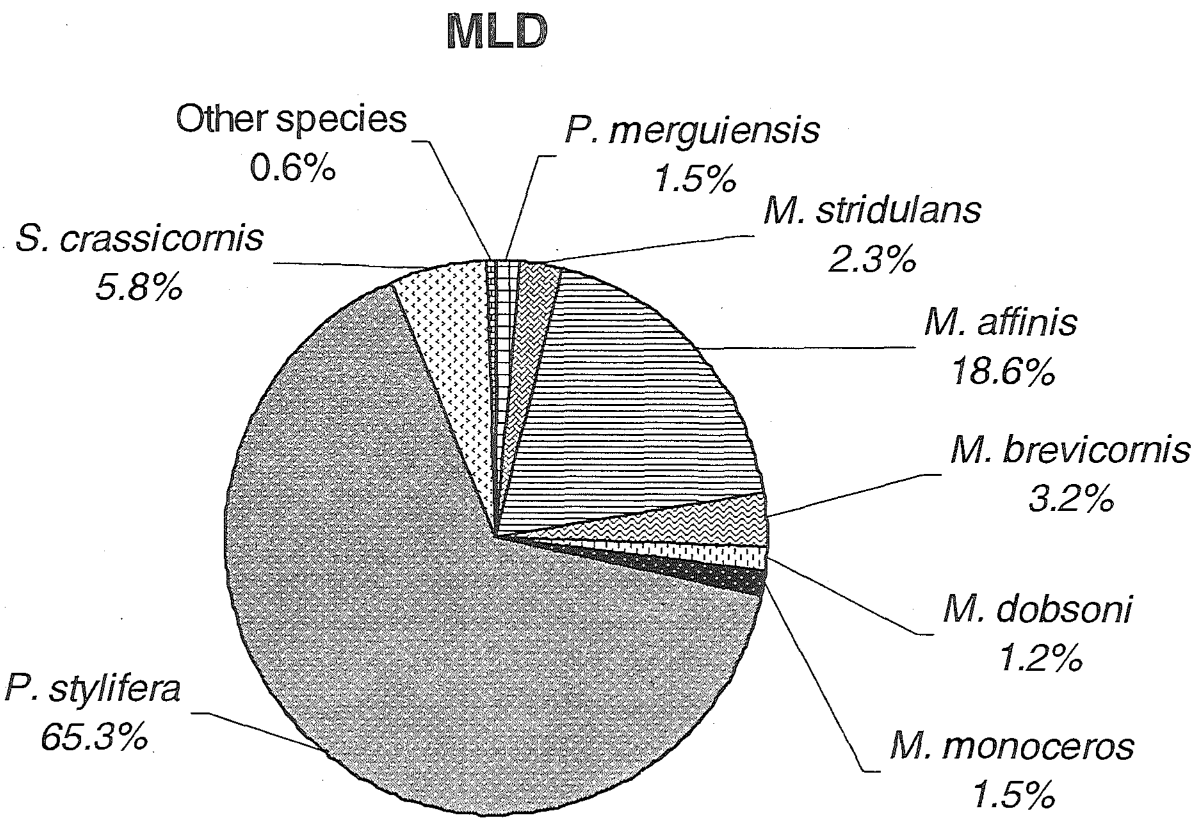
Gear	Mechanized trawl			Hand-trawl		
Month	CATCH (t)	% PRAWNS	CPUE	CATCH (t)	% PRAWNS	CPUE
SEP	16	56.8	1.96	-	-	-
OCT	430	56.3	10.64	103	18.8	12.9
NOV	420	34.7	6.69	115	65.6	18.57
DEC	675	69.6	10.5	177	57.6	13.2
JAN	290	17.4	4.83	44	40.4	2.86
FEB	137	5.4	3.36	24	35.3	2.57
MAR	181	22.7	5.31	19	55.8	2.19
APR	91	49.0	3.98	54	43.4	6.79
MAY	181	76.2	5.65	31	69.4	3.74
JUN	31	53.0	3.23	11	64.4	5.32
TOTAL for 2002-03	2452	28.9	6.53	578	40.6	7.29
AUG	27	54.9	2.14	7	59.2	2.97
SEP	183	24.2	7.25	-	-	-
OCT	134	56.1	3.49	22	55.2	4.85
NOV	165	37.2	3.66	2	13.1	0.72
DEC	90	47.4	2.33	-	-	-
JAN	205	70.8	4.48	3	38.4	1.06
FEB	218	53.3	5.35	0	12.6	0.14
MAR	77	48.5	2.84	8	35.8	3.7
APR	228	61.3	4.82	16	55.9	2.35
MAY	66	60.3	2.54	2	25.7	0.67
TOTAL for 2003-04	1393	46.2	4.02	60	45.2	2.39

contribution of prawns to the total fish was 40.6%. In 2003-04 the abundance of prawns was poor, as a result most of the HT switched over to gill netting and therefore the estimated catch of prawns was only 60 t at the annual catch rate of 2.4 Kg/hr. The catch during the season was maximum in October (21.7 t) and minimum in February (0.15 t); the contribution of penaeid prawns to total fish was 45.2%.

During the two fishing seasons, the catch of prawns pooled together showed that MLD landed 86% while HT landed only 14% of the total prawn catch. The trend in catch showed two peaks, a major during October-December and a minor during April-May in both the gears.

Species composition

Species composition of prawns pooled for the two fishing years (Fig. 1) landed by MLD showed that *P. stylifera* was the most dominant species contributing 65.3%. Other species in the order of abundance were *M. affinis* (18.6%), *S. crassicornis* (5.8%), *M. brevicornis* (3.2%), *Metapenaeopsis stridulans* (2.3%), *P. merguiensis* (1.5%), *M. monoceros* (1.5%) and *M. dobsoni* (1.2%).



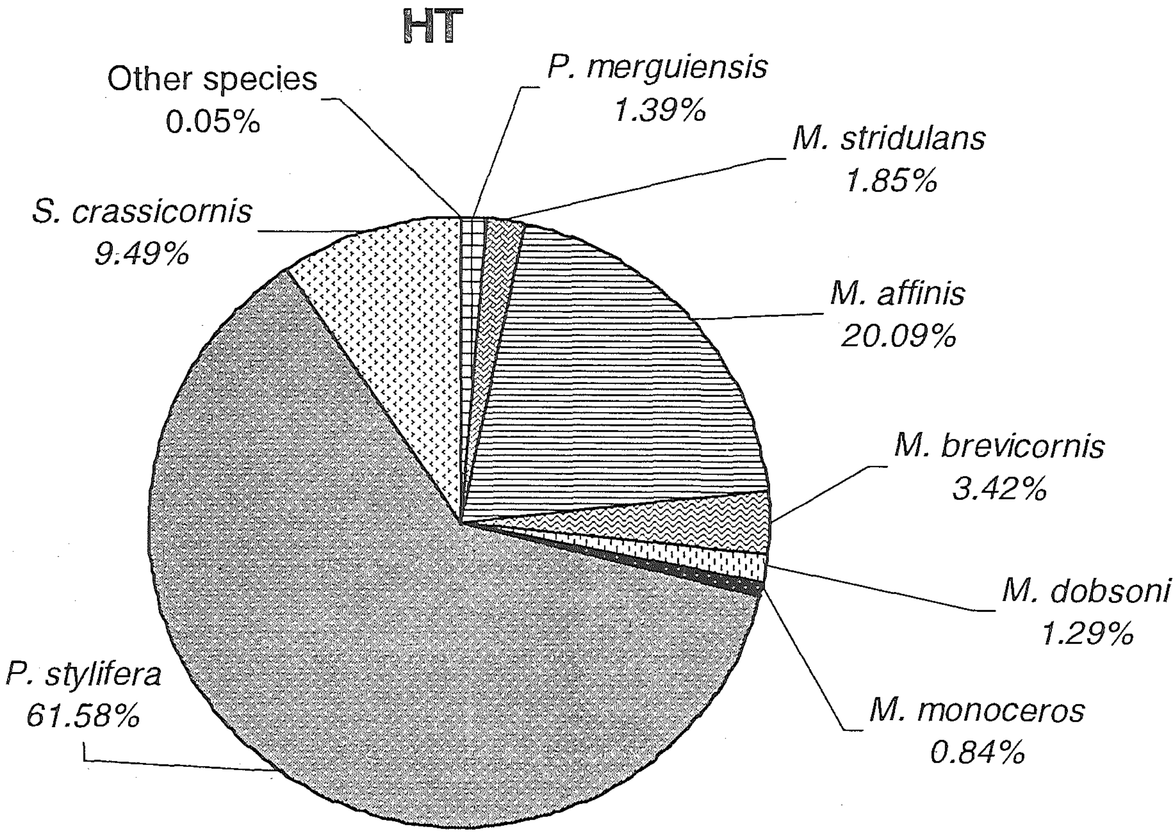


Fig.1: Species composition of penaeid prawns in mechanised trawlers (MLD) and hand trawlers (HT)

In HT, the order of abundance of the species during the two fishing seasons was *P. stylifera* (61.6%), *M. affinis* (20.1%), *S. crassicornis* (9.5%), *M. brevicornis* (3.4%), *Metapenaeopsis stridulans* (1.9%), *P. merguiensis* (1.4%), *M. dobsoni* (1.3%) and *M. monoceros* (0.8%).

Two species, *Penaeus monodon* and *Parapeneopsis cornuta* were landed by MLD and HT in both the fishing years but contributed less than 1%, while *P. indicus* occurred during 2003-2004 only.

Species abundance

Monthwise abundance as seen from the catch rates of important species *viz. P. stylifera, M. affinis, S. crassicornis, M. brevicornis, P. merguiensis* and *M. dobsoni* pooled for the two years in MLD and HT is depicted in Fig. 2. In MLD, abundance of *P. stylifera* in offshore waters (depth >20m) declined from September (5.4 Kg/hr) to November (3.5 Kg/hr) and increased again in December (6.1 Kg/hr). However, in HT the abundance was negligible in September, therefore hand trawling was not undertaken for the prawns in shallow waters (depth<20m). Interestingly, the abundance of the species in shallow waters increased from October (5.9 Kg/hr) to December (8.7 Kg/hr). From this trend it may be inferred that the species remains largely in the offshore waters until October but moves shoreward in November-December. The abundance declined from January-March, but increased during April-June in both MLD and HT.

M. affinis showed a major peak in October (2.1 and 3.1 Kg/hr) followed by a minor in April (1.1 and 1.2 Kg/hr) in both MLD and HT. *S. crassicornis* appeared only from November (1.0 Kg/hr) but declined gradually to show another peak during March-June (0.5-1.1 Kg/hr). Occurrence of *P. merguiensis* was poor throughout the year (0.08 Kg/hr) but increased significantly during February-April (0.14 Kg/hr). Substantial quantity of *M. brevicornis* was noticed during October-November (0.6 Kg/hr) and April-May (0.13 Kg/hr) while that of *M.dobsoni* in August-September (0.2 Kg/hr) and in June (0.3 Kg/hr).

Among the less important species, *Metapeneopsis stridulans* appeared in November and formed sizeable landing during February-May while both *M. monoceros* and *P. cornuta* formed noticeable quantity during December-February. *P. monodon* appeared in stray numbers almost throughout the year while *P. indicus* was noticed only during October 2003 and February 2004.

Size composition

Monthly size frequency raised to the catch and pooled for the two years is given in Fig. 3 and month-wise mean sizes of males and females of six commercially important species is presented in and Fig. 4. The size of *P. stylifera* ranged from 46-104 mm for males and 44-129 mm for females but the sizes between 71-100 mm formed the mainstay of the fishery. The mean size of both the sexes increased in October, February and June but declined in November, March and May, which may suggest three recruitments in a year.

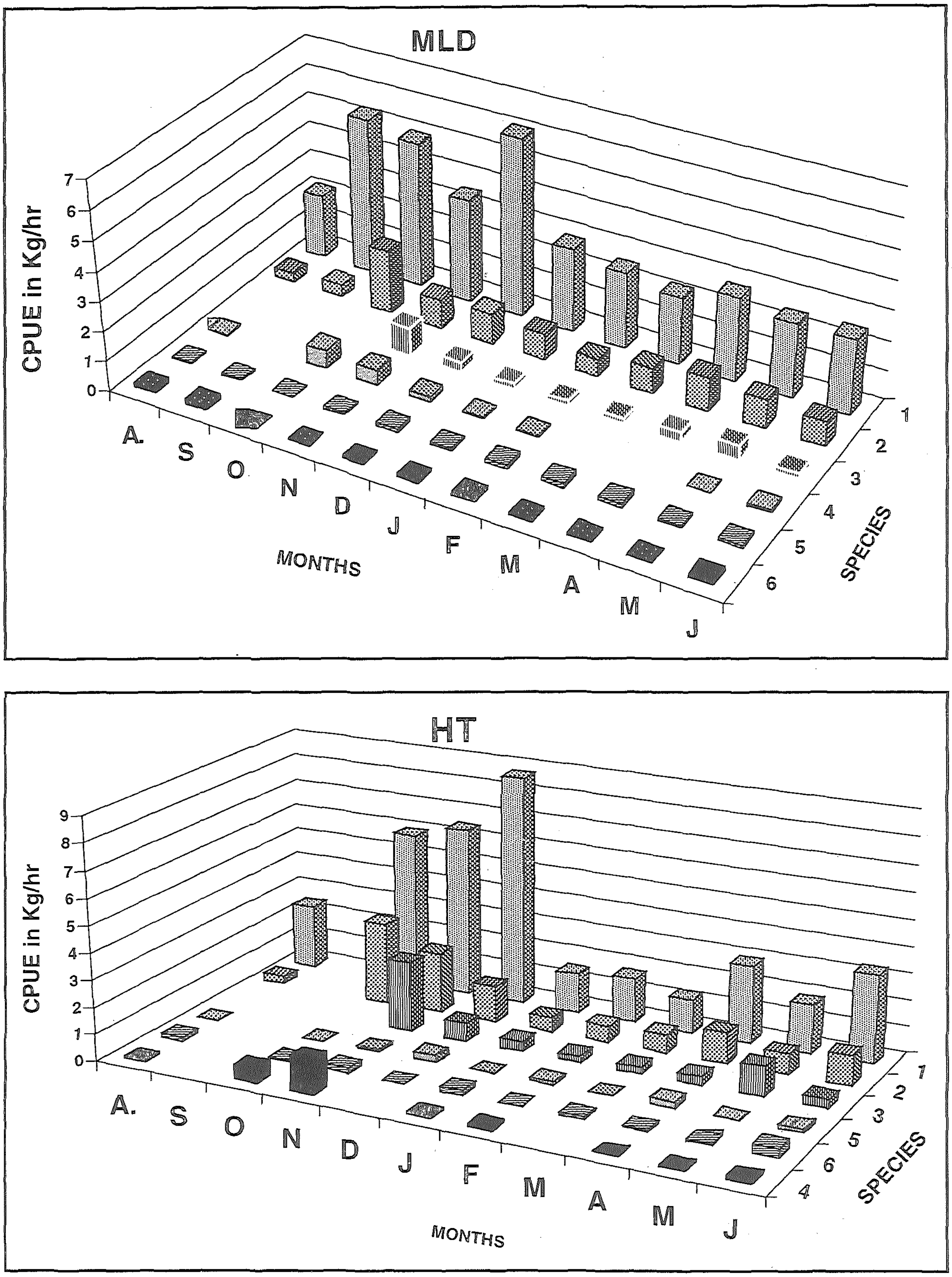


Fig. 2 : Monthwise abundance of species of prawns in MLD and HT. Species, 1: P. stylifera, 2: M. affinis, 3: S. crassicornis, 4 : M. brevicornis, 5: P. merguiensis, 6: M. dobsoni.

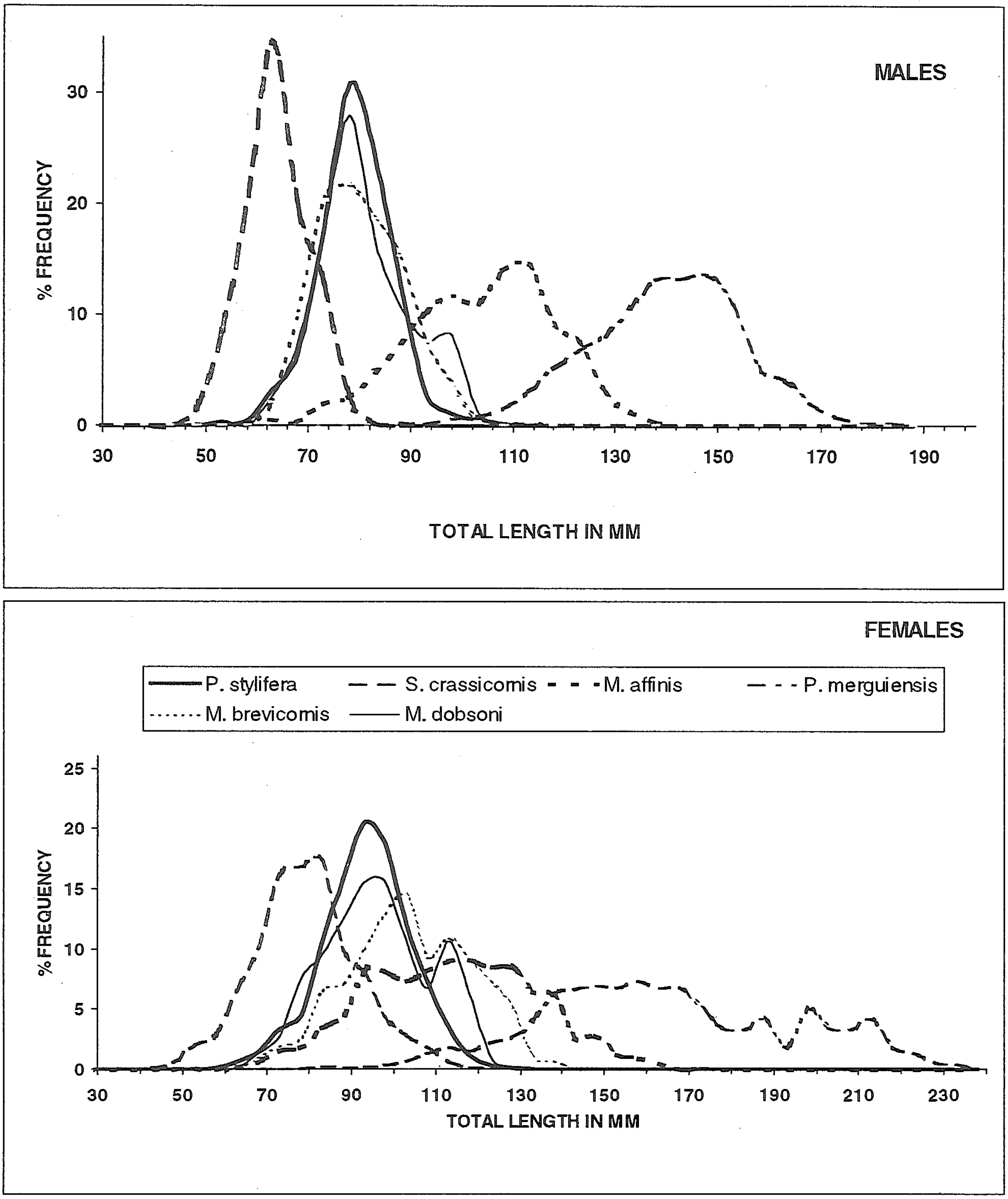


Fig. 3 : Annual size frequency of two sexes of penaeid prawns.

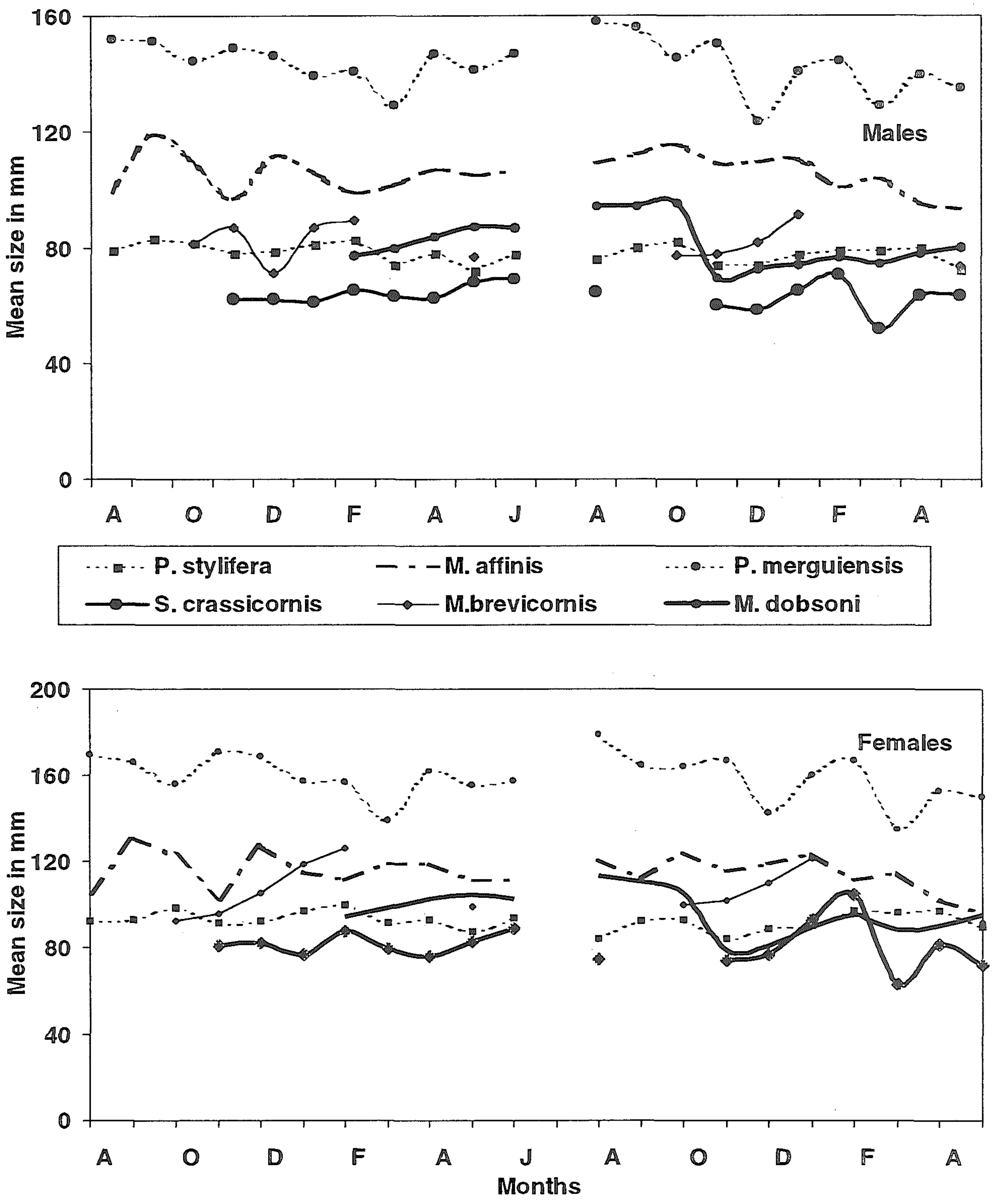


Fig. 4 : Monthwise mean sizes of male and female prawns.

In case of *M. affinis* the size ranged from 52-158 mm for males and 53-181 mm for females but the sizes in the range 96-120 mm formed the bulk of the catch. The mean size showed three peaks, in September-October, December-January and in March-April. The mean size for the species declined in August, November and feebly in February.

The size of *S. crassicornis* ranged from 43-82 mm for males and 42-127 mm for females and the sizes between 63-98 mm formed the mainstay of the fishery. The mean size showed two peaks, in February and June and it declined in November and March.

For the prime species *P. merguiensis* the males ranged in size from 68-188 mm and the females from 73-233 mm although sizes between 136-155 mm mainly contributed to the fishery. The mean size increased during November-December and April-June but declined considerably in October and March in 2002-03 and in December and March 2003-04 indicating two recruitment pulses annually.

The size of *M. brevicornis* ranged from 62-113 mm for males and 66-144 mm for females but the sizes between 81-105 mm formed the mainstay of the fishery. The mean size of the species increased from October to reach maximum in February.

The size of *M. dobsoni* ranged from 53-113 mm for males and 63-123 mm for females but the sizes between 76-100 mm formed the fishery. The mean size showed peaks in February and April but declined in November and March during 2003-04.

Species biology

Composition of food (in % IP) of four species *P. stylifera, M. affinis, S. crassicornis,* and *P. merguiensis* is given in Table 2. Reproductive details such as monthwise percentage of mature females (Fig. 5), sex-ratio in terms of percentage

Table 2 : Composition of food (% index of preponderance) of prawns at Harnai

Foor / Species	*P. merguiensis*	*M. affinis*	*P. stylifera*	*S. crassicornis*
No. of specimens examined	153	99	101	80
Acetes spp	4.7	0.3	3.1	9.9
Prawn remains	13.4	9.5	32.9	25.7
Other crustaceans	0.0	0.1	0.0	0.0
Cephalopods	0.4	0.0	0.0	1.1
Gastropods	4.5	4.0	0.4	1.3
Bivalves	43.8	0.1	5.3	14.6
Fish	3.7	3.3	8.3	1.5
Foraminifers	0.0	34.7	17.6	28.6
Polychaetes	16.3	25.6	1.7	2.0
Detritus	7.2	18.7	18.7	6.7
Semi-digested	2.9	3.6	11.3	8.5
Algae	0.0	0.1	0.6	0.0

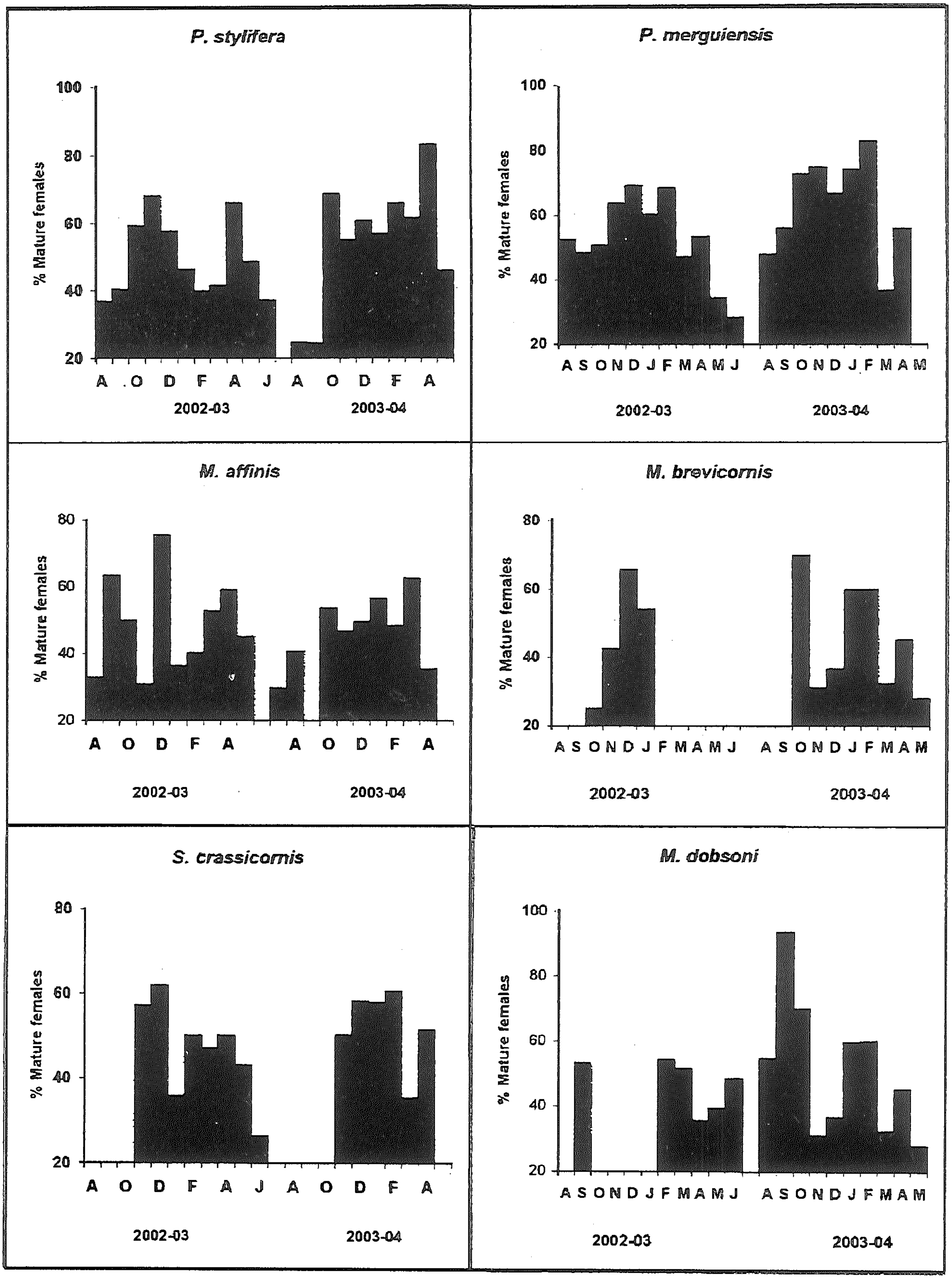


Fig. 5 : Monthwise percentage of mature females in 2002-03 and 2003-04

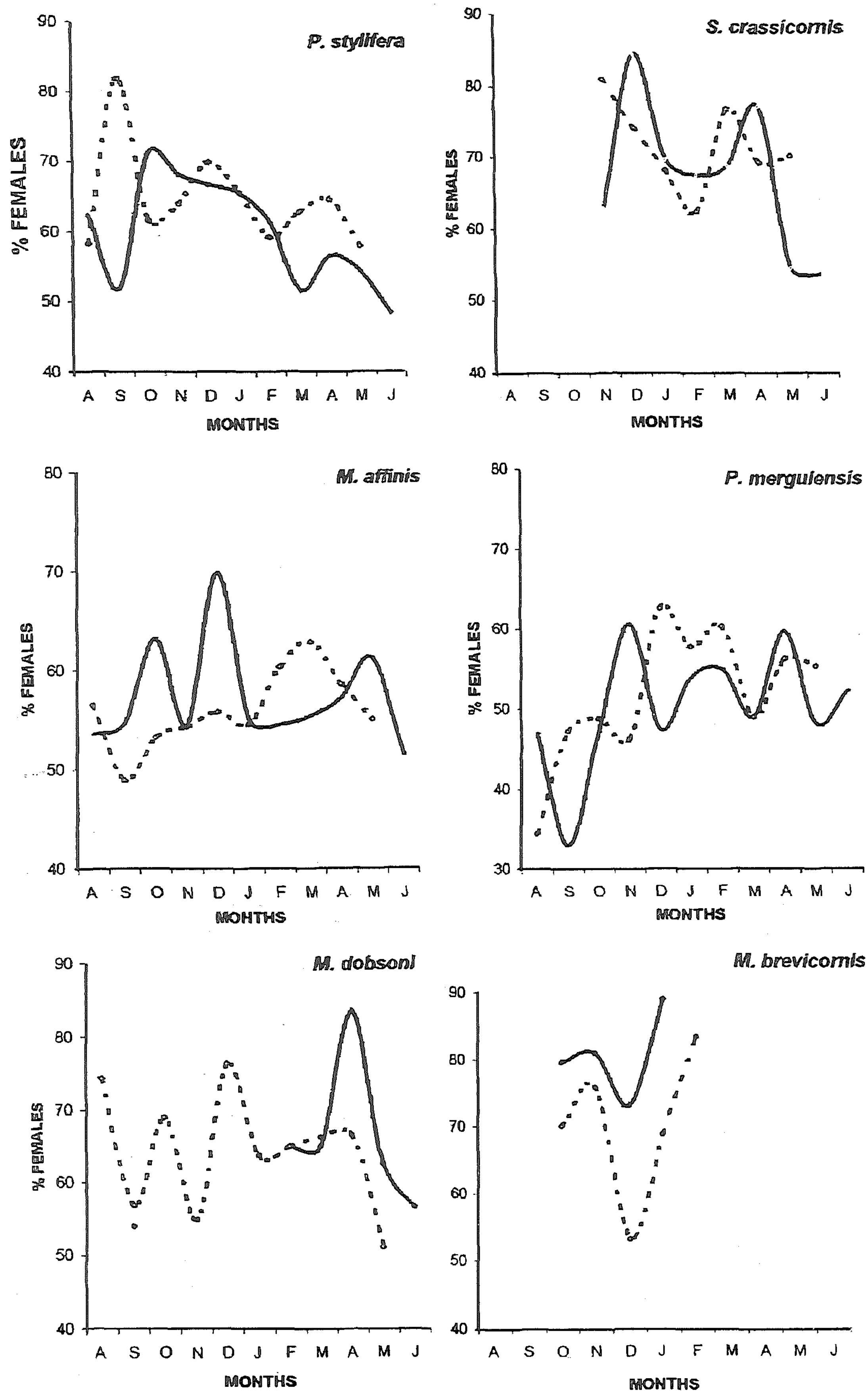


Fig. 6 : Monthwise percentage of females in total during 2002-03 (solid line) and 2003-04 (dotted line).

Table 3 : Monthwise percentage of juveniles of prawns at Harnai.

Months/Species	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
P. merguiensis	1.5	0.0	3.0	1.6	4.8	1.9	0.9	28.1	7.0	8.2	5.8
M. affinis	46.0	8.1	25.5	54.1	6.4	19.6	35.6	31.4	24.9	34.2	30.6
M. brevicornis	NA	NA	33.3	23.2	6.0	0.5	2.1	NA	NA	29.0	NA
M. debsoni	NA	6.6	11.1	45.5	65.3	19.0	4.2	15.2	11.9	6.8	3.6
P. stylifera	11.6	7.0	10.1	14.1	13.5	14.9	7.0	26.3	15.6	30.9	11.1
S. crassicornis	NA	NA	NA	46.2	64.0	46.9	9.8	61.6	57.3	40.3	26.4

of females among the sexes (Fig. 6) and proportion of juveniles in the population of six important species are presented in Table 3.

P. stylifera: Composition of food showed that the species fed mainly on 'prawns' (32.9%), detritus (18.8%), foraminifers (17.6%), fish (8.3%) and bivalves (5.3%). Although smallest mature male and female measured 60 mm and 63 mm, their sizes at maturity were 63.5 mm and 82.4 mm respectively. The mature and ripe females occurred throughout the year, however they showed peaks during October-December (with maximum in November) and in April (74.9%) in 2002-03, and in October (63.8%) and April (83.1%) in 2003-04 fishing season, thus exhibiting two spawning maxima annually. The females dominated throughout the fishing seasons but they out numbered significantly during October-December and in March-April in both the fishing seasons, in relation to spawning. The annual percentage of juveniles in the catch was only 13.9, yet their abundance was significant in during March (26.3%) and May (30.9%) in 2002-03, and in August (34.9%), November (39.7%), January (27%) and June (29.7%) in 2003-04.

M. affinis : Foraminifers (34.7%), polychaetes (25.6%), detritus (18.7%), 'prawns' (9.5%), gastropods (4.1%) and 'fish' (3.3%) formed the major dietary components. Smallest mature male and female measured 86 mm and 93 mm and their sizes at maturity were 89.1 mm and 109.2 mm respectively. The mature and ripe females occurred throughout the year showing peaks in September (63.4%), December (62.6%) and April (59.2%) in 2002-03 and in October (53.5%), January (56%) and March (62.6%) in 2003-04 fishing season. The females dominated over males in October (63.5%), December (70%) and March-May in the former and August (56.5%) and February-April in the latter year. Recruitment of juvenile prawns was mainly observed during August (46%), November (54.1%), February (35.6%) and May in 2002-03 and in September (23.4%), November (28.9%), February (32.8%) and in May (64.8%) in 2003-04 fishing season.

S. crassicornis: The food consisted of foraminifers (28.6%), 'prawns' (25.7%), bivalves (14.6%), *Acetes* spp (9.9%) and detritus (6.7%). Though males and females started maturing from 44 mm and 56 mm, their sizes at maturity were 45.5 mm 77.8 mm respectively. The percentage of spawning females was highest during December (61.9%) and February (60.5%) and the females predominated the males during November-December and March-April. The juveniles constituted 46.1% of the annual catch, but in December (64%) and March (61.4%) their number was significantly higher.

P. merguiensis: The food consisted of bivalves (43.8%), polychaetes (16.3%), 'prawns' (13.4%), detritus (7.2%), *Acetes* spp (4.7%) and gastropods (4.5%). It was noticed that the males and females started maturing from 116 mm and 118 mm onwards, but their sizes at maturity were 123.1 mm and 131.2 mm respectively. The matured females occurred throughout the year with two peaks, a primary peak in February (76.2%) and a secondary in November (69.8%). The females dominated throughout, excepting in August-October, when males dominated the catch. The annual percentage of juveniles in the catch was meagre 10.1% yet their abundance was significant in March (28.1%).

M. brevicornis: Though males and females matured from 65 mm and 81 mm, their sizes at maturity were 80.5 mm and 92 mm respectively. The mature females were maximum during December-January, the females dominated the males throughout, and in February they outnumbered by a factor of 5. The juveniles formed only 12.2% of the catch although their number increased to maximum in October (33.3%) and May 29%).

M. dobsoni : Though males and females matured from 44 mm and 67 mm, their sizes at maturity were 47 mm and 72.4 mm respectively. The highest percentage of spawning females was noticed in September-October (69.9%) and they dominated the males in November (76.3%). The annual percentage of juveniles in the catch was 14.2, which increased to maximum in December (65.3%).

DISCUSSION

Although prawn resources and abundance of the species in coastal waters of Maharashtra have been reported earlier (Shaikhmahamud and Tembe 1960; Kunju 1967; Mohmed 1967; Ranade and Waknis 1965; Kagwade 1987; Ramamurthy 1994; Deshmukh *et al.* 2002), present investigation showed for the first time that *M. dobsoni* contributed to the fishery at Harnaii in the state. The distribution of *M. dobsoni* is from Kerala to Goa, where it contributes substantially to the inshore and offshore prawn fisheries (Rao, 1987). In the present study it was noticed that juveniles of *M. dobsoni* appeared at Harnai in November 2002 in stray numbers, and perhaps the species established itself in the coastal waters along the central and northern Maharashtra later, which is evidenced by the presence of matured individuals in trawl that contributed to the fishery in 2002-03 and 2003-04. The penaeid prawns are not known for large-scale migration, therefore occurrence of the species at Harnaii and even at Mumbai (unpublished data) may be attributed to extended distribution of the species from Goa waters (Achuthankutty and Nair 1996) or drifting of its larvae from the southwest coast by unusually strong surface currents that prevailed in monsoon months (June-September) in 2002. Similar is the case of *P. indicus* which is rarely noticed in Maharashtra waters, but in 2002-03 fishing season the juveniles and subsequently adults appeared in good quantity; therefore its occurrence in the catch at Harnaii during the same period could be attributed largely to larval drifting.

Kagwade (1987) generalized that abundance of penaeid prawns in Maharashtra had two peaks, one in March-April and the other during October-November. The present study also showed two periods of abundance in general, but the individual species exhibited differing periods of abundance at Harnaii. *P. stylifera* showed two peaks in September-October and in April-May; *M. affinis* in October and April; *S. crassicornis* in November and March-June; *M. brevicornis* during October-November and April-May and *M. dobsoni* in October-December and in February. Only *P. merguiensis* showed a single peak of abundance during March. It is worth noting that abundance of all the species was not precise, and it deviated to some extent in the study period.

Of the six species of penaeid prawns four important species that occurred all through the fishing season, exhibited two spawning peaks followed by two maxima of juvenile abundance. The spawning peaks also showed synchronized changes in sex-ratio wherein the female abundance was evident, suggesting sexual segregation for spawning migration to deeper waters.

It is construed that spawning of *P. stylifera* in October-January is followed by the juveniles (recruits) appearing during March-May, but they move out to offshore waters during monsoon (Suseelan *et al.*, 1989) and immigrate shoreward to appear (as adults) again during August-October. The recruits arising out of April spawning on the other hand remain in the offshore waters (depth>20m), and as fishing is totally suspended in monsoon they together with the adults of the previous spawning contribute to heavy landings in October-December. This shoreward movement of the species is clearly evinced by the fall in mean size and the catch rate declining in MLD and increasing in HT during September-December period. *M. affinis* spawns in March-April and October-December and the juveniles arising from them appear in August-September and in April-May respectively; however, as the recruits from former spawning peak are not fished out in monsoon, they together with the adults cropping up due to growth of the latter recruits must be responsible for the heavy landings at the beginning of the fishing season in October. Since *M. affinis* is tolerant to low salinity (Rao, 1987), it probably does not exhibit discernible to and fro migrations like *P. stylifera*. *S. crassicornis* showing spawning peaks in December and February but the juveniles appear in significant numbers in December, March and May. The March and May recruits could be due to spawning peaks in December and February respectively, but those of December must be arising out of another spawning in September-October that takes place in offshore waters, where salinity is ambient.

The species is reported to migrate to offshore waters *en mass* during monsoon (Kunju, 1970) to avoid low salinity in the nearshore coastal water, and therefore appears in the catch in November when ambient salinity restores. The major catch during April-June however, may be attributed to December spawning and the May recruits should be responsible for spawning in offshore waters during September-October. Although *P. merguiensis* showed two spawning peaks in February and November it is the latter peak that appears to be responsible for the abundance of juveniles (mostly sub-adults) in the catch in March and subsequently the adults noticed in April-May. *M.brevicornis* showed spawning peak in December-January and the juveniles arising from it appeared in May but the October peak of juveniles may be the result of another spawning that could be taking place during monsoon. The offsprings from this monsoon spawning then contribute substantially to the catch during November-February. The highest percentage of spawning females of *M. dobsoni* noticed in September-October may be responsible for the juvenile abundance in December.

It may be concluded that the species of penaeid prawns in general, and *P. stylifera, M. affinis* and *S. crassicornis* in particular, which contribute to the bulk of the prawn catch exhibit distinct seasonality with two spawning peaks, one in pre-monsoon and the other in post monsoon period. These spawning peaks produce two discrete broods, but because of to and fro migrations the broods get thoroughly mingled up and remain indistinguishable in the catch.

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REFERENCES

Achuthankutty, C.T. and Nair, S.S.R., 1996. Marine prawn fishery of India-its problems and prospects. *In India's Exclusive Economic Zone* (Eds S.Z. Qasim and G.S. Roonwal) Omega Scientific Publishers, New Delhi. pp. 105-121.

Deshmukh, V.D. Patkar, D.S. and Karnik, P.C., 2002. Penaeid prawn fishery and its maximum sustainable yield at Versova, Mumbai. *Indian J. Fish.,* **48 (2):** 165-175.

Kagwade, P.V., 1980. Maturity size of the female population of certain commercial prawns form Bombay. *Indian J. Mar., Science,* **9:** 294-295.

Kagwade, P.V., 1987. Penaeid prawn resources of Maharashtra. In Proc. Natl. Sympo. On utilization of living resources of the Indian Seas (Ed. U.S. Srivastava). National Academy of Sciences, Allahabad pp. 271-278.

King, M., 1995. *Fisheries biology, assessment and management.* Fishing

News Books Limited, Farham Surrey England. 341 pp.

Kunju, M.M., 1967. Observation on the prawn fishery of the Maharashtra coast. *Proc. Symposium on Crustacea, Mar. biol. Ass. India.,* **Part IV:** 1382-1397.

Kunju, M.M., 1970. Synopsis of biological data on the penaeid prawn *Solenocera indica* Natraj 1945. *FAO Fish. Rep.* **57(2):** 467-486.

Mohamed, K.H., 1967. Penaeid prawns of in the commercial shrimp fisheries of Bombay with notes on species and size fluctuations. *Proc. Symposium on Crustacea, Mar. biol. Ass. India.,* **Part IV:** 1408-1418.

Natarajan, A.V. and Jhingran, A.G., 1961. Index of Preponderance - A method of grading the food element in the stomach analysis of fishes. *Indian. J. Fish.,* **8(1):** 54-59.

Ramamurthy, S., 1994. Penaeid prawn fisheries of the northwest coat of India. *Indian J. Fish.,* **36 (1&2):** 205-215.

Ranade, M.R. and Waknis, S.M., 1965. Prawn resources of southern Maharashtra. (Ratnagiri), an outlook for a new industry. *Curr. Aff. Bull. Indopacif. Fish.* Counc., **43:** 6-10.

Rao, P.V., 1968. Maturation and spawning of the penaeid prawns of the southwest coast of India *FAO Fish. Rep.* **57(2):** 285-301.

Rao, P.V., 1987. *A review of the present status of the prawn fishery of India.* In Recent Advances in marine Biology (Ed. P.S.B.R. James) Today and Tomorrow's Printers and Publishers New Delhi. pp 367-401.

Shaikhmahamud, F.S. and Tembe, V.B., 1960. Study of Bombay prawns. The seasonal fluctuation and variation in abundance of the commercially important species of Bombay prawns with a brief note on their size, state of maturity and sex ratio. *Indian J. Fish.,* **7(1):** 69-81.

Sukumaran, K.K., 1978. Studies on fishery and biology of *Solenocera crassicornis* (H. Milne Edwards) from Bombay waters. *Indian J. Fish.,* **20:** 32-39.

Suseelan, C., Rajan, K.N., and Nandakumar, G., 1989. The "Karikaddi" fishery of Kerala *Mar. Fish. Infor. Serv.,* T & E Series No **102:** 4-8.